LIFE AND STRESS: A BIO-CULTURAL INVESTIGATION INTO THE LATER ANGLO-SAXON POPULATION OF THE BLACK GATE CEMETERY, NEWCASTLE-UPON-TYNE

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ABSTRACT

The Black Gate cemetery in Newcastle-upon-Tyne was established within the abandoned remains of a Roman fort (*Pons Aelius*) in the 8^{th} century and was an active burial ground until the 12^{th} century AD. The cemetery has yielded 663 articulated skeletons, making it one of the largest skeletal assemblages recovered from later Anglo-Saxon England. Aside from the cemetery there is no physical evidence for settlement in the area from the abandonment of Pons Aelius in 410 AD. until the first phase of construction of a Norman castle in 1080 AD. Documentary evidence indicates the presence of a monastery within the immediate locality of the cemetery; however, archaeological evidence for a monastic settlement at the site has yet to be identified. Consequently, the origin of the contributory population is uncertain.

To determine the nature and origin of the Black Gate cemetery population a bio-cultural investigation was undertaken. Investigation into the relationship between health and the different demographic and social components of the assemblage, determined from burial form and variation, enabled a picture of the overall social and environmental impact on levels of physiological stress to be assessed. Indicators of stress were compared with thirteen sites of known context to determine if the health profile observed amongst the Black Gate population shared characteristics with urban, rural or monastic assemblages.

A detailed picture of the health and funerary behaviour of the Black Gate cemetery was attained. However, the origin of this population remains inconclusive. This research emphasises the multi-factorial nature of physiological stress and that age, diet, cultural practices and status had a greater impact upon the skeleton than settlement type in the later Anglo-Saxon period.

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CHAPTER 1

INTRODUCTION

1.1 The Black Gate Cemetery: An Introduction

> *We do not know where the settlement or settlements, which the cemetery served, were located. Was it a focal point for a number of agricultural communities or was there an 'urban' centre nearby?* (Nolan 1998: 1)

Newcastle-upon-Tyne is today a busy metropolis on the north-east coast of England. Located in the centre of this city, within the remains of an abandoned Roman fort (*Pons Aelius*), stands the New Castle from which its name is derived (Figure 1.1). This Norman castle overlooks the north bank of the River Tyne, which runs through the city, separating it from the opposing town of Gateshead.

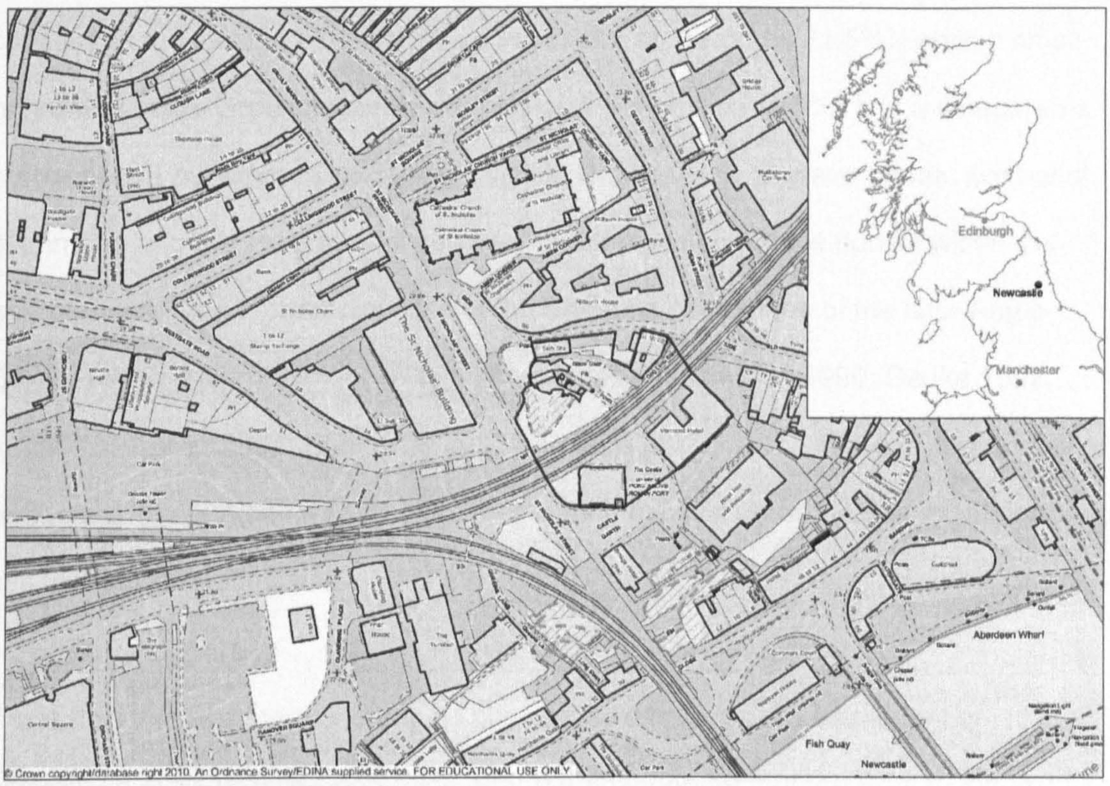


Figure 1.1 *Location of the Black Gate cemetery, Newcastle-upon-*Tyne (Dark blue line demarcates limits of excavation)

Excavations within the castle grounds have revealed a later Anglo-Saxon cemetery, which pre-dates the reconsolidation of the castle in stone in 1168. The cemetery is named after The Black Gate – the fortified gateway, or barbican standing adjacent to the cemetery – which was used to identify the excavation area. This fortified gateway was constructed between 1247 and 1250 to strengthen the pre-existing north gate of the castle and, therefore, has no direct relationship with the cemetery (Knowles 1926: 41).

Excavations of the cemetery between 1977 and 1992 revealed 660 inhumation burials dating from the 8th to 12th century. All the graves were orientated on a west-east alignment and contained no artefacts that could be described as grave goods (e.g. weapons, jewellery, clothing accessories etc.) (Nolan 2010: 222). Most individuals (71.1%) were interred supine with the arms extended or crossed over the pelvis or torso and the legs either extended straight or crossed at the ankles. Right-sided burials constituted the second most common disposition of the body (21.5%), while a small proportion of the population were interred on their left side (3.8%) and a comparable number were buried prone or flexed (3.6%). The absence of grave goods, west-east alignment, and the predominant supine-extended position of the burials within the cemetery are typical characteristics of the Christian cemeteries of the later Anglo-Saxon period dating from the 8th to 11th centuries (Boddington 1990; Geake 1992; 1999; Thompson 2004; Hadley 2011). This thesis presents the first comprehensive analysis of the human remains recovered during excavation at the Black Gate and the associated burial practices.

Aside from the cemetery, there is no physical evidence for any settlement or occupation in Newcastle-upon-Tyne after the abandonment of the Roman fort in 410 until the first phase of construction of the castle in 1080 (Harbottle and Clack 1976; Nolan 2010: 156). Historical sources dating to 1072 and 1074, which will be discussed in Chapter 2, allude to the presence of a monastic settlement called Monkchester in the locality of the castle but there is no definitive archaeological evidence for such a settlement (Nolan 2010: 156). Alternative hypotheses for the contributing population of the Black Gate cemetery and the occupation of pre-Conquest[1] Newcastle-upon-Tyne are that it was a trading settlement (Merrony *et al.* 1996) or that the site was used intermittently during the later Anglo-Saxon period for agricultural or industrial purposes (Snape *et al.* 2002). However, with no archaeological evidence to support or disprove these hypotheses, the origins and nature of the contributing population of the Black Gate cemetery is currently unknown.

1.2 The Black Gate Cemetery: Previous Research and Analysis

Several analyses of the Black Gate skeletal assemblage have previously been undertaken, in various degrees of detail, but this research is the first analysis of the population as a whole. D. A. Lake (1977) at the University of Newcastle produced the initial report on skeletons 1 to 18, recovered during the earliest phase of excavation. The location of this report and 13 of the skeletons is, however, currently unknown (Nolan 2010: 149). The skeletons that had survived (1, 8, 14, 17 and 18) were re-examined by S. Anderson (1988) at the University of Durham in 1988, alongside skeletons 19 to 148a from the 1978-9 excavations. In the late 1980s and early 1990s, C. M. Marlowe, also of the University of Durham, produced a summary catalogue of skeletons 150 to 430 from the 1980-2 seasons of excavation. The final excavations in 1990 and 1992 recovered skeletons 431-660, which were analysed by S. Boulter and E. Rega (1993) for Archaeological Research and Consultancy, University of Sheffield (ARCUS). Since 1993, most of the skeletal collection has been housed by the Department of Archaeology at the University of Sheffield and has been the subject of a number of MSc. dissertations. These theses discuss such issues as childhood trauma, the aetiology of specific palaeopathological conditions and the reliability of published and established osteological methodology (Eliopoulis 1998; McCreanor 1998; Brone 2001; Papadimitriou 2003; Ruiz 2003; Pantzer 2004; van de Vijver 2007;

[1] Throughout this thesis the term 'pre-Conquest' refers to the period before the Norman Conquest of 1066

Papadopoulou 2009). The Black Gate cemetery was also a principal case study in P. MacPherson's (2005) doctoral research at the University of Sheffield, which utilised stable isotopes to identify dietary and migration histories of individuals from northern England. Anderson's 1988 analysis of 140 of the Black Gate skeletons was later used as comparative data for her examination of the skeletal material recovered from the Anglo-Saxon monastic sites at Wearmouth and Jarrow (Anderson *et al.* 2006). Furthermore, researchers from institutions from across the world have also come to Sheffield to examine the assemblage for studies ranging from the relationship between social identity and acquired syphilis in early modern England (Zuckerman, Emory University, Atlanta) to the aetiology of musculo-skeletal stress markers (Niinimäki 2012). Since the collection has long proved invaluable to such a wide variety of national and international research projects it is essential that it should finally receive a comprehensive study by a single researcher, and that an attempt is made to determine the context of the cemetery.

1.3 The Impetus for the Present Research

There is limited documentary evidence pertaining to later Anglo-Saxon Northumbria. It is not included in the Domesday Survey commissioned by William the Conqueror to appraise the distribution of wealth throughout England between 1086 and 1087, and which also records information on pre-conquest landholding (Martin 2002: vii; Loyn 2003: 10). Consequently, research into later Anglo-Saxon Newcastle and the surrounding locality is heavily dependent upon the archaeological record. Unfortunately, there are few excavated cemetery sites or published reports for either settlements or burial sites from Northumbria dating to the later Anglo-Saxon period. The scarcity of published cemeteries dating to the 8th-12th centuries is highlighted by a gazetteer of Anglo-Saxon cemeteries in Northumbria produced just over a decade ago, and the situation has scarcely improved (Lucy 1999: 12). Lucy's gazetteer identifies only a few sites dating to the mid and later Anglo-Saxon period. Of these sites, the majority only possess small numbers of excavated inhumations or surviving skeletal remains (Table 1.1).

Site	No. Excavated Burials	Publications/ Unpublished Archive Reports
Cottam	13	Brewster 1969,241; Department of Environment 1968,13; Eagles 1979,427; Faull 1979, 303; Meaney 1964, 292; Mortimer 1905, 336-7.
Garton	30	Elgee & Elgee 1933,182; Geake 1997,158; Meaney 1964,289; Morris 1983,55; Mortimer 1905,247-57; Smith 1912b, 79-80; Trans Hull Scientific & Field Naturalists Club 4 (1918),312-3
Kilham	6	Eagles 1979,438; Faull 1979,306; Buckberry 2004
Sledmere	60	British Numis Jnl 30 (1960-1) 6-53; Geake 1997,158; Meaney 1964,289-90; Mortimer 1905, 264-70; Smith 1912b,82;Trans Hull Scientific & Field Naturalists Club 4 (1918),313
Thwing	132	Geake 1997,159 (citing Terry Manby pers. comm); Craig 2009.
Lamel Hill	38	Arch. Jour. 6 1849, 27-39,123-36; Elgee & Elgee 1933, 186-7; Geake 1997,190; Interim 9.3 (1983), 11-13; Meaney 1964,293; Med. Arch 28(1984,249; Sheppard 1979, Cat 1T5
Ripon- Ailcy Hill	177	Geake 1997,189; Hall & Whyman 1996, 65-124; Interim 11.4 (1986-7),29-37; 12.3 (1987),15-22; Med. Arch 31 (1987), 169; 32 (1988), 290.
Ripon- Deanery Gardens	3	Geake 1997,189 (YAT archives); Hall & Whyman 1996, 130-6
Ripon-Ladykirk	36	Geake 1997,190 ; Hall & Whyman 1996, 124-30; Morris 1983,61
Whitby	'suggestions of excavation of an 8th century cemetery associated with the abbey'	Archaeologia 89(1943), 27-88; Cramp 1976a, 223-9,455-7; Rahtz 1976a, 459-62.
Addingham	57	Adams 1996; Geake 1997,191
Pontefract	197[1]	Adams 1996; Current Arch 9 (1987), 340-4; Faull 1981,180; Geake 1997,191; Med Arch 30 (1986), 178-80; 31 (1987), 172; Sheppard 1902; Craig 2009.
Binchester	44+	Cramp 1983,268; Norton and Boylston 1997.
Hartlepool	68+	Antiquaries Journal 2 (1922)141-3; Archaeolica Aeliana 4, ser, 34 (1956); Archaeologia 26(1882), 479-82; Daniels 1992; Geake 1997, 148; Gentleman's Magazine 102 (1833), 218-20; Hodges 1905,212-13; J.British Archaeol. Assoc 1 (1846),185-96; Meaney 1964,84. Daniels *et al.* 2007).
Jarrow	132[2]	Cramp 1969, 45; 1976a, 236; Geake 1997, 184-5; *Medieval Archaeology* 16 (1972), 150; 35 (191), 194); Anderson *et al.* 2006: 482[2].
Monkwearmouth	168[2]	Cramp 1969, 31-4; 1976a, 231; Geake 1997, 1; *Medieval Archaeology* 9 (1965), 171; 16 (1972), 150; McNeil and Cramp 2005: 77[2].
Milfield	24 (only 3 with skeletal remains)	Geake 1997, 172; *Medieval Archaeology 22* (1978), 149; Miket 1980, 296; Scull and Harding 1990.
Yeavering	386+[2]	Geake 1997, 172-3; Hope-Taylor 1977, 67-78, 244-67; Meaney 1964, 199; *Medieval Archaeology* 1 (1957), 148-9; 24 (1980), 265-70; Miket 1980, 296.

Table 1.1 *Summary of published and unpublished Northumbrian cemetery sites dating to the mid and later Anglo-Saxon period (Lucy 1999: 12). ([1]Number of burials data from Craig 2009: 33, Table 1.4; [2]additional information added by thesis author)*

Few of these mid to later Anglo-Saxon cemeteries have been accorded more than a few pages in any given publication and a number of the larger assemblages, such as those from Thwing, Pontefract and Yeavering are awaiting publication. However, in recent years, reports have been published for Wearmouth and Jarrow (Cramp 2005) and Hartlepool (Daniels *et al.* 2007) and papers documenting later Anglo-Saxon Northumbrian cemeteries are appearing in edited volumes (Groves 2010).

The dearth of published literature has hindered bio-cultural studies of later Anglo-Saxon cemeteries in the past. However, the accomplishments of recent studies comparing burial practices with osteological data have improved the understanding of Anglo-Saxon cemeteries (Lucy 1998; Stoodley 1999a; Buckberry 2007; 2010; Craig 2009; Craig and Buckberry 2010). These studies have provided a foundation for improving the currently limited understanding of the contributing population of the Black Gate cemetery. A bio-cultural analysis of the large number of skeletons and burials recovered from the Black Gate cemetery will provide a valuable new body of data about health, lifestyle and socio-cultural status in this cemetery and the later Anglo-Saxon period in general.

During the period of use of the Black Gate cemetery the population of England had increased significantly from approximately 600,000 people in the 7th century to between 1,500,000 and 2,000,000 in 1086 (Howe 1997: 75-6; Reynolds 1999: 57; Roberts and Cox 2003: 165). By the time of the final burials in the early 12th century, England was becoming increasingly urbanised, albeit much below the levels present in the later and post-medieval periods. Trade centres such as *wics* and *emporia* and complex monastic sites were emerging in the 7th and 8th centuries and defensive *burhs* in the 9th to 10th centuries (Dyer 1985; Scull 1997; Griffiths 2003). Analyses of both archaeological and modern pre-industrial populations have identified differences in health profiles between rural and urban settlements, with the latter experiencing greater disease transmission, poorer sanitation, hygiene, greater nutritional stress and, subsequently, a reduced life expectancy (Manchester 2001: 142; Roberts 2009: 320; Walker *et al.* 2009: 115). People in later Anglo-Saxon rural and urban settlement types were also employed in different economic activities, which may have impacted upon the skeleton (Judd and Roberts 1999). Through comparisons of the health profiles of the Black Gate with thirteen cemeteries of known context, this thesis seeks to identify if the proposed differences between urban and rural settlements can be detected in the later Anglo-Saxon period. Identifying a settlement-specific health profile will potentially enable identification of the Black Gate cemetery population as rural, urban or monastic in origin.

1.4 Research Aims

The research presented in this thesis addresses three main research questions. The primary aim is to identify what conclusions can be drawn about health and lifestyle of the population interred in the Black Gate cemetery. The Black Gate is one of only a few later Anglo-Saxon skeletal assemblages from Northumbria; therefore, the knowledge gained from Black Gate can be used to enhance the currently limited understanding of later Anglo-Saxon life in Northumbria and across England as a whole.

The second focus of the thesis is to determine if variations in burial practice correlate with different health and lifestyle conditions. The later Anglo-Saxon period shows a shift in burial practices from plain graves containing grave goods to graves without additional artefacts that exhibited variability in their construction, ranging from plain earth cut graves through to stone lined graves and stone cists. A principal factor in this change is the increasing influence of Christianity. However, previous archaeological studies of mortuary behaviour have equated the greater a financial and labour investment needed to construct a grave with the higher or wealthier social standing of its inhabitant during life (Tainter 1978; Sullivan 2005: 258; Parker Pearson 1999: 31). To date, there has been limited bioarchaeological research aimed at interpreting the relationship between elaboration in grave construction and later Anglo-Saxon social organisation (Buckberry 2004, 2005; Craig 2009, 2010). The current study intends to use the different mortuary practices to examine social structure and status within the Black Gate cemetery. If those interred in stone-lined graves and stone cists do indeed represent a group with greater social status during life, relative to those interred in plain graves, it would be expected that there would be differences in health and physiological stress between the two groups, based on differential access to resources and the physical stresses experienced during life.

Finally, this project aims to identify the nature of the contributory population the cemetery contains and, by extension, what kind of site it was. Such an approach not only attempts to place the morbidity, mortality and mortuary behaviour observed in this assemblage into context, but also identifies if the negative effects on health commonly associated with urbanisation are discernible in later Anglo-Saxon cemeteries. The implication is that if differences do exist in health between urban, rural and monastic cemeteries, it may be possible to identify future settlement sites by the mortality and morbidity profiles of a skeletal assemblage. To answer this question, comparisons are made of the mortality and morbidity data for thirteen cemetery sites of known context, from a broadly similar period, and the Black Gate.

The information resulting from this research will make a significant contribution to the burgeoning field of bio-cultural analysis of later Anglo-Saxon cemeteries, which have until very recently been considerably less well studied and analysed than those of the earlier Anglo-Saxon period (Hadley 2011: 288-9).

1.5 Research Approach

The central methodology of this thesis is a bio-cultural analysis of the Black Gate skeletal assemblage and burial archaeology to provide a mortality, morbidity and socio-economic profile of the contributing population. First, age and sex data will be collected to determine the overall composition of the assemblage. A detailed picture of the health status of the population will be created via analysis of skeletal indicators of non-specific environmental stress, non-specific infection, dental health and biomechanical stress. An assessment will also be made of the overall characteristics of the cemetery in terms of its location, distribution of burials and form and variation in burial ritual. The Black Gate cemetery exhibits several burial practices that were common to the later Anglo-Saxon period, including the use of wooden coffins, stone cists and stones surrounding the head and body. The inclusion of support stones and the construction of graves from stone, and with stone linings, has been increasingly correlated with a higher socio-economic status of the deceased or their family in contrast to those interred in plain graves (Buckberry 2004; Hadley 2007, 2011; Craig and Buckberry 2010). Therefore, analysis of the relationships between health status and burial practices within the Black Gate cemetery should contribute to our understanding of the relationship between mortuary behaviour and social status. It is intended within this thesis to explore whether individuals interred in more elaborate or complex burials were of higher status than those interred in plain earth-cut graves by comparing skeletal health indicators between plain and elaborate burials. The skeletal indicators of health that will be analysed are immature growth, adult stature, cribra orbitalia, dental enamel hypoplasia, tibial periosteal new bone formation, maxillary sinusitis, dental health indicators (calculus, caries, abscesses and ante-mortem tooth loss), degenerative joint disease and skeletal manifestations of physical trauma.

Finally, the bio-cultural profile of the Black Gate cemetery will be compared to contemporary sites of known context to determine if the prevalence of health markers provides a reliable indication of the levels of physiological stress imposed upon a population and if the context from which that population originated can be identified. Comparisons between the Black Gate cemetery assemblage and osteoarchaeological reports from thirteen sites of known social context (listed in Table 1.2) will identify any similarities in mortality and morbidity between specific settlement types. The thirteen comparative cemeteries are representative of major towns, small proto-urban places, rural cemeteries associated with minster churches and rural cemeteries with local village churches. Chapter 2 provides detailed discussions of each of these sites. The results of these comparisons will be used to determine the origin of the Black Gate cemetery population, for which there is little contextual information.

Site	Date (AD)	No. Skeletons Analysed	Analysed by	Analysis date/ Publication Date	Notes
Black Gate	8-12th C	643	Swales	2009	All 'in-situ' burials analysed
York Minster	*-11th C	67	Lee	1995	Pre-Norman Cemetery
Swinegate	10-11th C	100	Buckberry	2004	All 'in-situ' burials analysed
St Andrews, Fishergate	10-12th C	131	Stroud	1993	Phase 4
St Nicholas Shambles	11-12th C	234	White	1988	All 'in-situ' burials analysed
Wearmouth	*c.*7-11th C	327	Anderson *et al.*	2006	All 'in-situ' burials analysed
Jarrow	*c.* 7-11th C	170	Anderson *et al.*	2006	Anglo-Saxon only
Llandough	*c.* 7-11th C	801	Loe	2003	All phases (I II III)
Ailcy Hill	*c.* 7- 10th C	27	Langston	1996	Phases 1-3
Raunds Furnells	*c.* 850-1100	339	Powell	1996	All 'in-situ' burials analysed
Wharram Percy	950-1066/ 1066-1348	255	Mays	2007	Phases I and II
Addingham	8-10th C	83	Boyleston and Roberts	1996	All 'in-situ' burials analysed
North Elmham	10-12th C	194	Wells and Cayton	1980	Phase III predominantly
St Peter's, Barton- upon-Humber	950-1150	446	Rogers	2007	Phase E

Table 1.2 *Summary of cemetery sites included within present study*

1.6 Thesis Outline

Chapters 2 and 3 provide background information to place the research presented herein in context. Chapter 2 discusses the Black Gate cemetery in detail, incorporating archaeological, documentary, osteological and burial information to present what is known about the cemetery and how this can be, and has been, used to infer the nature of the cemetery and the population which buried their dead therein. This is followed by a summary of the thirteen comparison sites, detailing the type of settlement served by each cemetery, cemetery size and burial practices represented. Chapter 3 places the Black Gate cemetery in context, providing information on the burial practices and types of settlement typical of the later Anglo-Saxon period. Chapter 4 describes the palaeopathological and statistical methods that will be applied to the osteological and burial material recovered from the Black Gate cemetery and the mortality and morbidity information available for the thirteen comparative sites. Chapter 5 documents the results of the palaeopathological analysis for the Black Gate cemetery, commencing with the preservation and composition of the assemblage followed by the results of the health indicator analysis. Chapter 6 is a bio-cultural investigation into the relationships between physiological stress, health and burial practices within the Black Gate cemetery. Chapter 7 investigates whether the mortality and morbidity profiles of the Black Gate cemetery can be used to infer the type of settlement from which the contributory population derived. Comparisons of adult stature and the prevalence rates of non-specific physiological stress markers (cribra orbitalia, dental enamel hypoplasia), non-specific infection (tibial new bone formation, maxillary sinusitis), dental health (calculus, caries, abscesses and ante-mortem tooth loss) and biomechanical stress (represented by appendicular and spinal degenerative joint disease) are made between Black Gate and thirteen broadly contemporary sites of known context. Chapter 8 considers the findings from chapters 5, 6 and 7 and presents the overall conclusions and the potential for future research presented by this study.

CHAPTER 2

THE BLACK GATE CEMETERY AND COMPARATIVE SITES

The Black Gate cemetery provides the only archaeological evidence for settlement within Newcastle-upon-Tyne from the abandonment of the Roman fort *Pons Aelius* in the late 4th to early 5th century until construction of the New Castle began in 1080 (Harbottle and Clack 1976; Nolan 2010: 156). The lack of evidence for settlement prior to the first interments within the cemetery in the late 7th – early 8th century suggests that the contributing population specifically chose the abandoned remains of *Pons Aelius* as a preferred location within which to bury their dead. The desirability of burial within the Black Gate cemetery is further indicated by its prolonged period of use for over almost four centuries. The interment of lay communities within such large cemeteries, both with and without church buildings, was becoming increasingly common in the later Anglo-Saxon period, as will be discussed in Chapter 3. The current chapter considers the evidence for the presence of a possible church or monastic building, the nature of the skeletal assemblage (i.e. its condition and demographic profile) and the variation in burial provision observed within the Black Gate cemetery.

2.1 The Cemetery: Background and Archaeology

In assessing the nature of the cemetery and the likely contributing population, it should be noted that the full extent of the cemetery has yet to be determined and an unknown number of burials have been destroyed by medieval and later intrusions (Nolan 2010: 161), preventing any accurate estimations of the size of the contributing population. Moreover, even though it is apparent that the cemetery was of a substantial size and was in use for a prolonged period, it is possible it was not the only local burial ground serving the surrounding population. Surrounding rural communities may have buried their dead in smaller burial grounds in the local area, which have yet to be discovered. Furthermore, the use of several burial grounds by the same contributing population has been identified in later Anglo-Saxon ecclesiastical contexts in the north of England at

Ripon, where the cemeteries of Ailcy Hill, Ladykirk, Deanery Gardens and St Marygate are all located within *c*.200-300 metres of St Peter's church and date between the 7th and 10th century (Hadley 2000a: 203-4). Alternatively, the Black Gate cemetery may have served several local settlements, such as Pandon and Newburn, which are addressed in the next section. Consequently, it is not possible to determine accurately the size of the population based on the number of individuals interred within the cemetery. The following section details the documentary evidence regarding the possible nature of settlements near the Black Gate cemetery during the period of its use.

2.1.1 The Black Gate Cemetery: Documentary Information

The anonymous author of the *Life of St Oswin King of Northumbria* (644-651), writing in the 12th to 13th century, states that William the Conqueror, on his return from his expedition to Scotland in 1072, passed 'near to the place which is called Newcastle, that used to be called Monkchester' (Raine 1838: 21; *Miscellanea Biographica* viii; Rollason 2000: 202). There is sufficient evidence in his text to determine that the otherwise unknown author was a monk from St Albans, who subsequently resided at the monastery at Tynemouth from 1111. Even though the anonymous author wrote long after the actual events documented in the biography of St Oswin, the king of Northumbria, much of his work was a compilation of the works of Bede, whose writings were more concurrent with events in the early 8th century (Raine 1838: 12-13).

The chronicler Simeon of Durham, a Benedictine monk of Durham Priory writing in the early 12th century, provides a second reference to Monkchester, as a place that was later to become known as New Castle. In both the *History of the Church of Durham* (1104 - 1107 to 1115) and the *History of the Kings of England* (1129) Simeon documents the journey of Aldwin, prior of Winchcombe, and two English monks, Elfwy and Reinfred, to Jarrow in 1074 (Rollason 2000: xlii, xlviii). He records that upon arrival in York they requested a guide to 'the place called Monkchester, that is, the city of the monks, now called New Castle' before they proceeded to Jarrow. Upon arrival at 'New Castle' they found it to have been laid to waste, as were Wearmouth and Jarrow when they arrived at their destination (Stevenson 1855: 559; Rollason 2000: 200-3; *HReg s.a.,*1074; *LDE iii,*21).

Based on the aforementioned references, it can be inferred that the Black Gate cemetery belonged to a monastery, and that the interments included the lay community that it served, given the mixed demographic profile of males, females and immatures. However, it must be taken into consideration that Simeon and the anonymous author were writing some time after the events they describe, and that there is no other written evidence for the existence of an Anglo-Saxon monastery at Newcastle-upon-Tyne. It is possible that the name Monkchester derived from the combined presence of a monastic settlement and the Roman fort (*Pons Aelius*) within which the cemetery is located. Indeed, the most definite example of a monastic settlement in Northumbria is also prefixed with the word monk i.e. Monkwearmouth. The Latin 'ceastre', meaning 'a fort', passed into Old English in the form of 'chester', and was commonly used as a suffix in place-names of former Roman fortified towns such as Chester, Winchester and Colchester (Harbottle and Clack 1976: 117; Corèdon 2004: 63).

Documentary sources occasionally allude to settlements in the locality of present day Newcastle-upon-Tyne, which the cemetery may have served. It is recorded in the *Anglo-Saxon Chronicle* that 'the [Viking] army went from Repton, and Healfdene went with some of the force into Northumbria, and took winter quarters by the river Tyne' and 'overcame that land' in 875 (Savage 1982: 93). This implies the presence of Viking winter camps along the River Tyne, but whether any such camp was created at or near Newcastle is unknown. Simeon of Durham in his *History of the Kings of England* associates Newburn '5 miles west of Newcastle' (Sykes 1833: 12) with the site at which

Copsi, the Earl of Northumberland was put to death in 1072 (Stevenson 1855: 557; *HReg, s.a.* 1072).

Antiquarian scholars have alluded to activity and settlement local to the site of Newcastle castle, but some of their suggestions and interpretations are highly speculative. The most common suggestion proposed by antiquarian scholars, such as Sykes (1833) and Hodgson Hinde (1858: 16-19), is that Newcastle is the site of *Ad Murum. Ad Murum* ('At Wall') is described by Bede as 'a famous royal estate' where Peada, son of Penda, the king of Mercia, was baptised before his marriage to Alhflæd, the daughter of Oswiu, the King of Northumbria (Colgrave and Mynors 1969: 278-9; *HE*, iii, 21). A second reference to *Ad Murum* by Bede provides geographical information, which is the principal reason that antiquarian scholars believed Newcastle to be the site of *Ad Murum*. Bede records that Sigeberht, king of the East Saxons, and his followers were baptised by Bishop Finan in 'the royal estate ... called *Ad-Murum* because it stands close by the wall which the Romans once built across the island of Britain ... It is about twelve miles from the east coast' (Colgrave and Mynors 1969: 282-3; HE, iii, 22).

A second settlement proposed to be within Newcastle and near the Black Gate cemetery is the ville of Pandon. Hodgson Hinde states that 'within the walls of Newcastle are united two towns or villes, which were distinct from each other until the 27th of Edward I, when the ville of Pandon was by royal charter annexed to Newcastle ... Pandon lies a little to the east of the bridge across the Tyne' (Hodgson Hinde 1858: 15-16). In this instance Hodgson Hinde is paraphrasing the topographer William Grey (1649) who states that after the departure of the Romans, the Northumbrian kings kept their residence at Pandon Hall in Pandon, which had 'the Picts wall on the North side and the river Tyne on the South'. This suggests occupation near to, and pre-dating, the Black Gate cemetery after the withdrawal of the Romans, but is purely hypothetical as there is no archaeological evidence for any such Anglo-Saxon settlement in the area. There is also a suggestion of settlement in Gateshead, which lies directly opposite Newcastle on the south bank of the River Tyne. Bede's reference to 'Utta, abbot of the monastery at the place called Gateshead' suggests some form of settlement there in the 8th century. However, as is the case for Newcastle, there is no archaeological evidence for settlement at Gateshead dating to the mid Anglo-Saxon period (Colgrave and Mynors 1969: 281; *HE*, iii, 21; Nolan 2010: 254). It is also likely that the proposed monastic community at Gateshead would have buried their dead there and not across the river in Newcastle, discounting the Gateshead monastic settlement as an origin for the Black Gate cemetery population. In summary, there is no conclusive evidence for the nature of settlement in the Newcastle area or the type of settlement the Black Gate cemetery served.

Despite the lack of reliable literary evidence for settlement in or near Monkchester there are some clues from the topography of the site about the nature of the activity at Monkchester. The location of the Black Gate cemetery, upon a steep escarpment approximately 30m above the River Tyne (Nolan 2010: 155), is consistent with the settings of early monasteries such as Wearmouth, Jarrow, and Tynemouth (Tyne and Wear) (Cramp 2005: 29, 348), Llandough (Glamorgan) (Loe 2003: 15), and Ailcy Hill, Ripon (North Yorkshire) (Hall and Whyman 1996: 65). A riverside, coastal or promontory location is often used as a defining characteristic for identifying monasteries in the archaeological record (Loveluck 2007: 144). The re-use of Roman structures by both early and later Anglo-Saxon religious institutions is a common occurrence (Williams 1997, 2006; Bell 1998; Blair 2005: 249). Evidence of such re-use is the inclusion of Roman stones in the construction of St Paul's monastery in Jarrow (Cramp 2005: 9). The establishment of monastic sites within Roman forts may indicate that there was a pre-existing religious focus for settlement in these areas, which attracted the founders of the new monasteries (Blair 2005: 249). Alternatively, these new Anglo-Saxon monastic sites may have been exploiting the same communication, trade, subsistence and defence benefits of their accessibility by land and water, that initially attracted the Romans (Palliser *et al.* 2000: 156; Cramp 2005: 348).

2.1.2 The Black Gate Cemetery: Location and Dating

The period of use of the Black Gate cemetery has been determined from datable artefacts, stratigraphic relationships between graves and structures within the cemetery, along with radiocarbon dating of the skeletons. Coins dating to 810-985 have been recovered from the cemetery, both within graves and archaeological deposits of known stratigraphic sequence. For example, a coin of Henry II dating from 1158-1180 was recovered from a cobblestone deposit sealing, and therefore post-dating, several cist burials. Unfortunately, the context numbers for the cists, which were sealed by this cobblestone deposit, are not identified by Nolan (2010). Four pins have been retrieved from graves and dated to the 8th - 9th centuries on the basis of stylistic parallels with other copper-alloy pins of this date from northern England (Bailey 2010: 264). Radiocarbon dating of the skeletons themselves has provided a date range of 670-1160. A complete list of the radiocarbon dates is provided in Table 2.1.

Skeleton No.	Radiocarbon Dates (A.D.)
BG99	211-357[1]
BG660	667-780[1]
BG422	670-900[2]
BG477	799-883[3]
BG368	808-973[1]
BG646	831-915[3]
BG575	832-916[3]
BG506	876-962[3]
BG22	880-1040[2]
BG40	880-1040[2]
BG580	880-1050[2]
BG375	960-1160[2]
BG175	1015-1155[1]

Table 2.1 *Radiocarbon dates for the Black Gate Cemetery skeletal assemblage.*
([1]Oxford Radiocarbon Laboratory. *Analysis funded by John Nolan and Dept Archaeology, University of Sheffield 2009; [2]Scottish Universities Environmental Research Centre (SUERC), East Kilbride. Analysis funded by John Nolan 2004; [3]Arizona State University Radiocarbon laboratory Analysis funded by the Global History of Health Project 2010. All radiocarbon dates presented in this table represent 95% confidence intervals (Sigma 2).)*

The alignment of the burial containing skeleton BG99 (211 – 357) respects, and therefore probably post-dates, the foundations of the south wall of Building 68

(Appendix A: Figure A.1). Several other dated burials located adjacent to, and in alignment with Building 68 – BG477 (799-883), BG368 (808-973), BG506 (876-962), and BG375 (960-1160) – provide a much later date range between 799 and 1160. Therefore, the radiocarbon date of 211-357 provided for skeleton BG99 is unlikely to be correct (Nolan 2010: 172; Nolan *pers. comm.*). Building 68 truncates, and therefore post-dates, a number of other burials within the Black Gate cemetery suggesting the building post-dates at least one phase of burial. Unfortunately, however, there are no radiocarbon dates for any of these truncated burials to verify the assumption that they are contemporary with the rest of the cemetery.

Overall, the radiocarbon dating results support the estimation that interments commenced in the remains of the Roman fort *Pons Aelius* by at least the late 7th century and had ceased by 1168 (Nenk *et al.* 1991: 194; Geake 1997: 185; Nolan 2010: 159). Burial was temporarily interrupted by the construction of the New Castle in 1080 by a large army under the direction of William the Conqueror's eldest son Robert Curthose (Rollason 2000: 202; *HReg, s.a.* 1080). Burials in the northern part of the cemetery were disturbed and concealed during the construction of the castle ditch and rampart (Young and Clark 1982: 211; Nolan 2010: 159). However, the original rampart slope of 1080 and the surviving ground within the bailey have been cut by a number of later burials (Nenk *et al.* 1993: 286; Nolan 2010: 159), providing evidence for occasional burial within the cemetery after the construction of the New Castle. Continued use of the cemetery up to the refortification of the castle in stone in 1168 is further confirmed by burials in stone cists marked by dressed stone slabs. These slabs are similar in design to recumbent grave markers associated with post-Conquest burials in other cemeteries such as York Minster and Hexham Abbey (Phillips 1995: 46; Cambridge and Williams 1995: 69-70; Geake 1997: 185; Nolan 1998; Nolan 2010: 220-1), further suggesting a later date for these cist burials. One such slab (3162) was carved with decorative motifs that have been dated on stylistic grounds to between

1080 and *c.*1100 (Nenk *et al.* 1991: 194; Nolan 2010: 221 cites personal communications with J. Lang as the source for this dating). The radiocarbon date of 960-1160 derived from the cist burial associated with skeleton BG580 is also consistent with the hypothesis that cist burials represent a later phase of burial within the Black Gate cemetery. None of these cist burials is cut by subsequent burials, indicating that they are most probably the latest interments within this cemetery.

2.1.3. The Black Gate Cemetery: Buildings

Within the castle walls, there is evidence of both wooden and stone buildings dating to the period of use of the cemetery. The majority were, unfortunately, too ephemeral for their function to be determined. However, what remains of the foundations of Building B (Appendix A: Figure A.1) appear to represent a small, single-celled building, possibly a chapel, which was constructed after the primary phase of burial in this area at least. Building B overlay senior adult female skeleton BG545, while a child burial (BG486) had been cut into the southern edge of the foundation suggesting that the building post-dates at least one burial in the cemetery, and pre-dates another (Nolan 1998; Nolan 2010: 187, 256-7). Unfortunately, the greater part of the foundations of this building were destroyed by the construction of the cellars of a post-medieval building – referred to as the 'Chapel House'– in the 18th century (Appendix A: Figure A.1) preventing any further interpretation of its construction or function (Nolan 2010: 158).

Buildings 68 and A (Appendix A: Figure A.1) are suggested by Nolan to be the tower and south wall, respectively, of the nave of a church (Nolan 2010: 187, 256-8). The 'footprint' of these buildings, in conjunction with wall 3168 (not recorded on the site plan), is identified by Nolan as being similar to that of the 10th-century phases of churches at St Helen's-on-the-Walls in York, Lincoln Castle and within the bailey of Norwich Castle (Nolan 2010: 257). As further support for this interpretation, the dimensions of Building 68, measuring 5.76m east-west by 4.88m north-south, are similar to those of Anglo-Saxon church towers at Whittingham (Northumberland) (5.18m by 4.80m) and Wharram Percy (Yorkshire) (5.18m by 4.95m) (Nolan 2010: 256-7). These dimensions are also similar to the pre-Conquest foundations of the tower of St Paul's church at Jarrow (with internal dimensions of 4.00m by 4.40m) (Cramp 2005: 165). A green and yellow tiled floor was found within buildings 68 and A (Nolan and Harbottle *unpublished*: 23). This tiled floor was 0.44m above the foundation base of this proposed church building, upon layers of mortar which may represent renewed floor surfaces (Nolan 2010: 154, 193; Nolan and Harbottle *unpublished*: 23). The use of green and yellow tiles is commonly associated with monastic and ecclesiastical buildings from the 13th century onwards (van Lemmen 2004: 7). The presence of these tiles provides supporting evidence that these buildings represent a church, albeit at a later date than the period of use of the cemetery. It is possible that these buildings existed as a church during the period of use of the cemetery and the tiles represent a later floor layer of the church, which continued to be in use after the cemetery had ceased to be active.

Archaeological evidence for substantial timber framed buildings dated stratigraphically to the early phase of the Black Gate cemetery has been recovered in Railway Arch 28 and Area D (Appendix A: Figure A.1; Figure 6.2). Trenches containing post holes in Railway Arch 28 clearly post-date skeleton BG645 while other burials overlay the projected building outline. Two longitudinal features in Area D are defined by stone edging. The first of these features is orientated north-east with a width of *c.* 1.5m (Nolan 2010: 170). The second linear feature is *c.* 1.35m wide and is orientated west-east, possibly forming a return to the accompanying linear structure. These two structures appear to form a substantial timber-framed building (Nolan 2010: 170). The post holes and post-trench features in Railway Arch 28 seem to represent the remains of one or more timber structures. The overall character and combinations of post and trench foundations recalls the presumed monastic structures excavated at Church

Close, Hartlepool, dated from the mid-7th century to the later 8th century (Nolan 2010: 256). It is possible that one of these buildings represents an earlier church structure at this site which was abandoned in preference for a more substantial stone building, represented by buildings A, B and 68. In sum, none of this evidence for a later Anglo-Saxon ecclesiastical building is conclusive, but given that the buildings were located within a cemetery it is difficult to avoid the conclusion that the building remains represent a church.

2.2 The Black Gate Cemetery: Burial Practices

The cemeteries of high-status churches, such as cathedrals, particularly those situated in urban contexts, have been suggested to display the greatest variety of burial rites (e.g. Kjølbye-Biddle 1975, 1995; Phillips 1995; Heighway and Bryant 1999: 194-216; Rodwell 2001). In contrast, rural and lower status urban cemeteries are believed to be typically restricted to two or three main variations (White 1988: 18-27; Boddington 1996: 26-48; Buckberry 2007:119-20, 2010: 11). Therefore, it may be possible to determine the context of the Black Gate cemetery by the degree of variability of burial rites observed within it. Within this thesis, the following definitions of *grave type* and *grave variation* are utilised, following the definitions employed by Buckberry (2007: 117). *Grave type* relates to the physical construction of the grave and additional structures, such as shrouds, coffins and chests, within which the body was contained. *Grave variation* refers to any features within the different burials which are not grave goods nor constitute the physical construction of the grave. Examples of grave variations are charcoal deposits within the grave, grave markers and stone inclusions such as head support stones (Buckberry 2007: 117). The types and variation of grave goods present in the Black Gate cemetery are presented below.

2.2.1 Grave Types

2.2.1.1 Earth-Cut Graves

The majority (596/616; 96.8%) of graves excavated within the Black Gate cemetery, for which burial information is available, are earth-cut graves. There is evidence, as will be discussed subsequently, to suggest that some of these earth-cut graves contained shroud burials and were either wood lined or contained wooden structures such as coffins and chests. Variation within the structure of the earth-cut graves is also visible, including the presence of stones set around the head in various positions, which will also be considered.

2.2.1.2 Shroud Burial

The interment of the deceased in shrouds in the Anglo-Saxon period is evidenced by the recovery of shroud pins and the position of the body. Proposed shrouded interments are characterised by individuals lain supine extended with a maximum distance of 10 cm between the ankles. These burials are described by Boddington (1987: 36-7), in his work on Raunds Furnells, as 'parallel-sided' burials. No skeletal elements are located outside a hypothetical line drawn from the shoulders to the ankles suggesting constriction of the body within a tightly fastened or wrapped shroud (Boddington 1987: 36-7). Constriction of the arms to the upper body has been observed at Llandough and also been interpreted as indicating the interment of the body in a shroud, although it was also acknowledged that it might alternatively indicate that the individuals were constricted within the confines of a compact coffin (Holbrook and Thomas 2005: 27).

From the Black Gate excavation photographs of each skeleton, it was possible to identify 67 (10.9%) individuals interred in the 'parallel-sided' body position. These individuals exhibit superior displacement of the lateral ends of the clavicles, the scapulae are displaced superiorly and rotated medially towards the body and the arms are either crossed across the torso or pelvis or extended alongside the body. Skeleton BG570 provides an example of such restriction of the body in an earth-cut grave within the Black Gate cemetery (Figure 2.1). However, due to the incomplete nature and disturbance of the majority of the graves (discussed previously) it is not possible to determine exactly how many individuals were bound within a shroud at the time of burial.

Figure 2.1 *Skeleton BG570 indicating the constricted placement of the skeletal elements that suggests a shroud burial (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)*

There is evidence to suggest that individuals were shrouded before being placed within the coffin at both Black Gate (e.g. skeleton BG506 shown in Figure 2.2) and Wearmouth (Cramp and Lowther 2005: 85). At both sites, coffined interments display the 'parallel-sided' burial position perceived by Boddington (1996: 35) as being characteristic of shrouded burials. This may indicate that the coffined individual was wrapped within a shroud for burial, but is not conclusive evidence because the constriction of the body may result from limited space within the coffin (Holbrook and Thomas 2005: 27). A mortar deposit upon the floor of the cist burial of skeleton BG509 contains a textile impression (Nolan 2010: 280), which suggests that individuals buried within cists were shrouded before burial.

Figure 2.2 *Coffined, and possibly shrouded, burial from the Black Gate cemetery (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)*

Further evidence for the presence of shrouds within the Black Gate cemetery is in the form of four copper-alloy pins recovered from within four grave cuts (Bailey 2010: 262-4). The small number of shroud pins recovered does not necessarily indicate that shrouds were not a common occurrence within the cemetery, only that such pins were not the preferred form of shroud fastening. In the period from the 8th until the 12th century the most common form of burial was in a 'shroud' which consisted of a white wool or linen sheet wrapped tightly around the body, apparently without fastenings (Taylor 2001: 174). This type of shroud emulates those of the Mediterranean and Near East, which were intended to imitate the Biblical description of Christ's burial (Taylor 2001: 174). Shroud pins did not become a common occurrence until the early 12th century, therefore, it is probable that pins recovered from earlier cemeteries, such as those found at Black Gate, were either clothing or hair accessories, or were temporary fastenings for the shroud which were mistakenly left in, as argued for later medieval burials by Gilchrist and Sloane (2005: 110).

2.2.1.3 Coffins and Wooden Structures

The well-drained boulder clay natural of the Black Gate cemetery was not conducive to the preservation of organic material such as wood. However, a black sooty or carbonized deposit was recorded for 20.6% (127/616) of the graves. These deposits may represent plank linings of the grave or the side panels and lids of wooden coffins, the external surfaces of which may have been charred to enhance their preservation (Nolan 2010: 205).

Forty-two iron nails were recovered from the Black Gate cemetery, typically as single finds from individual grave cuts. The small quantities of nails and absence of graves containing nails distributed in a pattern indicative of a coffin suggests the nails recovered are residual deposits and not necessary components for the construction of the coffins (Nolan 2010: 269). There is further evidence which suggests that nails were not necessary for the construction of coffins in the later Anglo-Saxon period. The waterlogged conditions at Barton-upon-Humber have preserved excellent evidence for coffins and other wooden structures within the grave. Examples of such are hybrids between coffins and beds, or biers, and wooden boards lining the grave deriving from clinker-built boats, which have also been observed at York Minster (Kjølbye-Biddle 1995: 517). Nevertheless, the typical coffins observed at Barton-upon-Humber were parallel-sided, or slightly tapered, constructed from six oak-boards principally jointed together with wooden pegs, although nails were occasionally utilised (Rodwell 2007: 23). Wooden pegs (or 'dowels') were also recovered from Swinegate, York (Buckberry 2004: 23-4). The predominant use of wooden dowels to secure the separate components of the coffin at Barton-upon-Humber and Swinegate highlights the potential loss of evidence for wooden coffins on sites with no organic preservation, and the false assumption that the absence of metal coffin nails and fittings equates with an absence of wooden coffins. This evidence supports the proposal that the paucity of nails within the Black Gate cemetery does not demonstrate a scarcity of coffins and other wooden structures within the graves.

Two chest burials (Figures 2.3a and 2.3b) have been identified in close proximity within Railway Arch 28 (Appendix A: Figure A.4), based on the presence of locks and hinge-straps within the graves (Nolan 2010: 272, 274). Chest burials have been observed within the contemporary high-status cemeteries of Ailcy Hill (Hall and Whyman 1996: 99) and York Minster (Phillips 1995: 83-7). Craig, in her survey of burial practices in middle Anglo-Saxon cemetery sites in the north of England, identified chest burials at 17 sites, indicating that chest burials were particularly characteristic of burial in Northern England in the 8th and 9th century (Craig 2009: 138). Coffins and chest burials would have necessitated more effort on the behalf of those interring the dead. However, coffins are not necessarily the privilege of the social elite and, although there is an assumed higher status associated with chest burials, there has been little discussion in the literature about their function and status (Craig 2009: 330). Indeed, the chest burials found at York Minster were recovered from the north-east of the church, whereas the elaborate, high-status graves such as those with stone lining, carved grave covers and a sarcophagus were excavated from the area north-west of the church (Buckberry 2007: 119). A similar pattern is seen at Black Gate. The chest burials are located on the northern side of the proposed church (in close proximity to graves containing various stone settings around the head), whereas the stone cists and rubble lined cists, which represent greater levels of effort in preparing the grave, are located adjacent to the south wall of the possible church building (Appendix A: Figure A.4).

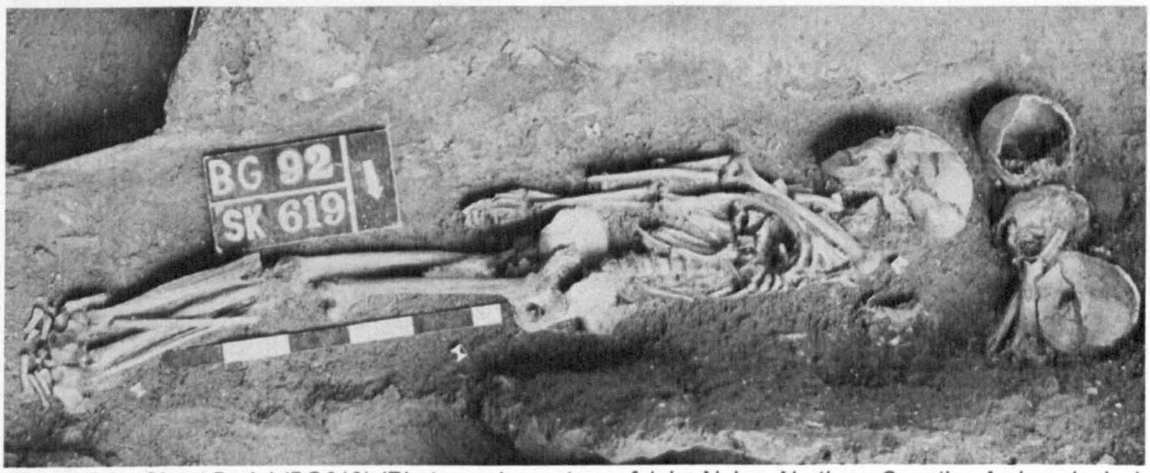


Figure 2.3a *Chest Burial (BG619) (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)*

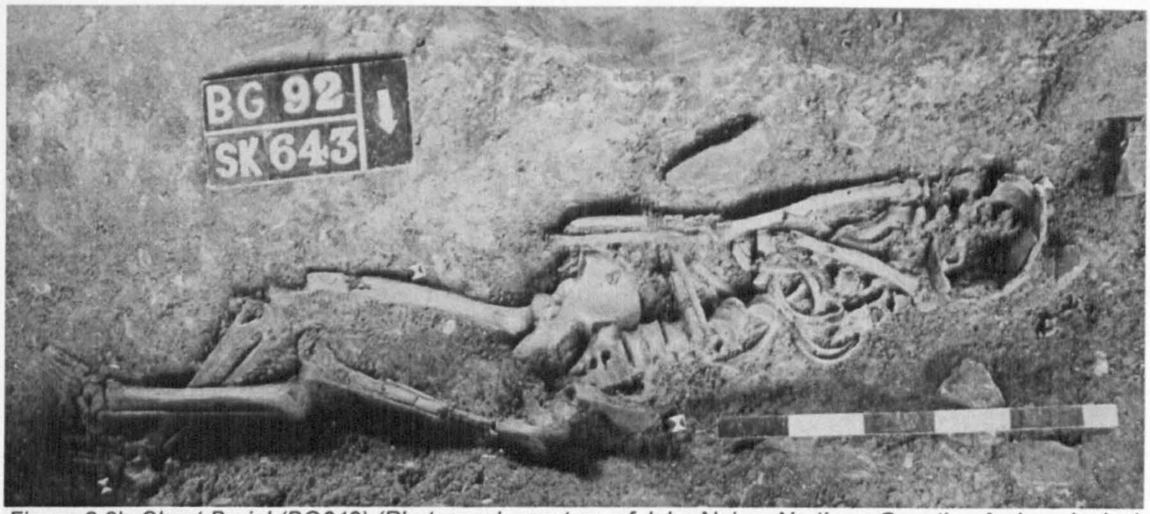


Figure 2.3b *Chest Burial (BG643) (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)*

2.2.1.4 Stone Cists and Linings

Sixteen (2.6%) stone cists were recovered from the Black Gate cemetery. These cists are shallow rectangular boxes, the sides and lids of which are constructed from rough-hewn stone slabs (Figures 2.4 and 2.5). The 'floor' of the cists typically consist of the naturally occurring earth. Exceptions to this observation are the cist containing skeleton BG511, the base of which is lined with stone slabs, and the layer of mortar covering the base of the cist containing skeleton BG509.

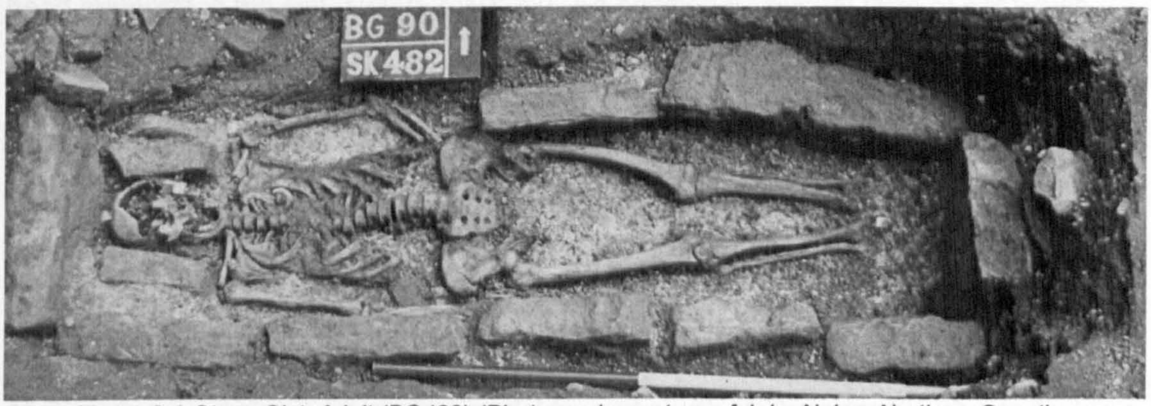


Figure 2.4 *Stone Cist: Adult (BG482) (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)*

Figure 2.5 *Stone Cist: Immature (BG478) (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)*

Marker stones were occasionally re-used as cap stones on some cists, such as BG3240 where one of the cap stones is a re-used rhomboid 'surface slab' (Nolan 2010: 217). The internal surfaces and joints of the cists associated with skeletons BG509 and BG375 had been rendered with mortar, as had the cap stone of the cist associated with skeleton BG509. Mortar containing small stone inclusions was also used to construct head supports in the cist (Nolan 2010: 32). An additional unusual form of cist which appears to be contemporary with the other cist burials within the Black Gate cemetery consists of a 'tent' – protecting infant skeleton BG544 – composed of 'two rectangular, rough-hewn sandstone slabs' propped against each other like a 'tent' along the superior longest edge (Nolan 2010: 220).

All the excavated cists lie broadly parallel to, and south of, the possible church building or buildings, which are believed to have existed from *c.* 1000. Skeletons BG368 and BG375, both of which were interred in stone cists, have provided radio-carbon dates of 808-973 and 960-1160 respectively. These dates suggest the church and the cist burials may have existed from at least the 10th century, and perhaps as early as the 9th century. A comparably dated stone cist was recovered from Wharram Percy from which an associated skull was radiocarbon dated to 950-1050 (Heighway 2007: 224). A number of cists were cut or overlain by the foundations of the Keep, built during the period 1168 to 1178, and others were sealed below a deposit containing a coin of Henry II (1158 – 1180). This suggests the cessation of cist burials by 1178 but a continuation of the practice after this date cannot be entirely dismissed, particularly where there is no clear stratigraphic connection between cists and datable structures (Nolan 2010: 220). Aside from those at Wharram Percy, cist burials of this form are also known from other sites such as St Mark's, Lincoln, where the earliest seem to be late 11th or early 12th century (Gilmour and Stocker 1986), Raunds Furnells (Boddington 1996: 40), York Minster (Phillips 1995: 86) and St Nicholas Shambles (Schofield 1988: 18, 22-3). Where stone cists occur as a minority burial rite, such as the singular example recovered from St Marks, Lincoln (Gilmour and Stocker 1986: 16), they have been interpreted as possibly representing more prestigious burial (Schofield 1988: 25).

Some of the graves at Black Gate containing cist burials were inter-cutting. The cist burial of skeleton BG381 was cut by a second cist burial containing skeleton BG375, and the grave associated with skeleton BG394 was cut by the grave of skeleton BG377, both of which contained cists. The recumbent slab marking the grave of skeleton BG377 was overlain by infant skeleton BG374, which appeared to be interred in a plain earth-cut grave. Coffined neonate skeleton BG495 was deposited on the cap stones of the cist of skeleton BG499 (Nolan and Harbottle *unpublished*: 31). Placement of infant remains upon the capstones and recumbent grave markers of pre-existing cist burials may possibly indicate familial links between the infant and the inhabitant of the cist burial, or simply that the grave cut was utilised for the infant burial instead of a separate grave being created for their interment.

Of the Black Gate burials, 0.6% (4/616) were interments within rubble cists (Figure 2.6). These are essentially grave cuts fully or partially lined by a single layer of un-mortared sandstone rubble (Nolan 2010: 205). The most substantial and complete rubble cists belong to skeletons BG523 and BG580. The other rubble cists are fragmentary and, in the case of skeleton BG435, seem to have been constructed from Roman building material encountered whilst digging the grave (Nolan 2010: 205).

Figure 2.6 *Rubble Cist (BG523) (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)*

None of the rubble cists had associated cap stones. Boddington suggests at Raunds Furnells that the inclusion of slabs may have served as supports for wooden covers to protect important burials (Boddington 1996: 38-43), which might explain the absence of cap-stones associated with the rubble cists in the Black Gate cemetery. It has also been suggested that these rubble lined cists were cheaper versions or prototypes of the more substantial and structured stone cists found within the Black Gate cemetery (Nolan 2010: 205).

Buckberry (2007: 118) has identified that both urban and rural cemeteries of the later Anglo-Saxon period contain two or three different grave types and between one and three grave variations, which were usually only found in a small number of graves at each cemetery. This suggests the variety of burial practices observed within a cemetery cannot be used to determine if it is urban or rural in nature. She identified that the great variety of burials seen at York Minster is a consequence of the high status associated with the burial ground, rather than the fact that it was an urban cemetery.

2.2.2 Grave Variations

2.2.2.1 Stone Inclusions

A variation in the Black Gate earth-cut graves is the inclusion of so-called 'pillow stones' (one or more stones placed below the skull, upon which it rests) (Figure 2.7), stone 'earmuffs' (large stones placed adjacent to the head, occasionally on both sides) (Figure 2.8) and head cists (total enclosure of the skull within a stone slab structure) (Figure 2.9).

Figure 2.7 *Pillow Stones (BG572) (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)*

Figure 2.8 *Earmuffs (BG601) (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)*

Figure 2.9 Head Cist (BG605) (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)

Within the Black Gate cemetery, four (0.7%) graves contained pillow stones and ten (1.6%) graves contained earmuffs. In two graves, disarticulated human remains, presumably disturbed during digging of the grave, supported the head, instead of stones. An adult tibia supported the head of skeleton BG613 and an adult skull formed one of the earmuffs adjacent to the skull of skeleton BG627. All the earmuffs and pillow stones were recovered from plain earth-cut burials, save for the earmuffs adjacent to the skull of skeleton BG499, which was interred in a stone cist. Skeletons BG435 and BG580 interred in rubble cists had separate pillow stones while those included within the burials of skeletons BG523 and BG584 were constructed from two of the stones of the rubble lining. The head cists observed within five of the Black Gate graves were formed by laying a flat slab across two stones located adjacent to either side of the skull to cover the face (Nolan 2010: 204-5).

The inclusion of earmuffs and stones within graves is a common burial ritual of the later Anglo-Saxon period. Stone inclusions associated with the skull have been observed in both coffin and shroud burials at Barton-upon-Humber, with the majority occurring in coffined burials (Rodwell 2007: 27). The inclusion of stones to surround or prop-up parts of the body has also been observed at Wearmouth and Jarrow (between the 7th and 11th centuries) (Cramp and Lowther 2005: 85; Lowther 2005: 180). It is very likely that the purpose of these stones was to support the head. However, one waterlogged burial at Barton-upon-Humber revealed that in that specific instance pillows made from organic material rested upon these stones and supported the head (Rodwell 2007: 27). The use of disarticulated remains as support stones for the head, seen in the two Black Gate graves, is also observed in the 10th – to 12th – century manorial cemetery at Trowbridge (Wiltshire) (Graham and Davies 1993: 41). At St Helen-on-the-Walls it was presumed that the limestone blocks associated with the skull in burials outside the church were from un-coffined burials and consequently served a protective function (Dawes and Magilton 1980: 15). Protection and preservation of the head was probably the main purpose of the five head cists observed within the Black Gate burial assemblage.

The discussion of grave types and variation in Chapter 6 separates the burial practices into 'plain' and 'elaborate' burial types. The inclusion of stone, both within burials and in the construction of stone and rubble cists, was the primary criteria for determining a grave as 'elaborate' as it represents an investment of labour and resources into the burial rite. 'Plain' burials, as used in Chapter 6, refers to basic earth-cut graves, which may have included a shroud but no more. Coffined burials are also included within the 'plain' category, based predominantly on the fact that, due to the low levels of preservation of organic material, the the lack of wood within graves cannot be used as evidence that the coffin was not present. Therefore, it is not possible to determine within the Black Gate cemetery whether a grave lacking stone inclusions included a coffin. Consequently, coffined and truly plain earth-cut graves are indistinguishable and so are grouped together. Indeed, a full coffin of carpentered oak planks would be a substantial labour and financial investment, but the lack of wood preservation would influence the outcome of any biocultural analysis. The theory behind the segregation of 'elaborate' burials from 'plain' representing social distinctions such as wealth and social prominence is assumed from the investment into their construction, as in other studies (Daniell 1997: 160; Buckberry 2007; Craig 2010). However, one could imagine for example that segregation and variability in burial practice reflected ritual status or circumstances of burial, not the social class of the deceased. The relationship between health, lifestyle and burial practice is investigated in Chapter 6.

2.2.2.2 Grave Markers

Five of the sixteen cist burials recovered from the Black Gate cemetery are associated with recumbent stone surface grave slabs (Figure 2.10) and 'head' and 'foot' stones. Three cist burials recovered from Area C were marked on the surface by *in-situ* recumbent slabs and upstanding stones at the head and foot. Two cists associated with skeletons BG368 and BG478 had head and foot stones but no slab, which may have been removed during the lifetime of the cemetery or robbed when the keep was constructed in the 12th century. Seven of the sixteen cists had no surviving surface markers. This may also result from stone robbing (Nolan 2010: 215-17). The presence of above-ground stone markers was not determinable for the remaining four cists.

In seven instances, recumbent slabs overlay coffined or plain graves. The exact dimensions of these recumbent grave markers is not provided in Nolan's publication, but the scale drawings provide an approximate length of 0.80m and width of 0.50m (Nolan 2010: 277). The slabs associated with skeletons BG265 and BG3162 were set between vertical stone grave markers at the head and foot ends of the grave. The slabs associated with skeletons BG246 and BG266 had only head stones. However, it is possible that the foot stone for BG266 was removed to accommodate the slab associated with skeleton BG3180. The slabs associated with skeletons BG3161, BG3163 and BG3164 had neither head nor foot stones. This need not represent a significantly different form of burial practice, but rather a consequence of the slabs having been removed for re-use elsewhere (Nolan 2010: 217).

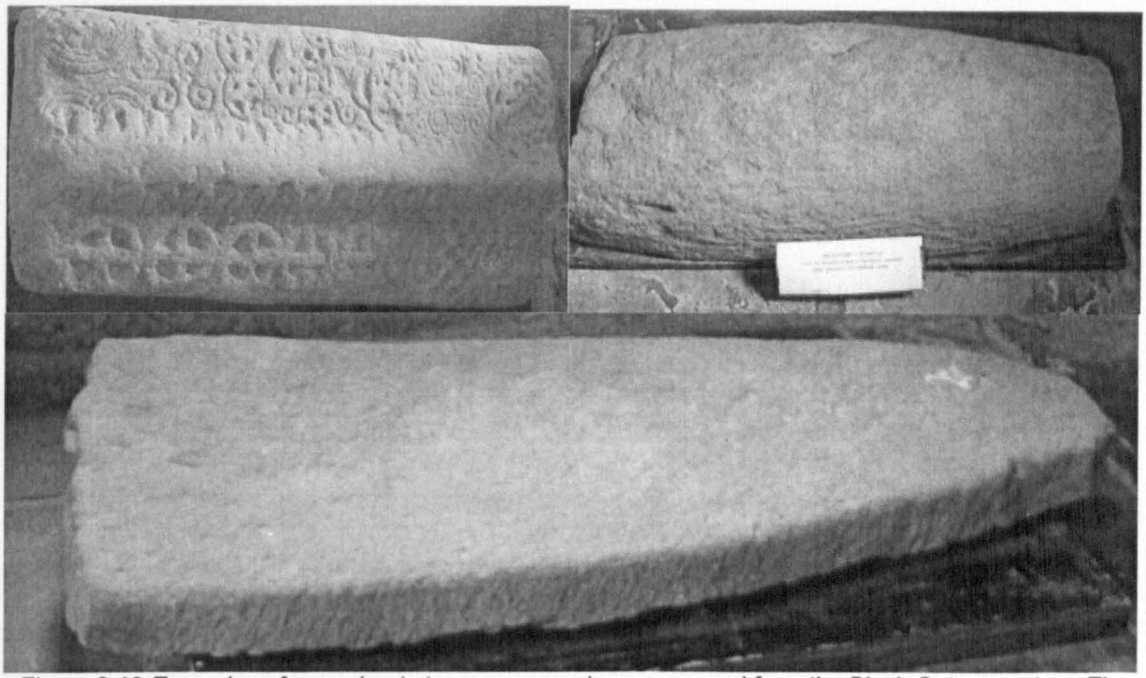


Figure 2.10 *Examples of recumbent stone grave markers recovered from the Black Gate cemetery. The top left stone is recumbent grave cover context (3162). The other two slabs are unstratified possible upright grave markers bearing carvings of crosses (which are not discernible on the photograph)*

Post-holes encountered at the head and foot ends of graves within Railway Arch 25 have provided secondary evidence for upright grave markers (Nolan 2010: 217-18). Further evidence for upright grave markers is present in the form of two slabs, one of which was a Roman quern stone, incised with cruciform images (Figure 2.10; Nolan 2010: 277).

Stone sculptures in the forms of grave slab and hogback grave markers and crosses were an increasingly common characteristic of later Anglo-Saxon cemeteries, particularly in the 10th and 11th centuries (Hadley 2002: 224). Carved stone grave covers, including some with 8th- and 9th-century style crosses and names of ecclesiastics, and head and foot stones have been excavated *in situ* within the cemetery of York Minster and monasteries at Wearmouth and Jarrow (Lang 1995; Cramp and Lowther 2005: 85-6; Lowther 2005: 181-2). Plain and carved stone grave markers and covers have been recovered from non-burial contexts from both Raunds Furnells (Boddington 1996) and St Mark's, Lincoln (Gilmour and Stocker 1986). Evidence for wooden markers, in the form of post-holes and rectangular voids associated with individual graves has also been identified at St Mark's, Lincoln (Gilmour and Stocker 1986), St Peter's, Barton-upon-Humber (Rodwell 2007: 20) and Thwing (Craig 2009: 133). The neat alignment of graves at sites such as Addingham (Scull and Harding 1990: 22; Adams 1996: 181) and Ailcy Hill (Hall and Whyman 1996: 76) further indicates the use of grave markers, which have failed to survive in the archaeological record. The graves at Addingham were demarcated by small mounds of earth and it is probable that post-holes at the ends of graves at St Peter's, Barton-upon-Humber contained wooden grave markers. Furthermore, a rectangular 'socket' excavated at the head end of one grave from St Peter's has been interpreted as being for a timber headboard (Rodwell 2007: 20).

Gravestones and stone markers dating between 850 and 1100 in Lincolnshire, Yorkshire and Northumberland have been identified in the past as being exclusive to Christian graveyards. In northern and eastern England and Northumbria concentrations of pre-Viking memorials have often been linked to minster or monastic churches, such as at Wearmouth (Stocker 2000: 186). However, in the post-Viking period stone sculpture is also found at smaller village churches such as Bedlington and Ponteland (Northumberland) and Dalton-le-Dale (Durham) (Morris 1989: 153; Stocker 2000: 179-80) further indicating their use as Christian symbols. Nevertheless, the high costs involved with the commission and construction of stone gravestones and markers such as the stone itself, its carving and transport implies that such sculptures were most probably utilised as a medium of social display (Stocker 2000: 180). For instance, lords utilised the commission and display of specific stone sculptures to advertise their status and political and religious allegiances (Hadley 2002: 225). There are a few exceptional 10th-century cemeteries associated with distinctive elite populations or merchant and trading communities containing multiple stone sculptures (Stocker 2000; Hadley 2002: 225; see below); however, the majority of cemeteries, as at Black Gate, have only revealed one or two. These few stone sculptures have been interpreted as 'founding monuments' among the new generation of local churches which arose in the 10th century (Hadley 2002: 225). One such monument is the stone cover and possible cross associated with the adult male burial adjacent to the church at Raunds Furnells, which has been identified as a 'founder's grave' of the individual who established the manor, church and churchyard (Boddington 1996: 45; Stocker 2000: 182).

Stocker (2000) has noted that cemeteries containing numerous stone funerary monuments in northern England in the 10th century, such as Marton (Lincolnshire), Wigford in Lincoln and York Minster, appear to have been more commonly located in urban and trading centres than in the cemeteries of rural churches, even including mother churches (Stocker 2000: 207). This, and the strong presence of stone sculpture in minster contexts, supports an interpretation that the Black Gate cemetery, which revealed several stone grave markers, was associated with an urban settlement associated with a Minster or Christian church. Alternatively, the contributing population may represent merchant or trading communities. This is a feasible hypothesis in consideration of the cemetery's close proximity to the River Tyne. However, at Black Gate the cemetery had been in use for many generations before the earliest known carved monuments were in use. It must be considered that there may have been more stone sculptures present in the cemetery than are surviving today, as has been discussed previously.

2.2.2.3 Charcoal Burial

Charcoal burials contain a uniform layer of charcoal lining the grave cut – upon which the corpse, either within or without a coffin, is laid – or a deposit recovered from above the body (Thompson 2004: 118; Holloway 2010: 83). The purpose of charcoal inclusion within burials has been ascribed to a number of factors such as absorbing odours, containing disease, or a symbolic association with the penitential ashes upon which monks were occasionally lain (Daniell 1997: 158-9; Hadley 2002: 218-19; Thompson 2004: 119; Holloway 2010: 87). Rodwell (2007: 25) argues that such charcoal deposits are most commonly associated with prestigious burials (Daniell 1997: 159; Rodwell 2007: 25; Fleming 2010: 26), and its presence represents an additional effort in the burial process, thus its inclusion in a grave may indicate the burial of a high-status individual. Alternatively, the charcoal may have been used to preserve the body of the deceased in accordance with ideals of corporeal resurrection on the Day of Judgement. Charcoal burial commenced in the early 9th century and has been seen as a diagnostic feature of late Anglo-Saxon burial practices (Daniell 1997: 158; Buckberry 2007: 119). However, charcoal is much more commonly associated with the larger churches and Minster sites, such as Winchester where almost fifty per cent of the burials contained charcoal (Thompson 2004: 120). Only solitary charcoal burials were recovered from the urban parish churches of St Helen-on-the-Walls(York) and St Nicholas Shambles (London) and the rural parish cemetery of St Peter's, Barton-upon-Humber (Thompson 2004: 120). The use of charcoal in burials at the Old and New Minsters at Winchester and a cluster of burials from St Mark's, Lincoln has been suggested to have been to both preserve and mark the grave (Holloway 2010: 87, 89), which could represent attempts to preserve or increase the visibility of ecclesiastical or secular elite burials, such as monks or family groups.

At Black Gate, three graves contained slight charcoal deposits similar to the 'flecks of charcoal' recovered from six graves within the rural cemetery of Addingham (Yorkshire)

(Adams 1996: 165), and the fifteen graves containing charcoal deposits from Raunds Furnells (Northamptonshire). However, Thompson (2004: 120) argues that a distinct layer or deposit, more substantial than that observed at Addingham, is necessary to ascertain a charcoal burial. The charcoal deposits observed at Raunds Furnells are interpreted as being the result of organic inclusions, such as decayed organic pillows, rather than 'charcoal burials' (Boddington 1996: 37). All the charcoal inclusions recovered at Black Gate are small and associated with other contaminants such as coal and grains. This suggests that they were not deliberate charcoal burials, and it is probable that the charcoal recovered from these graves derived from Roman deposits which were disturbed during the initial digging of the grave for burial (Nolan 2010: 281), or were similar organic inclusions to those found at Raunds Furnells.

2.3 The Body

Not only were some bodies 'contained' and 'supported' in later Anglo-Saxon graves but there were variations in the orientation and position of the body and location of burial which may possibly have been indicators of social status. These variations are now discussed.

2.3.1 Alignment

All the excavated inhumations from within the Black Gate cemetery were orientated west-east. The majority of interments were orientated a few degrees either side of 90° and appear to be in alignment with the probable church represented by buildings A and B. However, there is a slight variation in the orientation of burials in the different phases of the cemetery (Nolan 2010: 172). Nolan (2010: 221) has identified that 'a significant proportion of the lowest generations' of interments were orientated 283° from north and the most frequent occurrence of burials orientated a few degrees either side of 270° from north including the 'upper generations' of interment, which incorporated graves that cut, and therefore post-dated, the 1080 rampart. The divergence in orientation in the different phases of burial most probably reflects the absence of buildings with which to align the earliest burials in contrast to the later burials which may have been aligned with structures associated with the proposed church and subsequently with development of the castle (Nolan 2010: 221).

An additional, but less likely, proposition for the slight divergence from west-east in burial alignment in later Anglo-Saxon cemeteries is the 'solar hypothesis' (Rahtz 1978). The central idea of the 'solar hypothesis' is that graves were dug for burial in line with the sunrise or sunset, most probably the former, and that the variation in the positioning of the sunrise throughout the different seasons of the year resulted in the slight variation in the orientation of the grave (Rahtz 1978: 1-3). However, studies of sunrise location and frequency of burial at the mid Anglo-Saxon site of Finglesham, Kent have shown that if the solar hypothesis is correct the predominant time of burial within that cemetery would have been spring and autumn. This contradicts epidemiological and documentary evidence, which indicate that the greatest loss of life is typically during the winter months (Brown 1983: 323; Craig 2009: 131).

2.3.2 Body Position

Of the 613 individuals excavated from the Black Gate cemetery, for which body positioning could be determined, 436 (71.1%) were interred supine and extended. However, there were variations in body disposition. Six burials were flexed; 16 burials were prone; 23 interments were positioned on their left side and 132 were positioned on their right.

The majority of the supine interments had their arms either crossing the body at the pelvis or torso (51.3%; 80/156), extended straight along the sides (17.3%; 27/156) or in a combination of both positions (25.6%; 40/156). The legs were predominantly extended with the ankles positioned close to one another (98.7%; 154/156). Further supine, prone, flexed, left and right sided burials were present with a variety of arm and leg positions. A total of 78 combinations of body position were observed in the 133 individuals for whom the disposition of the body, head, arms and legs could all be recorded. Most of the body positions observed occurred only once or twice suggesting them to be rare and therefore very likely to be random occurrences. Consequently, it was decided to group some of the body positions together to reduce the number of comparable cases. The 36 combinations of body position observed within the Black Gate burials are summarised in Table 2.2.

Body Position			
A1	Supine		
A2	Prone		
A3	Lain on Right Side		
A4	Lain on Left Side		
A5	Flexed/ Crouched		
Head Position			
B1	Facing Upright		
B2	Facing Downwards		
B3	Facing to the Left		
B4	Facing to the Right		
Arm Position			
C	Both arms extended alongside body	Arm Position 1	Both arms straight
D	Arms crossed across pelvis/ waist/ chest	Arm Position 1	Both arms bent onto pelvis
		Arm Position 2	Both arms bent on waist
		Arm Position 3	Both arms bent on chest
E	One arm extended, other bent on pelvis/waist chest	Arm Position 1	Left arm straight, right arm bent on pelvis
		Arm Position 2	Right arm straight, left arm bent on pelvis
		Arm Position 3	Left arm straight, right arm bent on waist
		Arm Position 4	Right arm straight, left arm bent on waist
		Arm Position 5	Left arm straight, right arm bent on chest
		Arm Position 6	Right arm straight, left arm bent on chest
F	Arms extended/ flexed/ crossed along front of torso of individual lain flexed or on side	Arm Position 1	Both arms extended along front of body
		Arm Position 2	Both arms bent slightly in front of body
		Arm Position 3	Both arms held close to chest
G	Arms extended behind the back	Arm Position 1	Arms extended behind the back
Leg Position			
H	Legs fully extended	Leg Position 1	Legs fully extended knees and feet apart
		Leg Position 2	Legs fully extended knees and ankles together
		Leg Position 3	Legs fully extended knees together feet apart
		Leg Position 4	Legs fully extended knees apart and feet together
I	One leg flexed, the other fully extended	Leg Position 1	Left leg flexed, right leg fully extended
		Leg Position2	Right leg flexed, left leg fully extended
J	Both legs flexed/bowed to left or right	Leg Position 1	Both legs flexed or bowed to left
		Leg Position 2	Both legs flexed or bowed to right
K	Lower legs crossed	Leg Position 1	Lower legs crossed

Table 2.2 *The 36 body positions observed in the Black Gate cemetery subsequent to re-grouping*

Heighway (2007: 233) proposes that different burial positions are a matter of local or even family custom. At St Andrew's, Fishergate (Stroud and Kemp 1993: 149) the extension of the arms alongside the body was the most common disposition in the Anglo-Saxon phases with both arms crossed on the pelvis a close second. At Hereford, the placement of the hands upon the pelvis was the most common arm position and it is possible that this position represents burial in a shroud (Heighway 2007: 235). Heighway suggests the positioning of one arm on the body and one by the side may represent the arm falling out of position as the body is moved. However, the high prevalence of burials at Jewbury, York (30%) with one arm extended along the body suggests this to be a deliberate positioning of the arms within that cemetery (Heighway 2007: 235). Indeed, it also forms the most common arm position at Llandough accounting for 33% of burials if 'Arm Position B' (left arm bent on to pelvis, right arm straight) and 'Arm Position C' (left arm straight, right arm bent onto pelvis) are combined. Crossing the arms across the body has been suggested to be representative of Christianity (Holbrook and Thomas 2005: 19), but is not an overly common burial form in the Anglo-Saxon period. It only forms 1% of early medieval burials at both St Oswald's and Llandough, and a small proportion of Anglo-Saxon burials at Wharram (Heighway 2007: 235). Holbrook and Thomas (2005: 25) observe a higher frequency of burials with the arms crossed across the waist or pelvis in the northern part of the cemetery at Llandough, which they suggest may indicate that these arm positions were more prevalent in the later period of cemetery use i.e. the 9th to 10th century. Heighway (2007: 236) and Holbrook and Thomas (2005: 25) observed no relationship between arm position and the age and sex of the deceased, save for a slightly higher prevalence of immature burials exhibiting Arm Position B (left arm bent on to pelvis, right arm straight) within the Llandough assemblage. A statistical analysis of the relationship between arm and leg positions and bio-cultural indicators of health and status in the Black Gate cemetery was not undertaken due to the small sample sizes of most arm positions.

A total of sixteen prone burials were recovered from the Black Gate cemetery. The fragmentary, prone burial of mature adult male skeleton BG638 has been identified as having been buried with his hands tied together behind his back (Figure 2.11) (Nolan 2010: 223). Prone interments have in the past been regarded as being 'deviant' and strongly associated with criminals (Daniell 2002: 243; Reynolds 2002: 187; Hadley 2010). However, the occurrence of prone burials within the cemeteries of the later Anglo-Saxon religious communities of Wearmouth (McNeil and Cramp 2005: 82, 85) and Jarrow (Lowther 2005: 176), and in other ecclesiastical cemeteries, such as Beckery Chapel (Somerset) and Shipton-under-Wychwood (Oxfordshire) (Hadley 2010: 108), undermines the argument that such interment is a sign of damnation; or even simply of careless or hurried burial. Indeed, two of the prone burials at Wearmouth possessed upright stone markers (McNeil and Cramp 2005: 85), and one was provided with a stone setting around the skull, suggesting that these burials were intentional and no lower in status than the rest of the burials interred within that cemetery.

Figure 2.11 *Prone – possibly bound – interment within Black Gate cemetery (BG638) (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)*

It is possible that prone burial may have held a penitential significance. Chapter XII of the *Regularis Concordia* instructs that should a monk die the singing of the penitential psalms is 'to accompany him to the grave and, still singing, the monks are to return to the church and complete the psalms prostrate before the altar. The position of the living brothers as they sing mimics the horizontal body of the dead brother'. There is, however, no comparable explanation for the occurrence of prone burials amongst the lay populace (Thompson 2002: 239).

2.3.3 Multiple Interments

The majority of graves within the Black Gate cemetery contained only a single individual. However, there are a number of cases of multiple individuals interred within the same grave. Nolan (2010: 223) documents two examples of multiple interments within a single grave. Mature adult male BG175 and senior adult female BG176 were interred together (Figure 2.12). The torso of skeleton BG176 was supine, but her legs were bent to the right. Skeleton BG175 was laid prone, partly on top of BG176 with the left arm extended with the hand resting upon the pelvis of the underlying individual with her legs bent to the left, fitting closely with those of underlying body. Senior adult female BG341 and mature adult female BG345 were interred together in a similar fashion to BG175 and BG176 (Nolan 2010: 223).

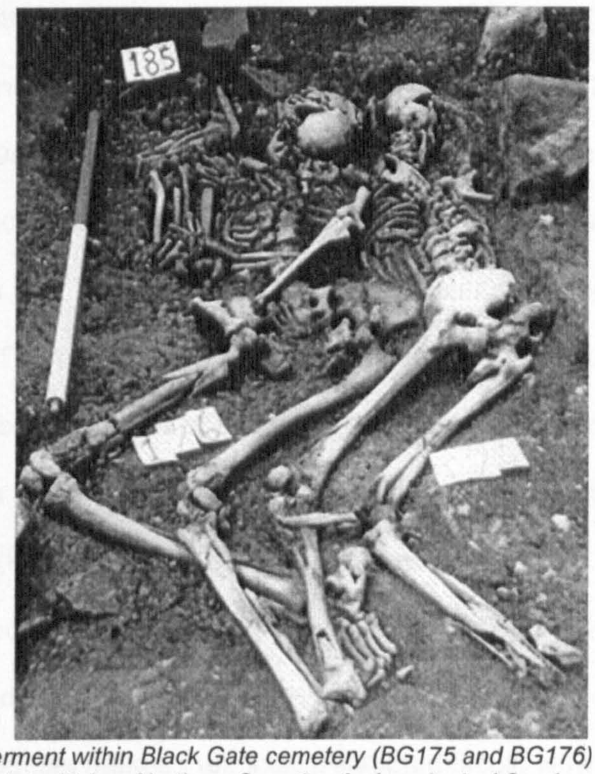


Figure 2.12 *Multiple interment within Black Gate cemetery (BG175 and BG176) (Photograph courtesy of John Nolan, Northern Counties Archaeological Services)*

Analysis of the excavation records, including AutoCad® plans of the burials, revealed several more instances of multiple interments. Three graves – in addition to the two described above – contained a male and female interment (BG315/316; BG411/540 and BG530/482). Two graves contained an adult male with an infant (BG98/99 and BG485/489). The majority of multiple interments contain two neonates or infants aged less than six months (BG253/258; BG263/264; BG234/235 and BG496/497). A further two graves contained a young child and an older child (BG520/522 and BG521/523). The majority of the double burials were simultaneous. However, there is evidence of consecutive burials, an example of which is the aforementioned deposition of the coffined neonate skeleton BG495 on the cap stones of the cist of skeleton BG499 (Nolan and Harbottle *unpublished*: 31).

Both simultaneous and consecutive multiple burials are a more common occurrence in later Anglo-Saxon cemeteries relative to those of the early Anglo-Saxon period (Stoodley 2002; Hadley 2011: 294). Multiple interments of the later Anglo-Saxon period typically comprise of an adult with an immature, as seen at Wharram Percy (Mays 2007: 85), Wearmouth (McNeil and Cramp 2005: 84), Llandough (Holbrook and Thomas 2005: 10) and St Peter's, Barton-upon-Humber (Rodwell 2007: 20). However, two adult males (as at St Andrew's, Fishergate) or females can be interred in the same grave as seen at Black Gate. The double interment of immatures was also present at Llandough (Holbrook and Thomas 2005: 10) and St Peter's, Barton-upon-Humber (Rodwell 2007: 20). There is a greater range of variations in the number of interments within single graves beyond those observed in the Black Gate cemetery. Examples of such variations are a burial from St Andrew's, Fishergate, which contained two adult males and a female (Kemp 1993b: 157-8; Stroud and Kemp 1993: 263) and a grave at St Peter's, Barton-upon-Humber, which contained the remains of two adult males and three immatures (Rodwell 2007: 20). The complex combination of ages and sexes included in multiple burials makes their interpretation difficult. However, a viable explanation is that they are successive family burials and represent an increase in the influence of family status on later Anglo-Saxon burial practices (Hadley 2010: 107; 2011: 294). Hadley's interpretation is supported by the evidence from Wearmouth, where a much smaller grave cut for an immature interment (Grave 64/22) is cut into the larger primary burial of an adult (Grave 64/26) and has been interpreted as a relative inserted on top of a family burial (McNeil and Cramp 2005: 84).

2.4 Comparative Sites: Information and Background

The following section provides summary descriptions of thirteen cemetery populations representing a range of settlement sites contemporary to the Black Gate cemetery, which were used to place the results of the current study into their archaeological context. Even though limited comparisons can be made between Black Gate and the small volume of existing data available for Northumbria, it was necessary to widen the topographic and temporal boundaries of this research to provide a clearer context within which to place the Black Gate cemetery. A summary of the sites included within this thesis is provided in Table 1.2. Figure 2.13 shows the location of each site.

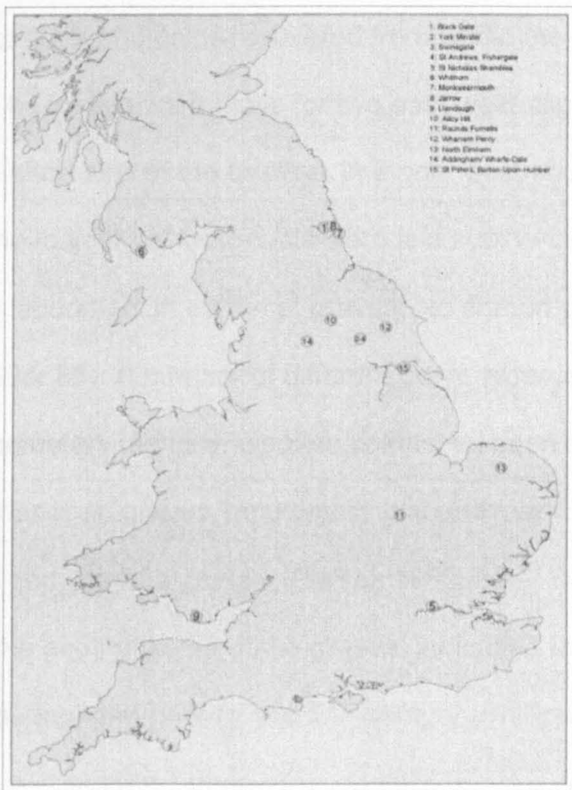


Figure 2.13 *Locations of Black Gate and Comparative Sites*

The following summaries describe the location of each site, the date of burials, the number and types of burials and the extent of osteological analysis undertaken. In addition, the publications and reports from which the osteological data included within this text were derived are identified.

2.4.1 York Minster

York Minster is located within the current city centre of York (North Yorkshire). Excavations within the south arm of the transept of the present minster undertaken between 1969 and 1973 exposed a pre-Conquest cemetery thought to be associated with the – at present – undiscovered church of Saint Peter the Apostle (Rollason 1998: 134; Buckberry 2010: 13). The pre-Conquest date for this cemetery was established because it underlies the 11th-century transept and the apsidal chapel, which projects from the south arm of the transept (Phillips 1995: 75, 78). Burials within the cemetery were concentrated within the walls of the pre-existing Roman *basilica* (Philips 1995: 81). A total of 111 inhumation burials recovered during these excavations have been dated to between the 8th and 12th centuries by radiocarbon dating, stylistic features of carved stone grave markers and coins recovered from within the graves (Phillips 1995: 75, 88-92, Table 2). The burials were, save for two east-west aligned burials, arranged in rows parallel to the short axis of the *basilica*, in a northeast-southwest orientation (Phillips 1995: 81). The majority of individuals were laid supine-extended, with the arms positioned across the 'abdomen' in earth-cut graves. No shroud pins or fastenings were recovered (Phillips 1995: 85). A number of different grave types and variations were observed within this cemetery, namely, wooden coffins, wooden chests, a single stone coffin, stone- and mortar-lined graves, 'make-shift' cist and 'part-cist' burials, pillow stones, wooden biers and charcoal burials (Phillips 1995: 83-7). Head and foot stones were found *in situ* at the ends of some of the graves, indicating that a number of graves were clearly marked during, and prior to, the 11th century (Phillips 1995: 81).

The remains of 67 skeletons of varying levels of completeness underwent osteological analysis (Lee 1995: 559). The osteological data provided from Lee's analysis will be used to compare the health status of the York Minster skeletal assemblage with the Black Gate skeletons. However, for comparisons of demographic structure and burial practices observed at York Minster the inventory of pre-Conquest burials compiled by M. O. H Carver (Table 2; Phillips 1995: 88-9) is utilised as it documents information for all of the recorded graves.

2.4.2 Swinegate, York

The Swinegate cemetery was excavated in 1989 and 1990. The cemetery dates to between the 10th and 11th centuries and is possibly the cemetery of the lost church of St Benet (Pearson 1989). A metalled surface dating to the 11th century overlay much of the cemetery site. This metalled surface sealed a number of burials signifying the general cessation of burial within the cemetery. However, some burials cut through the metalled surface indicating occasional burial did continue after its construction (Buckberry 2004: 25). Fifteen trenches were excavated at Swinegate and eight of these trenches contained a total of 100 inhumation burials. An additional 800 identifiable disarticulated human bones, which represented a minimum of 54 individuals, were recovered from grave fills, charnel pits and unstratified contexts (Buckberry 2004: 25). Dendrochronological analysis of seven wooden coffins recovered from the burials dated them to the late 9th to the early 11th centuries (Bagwell and Tyers 2001; Buckberry 2004: 23-4). The burials were orientated west-north-west and east-south-east in alignment with surrounding Roman structures (Pearson 1989), and the individuals within these burials were laid supine-extended. Within the Swinegate cemetery only earth-cut graves, plain coffins and planks were recorded (Buckberry 2004: 185). Many of the coffins recovered from the cemetery were constructed of oak using dowel pegs rather than iron nails. All the graves were well spaced, with limited inter-cutting, suggesting the presence of some form of above-ground markers, which have not survived.

An osteological report has yet to be published; therefore, the information included within this thesis derives from the osteological analysis of the 100 articulated skeletons undertaken by Buckberry for her doctoral thesis (Buckberry 2004).

2.4.3 St Andrew's, Fishergate

The extensive settlement at St Andrew's, Fishergate was situated in the riverside area of York on the outskirts of the Roman fort and town, and it has been suggested that Fishergate was the site of an *emporium* (Welch 1992: 119; James 1995: 11). Excavations in 1985-6 recovered 412 inhumation burials spanning the mid-11th to 16th century (Kemp 1993b: 130; Stroud and Kemp 1993: 121). A clay layer overlying a dark loam deposit, which contained the earliest burials, and a slot probably associated with the clay layer, have been interpreted as the floor and south wall of a timber church. Layers of stone chips found above the earliest burials and surrounding the clay floor are probably debris from the construction of a stone building nearby. This is thought to be a stone church replacing the timber structure in the late pre-Conquest or early Norman period. The dating for the stone structure comes from the fact that the layers of stone chips were cut by further burials, some of which were in turn cut or overlain by the walls of the Gilbertine Priory church (Kemp 1993a: 127; Kemp 1993b: 130). Kemp speculates that the original church was probably that dedicated to St Andrew and recorded in the Domesday Book as belonging to the fief of Hugh Fitzbaldric in 1086, but the status of which is unknown (Kemp 1993a: 127).

At the end of the 12th century, a new priory of St Andrew of the Order of St Gilbert of Sempringham was constructed upon the site. Burials took place within the later priory church, the chapter house and cloisters and externally to the south and east of the church. Burials became less frequent in the 14th century, being almost exclusively confined to within the church and in the area to the south. Burial ceased with the dissolution of the religious community in 1538, after which the church was demolished and a limekiln was built in the cloister garth using parts of the cloister arcade. The rest of the associated buildings had been robbed of all usable building materials (Kemp 1993a: 128).

For the purpose of this thesis, only the 131 inhumations recovered from the Phase 4 cemetery are included for comparative purposes. Phase 4 of the cemetery has been associated with the earlier church of St Andrew's, which dates from the late 10th to the 12th century (Kemp 1993a: 124). Dating evidence for the church and cemetery was provided by pottery recovered from refuse pits (Kemp 1993a: 127). All the burials from Phase 4 were aligned west-east and supine-extended, the majority of which either had their arms extended alongside the body or placed across the torso. Kemp (1993b: 157-8) ascribes a number of 'abnormal' burials within the St Andrew's, Fishergate cemetery to 'ritual'. For example, one 12-14 year old adolescent skeleton had been bound 'in an advanced stage of decomposition'. A prime adult male exhibiting blade injuries was buried supine extended with both arms crossed above his head. A second prime adult male skeleton, which had suffered blade injuries, was buried with his arms placed around another prime adult male skeleton 'as if in an embrace' (Kemp 1993b: 157-8) There are six examples of multiple burials in a single grave from the Phase 4 cemetery, of which five contained two adult male interments. In three of these burials, both males exhibited blade injuries, whereas only one of the males exhibited blade injuries in the remaining two. The sixth multiple interment contained one adult female and two adult males (Kemp 1993b: 157-8; Stroud and Kemp 1993: 263).

Sixty-nine of the Phase 4 burials were earth-cut graves, some of which may have included wooden coffins. Evidence for wooden coffins from Fishergate is limited to a small number of nails and 'clench bolts' and reddish brown iron staining observed within 26 burials, which probably represent coffin nails. The disposition of one senior adult female skeleton was interpreted by the excavators as suggesting this individual was 'wrapped' in a shroud (Kemp 1993b: 149). The positioning of the arms close to the body, flexed at the elbow across the torso and the legs extended closed together with the ankles touching is shown in Figure 2.14.

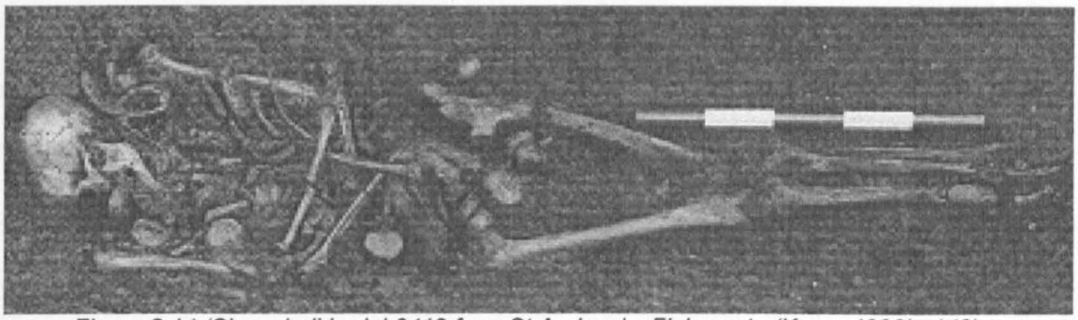


Figure 2.14 *'Shrouded' burial 6412 from St Andrew's, Fishergate (Kemp 1993b: 149)*

Copper-alloy staining was observed on the bones of two individuals, which Kemp (1993b: 153) ascribes to 'coffin fittings' but Buckberry (2004: 172) interprets as possible evidence for shroud pins. The remaining grave variations observed in Phase 4 were tile-lined graves, cobbles surrounding the head of one adult male (1589) who had suffered blade injuries and decapitation, and a single un-inscribed stone slab placed at the head of a child burial (6330) (Kemp 1993b: 151-3).

The osteological and burial information for St Andrew's, Fishergate included within this thesis derives from the catalogue of skeletons and chapters by R. L. Kemp, G. Stroud and P. Watson within Stroud and Kemp (1993: 242-50).

2.4.4 St Nicholas Shambles

St Nicholas Shambles was an early medieval parish cemetery, located within the City of London. Excavations undertaken by the Museum of London in 1975-7 recovered ceramic sherds from the cemetery soil dating to the 11th and 12th centuries (White 1988: 6, 9). Further pottery dating to the 10th-12th centuries was recovered from pits underlying, and therefore pre-dating, the burials (White 1988: 9). Consequently, the

11th and 12th centuries have been established as the period of use of the cemetery. A total of 234 articulated skeletons were recovered, all of which were laid supine-extended with the arms extended alongside the body (White 1988: 18). The majority of burials were earth-cut graves, some of which contained evidence for wooden coffins. Additional variations observed within the graves were pillow stones; graves with crushed chalk and mortar floors; cists formed from mortared stones, or lined with chalk and mortar; and stone- or tile-lined graves (White 1988: 19). A single charcoal burial was recorded along with several graves containing Roman tiles and pebbles (White 1988: 25-6). All the skeletons excavated are included within the analysis undertaken for this thesis. The osteological data included within this thesis comes from within the body of the text and the catalogues of skeletons in Appendix 1 from the published site report (White 1988).

2.4.5 – 2.4.6 Wearmouth and Jarrow

The Anglo-Saxon church of St Peter at Wearmouth and the church of St Paul at Jarrow were both monastic sites located in close proximity to each other on a plateau between the sea on the east and the rivers Wear and Tyne to the south (Cramp 2005: 5). The formal foundation of Wearmouth occurred in 673 and construction of the monastery began in 674 (Cramp 2005: 31). Construction of the allegedly smaller monastery at Jarrow started nine years later, in 682. Bede – in his *Ecclesiastical History of the English People* (*Historia Ecclesiastica Gentis Anglorum*) (*c.* 673-735) –makes specific reference to the foundations of St Peter and St Paul being a single monastery located in two places: 'I, Bede, servant of Christ and priest of the monastery of St Peter and St Paul, which is at Wearmouth and Jarrow' (*HE,* 24; Colgrave and Mynors 1969: 566-7). Numismatic and stratigraphic relationships with the standing structures at Wearmouth indicate that burial commenced within the cemetery with the foundation of the minster in 673, or just before, and continued into the 11th century (Cramp 2005: 78-9). Stratigraphic relationships between the burials and monastic buildings within the

Jarrow cemetery have enabled pre-Conquest burials to be identified and excavated to the south-west of the church (Lowther 2005: 173-5). A total of 178 *in-situ* burials were recorded during excavation at Wearmouth and 132 *in-situ* Anglo-Saxon burials were exposed at Jarrow (McNeil and Cramp 2005: 77; Anderson *et al.* 2006: 482) containing the skeletal remains of 327 and 170 individuals respectively.

All of the Wearmouth pre-Conquest skeletons were orientated in an approximately west-east alignment (McNeil and Cramp 2005: 82). Body position was recorded for 117 of the pre-Conquest skeletons. The majority (67.5%) were laid on their right side. The second most common burial position was supine (25.6%), after which 5.1% of burials were prone and 1.7% were interred on their left side. The majority of individuals were interred in an extended position save for a small group of three crouched burials recovered from the extreme south-east of the site (McNeil and Cramp 2005: 82). The majority of individuals were buried in plain earth-cut graves. Graves containing coffins (evidenced by nails, fragments of iron and coffin 'studs') and shrouded burials (identified by two graves containing shroud pins and further burials within which the long bones were positioned tightly parallel to the body) were also recovered (McNeil and Cramp 2005: 80, 85).

A number of graves included support stones. For example, a large rectangular stone was placed upright against the skull of skeleton 64/22 and an additional pillow stone had been placed beneath the skull of this individual. The support of the skull by these stones has been interpreted as indicating that individual 64/22 was not interred within a coffin (McNeill and Cramp 2005: 85). Skeleton 67/8 was interred with stones supporting the head and feet and overlying the pelvis and right arm. Both these skeletons and a third (69/18) which had stones placed over the feet were interred prone. McNeil and Cramp (2005: 85) hypothesise that it is possible that these burials held some significance within the community burying them in terms of social status, or else the burial reflected medical or superstitious factors. Stones supporting the skull were recovered from a total of four burials and a further 22 burials contained stones either supporting or 'outlining' parts of the body (McNeill and Cramp 2005: 86).

All the burials within the Jarrow cemetery were orientated west-east (Lowther 2005: 183). All the individuals interred within the Jarrow cemetery were placed in an extended position. Equal numbers of individuals were interred supine (48%) and on their right side (48%). A number of the right sided burials have been explained as burials in coffins which were originally supine, but had 'rolled over' within the void created by the coffin structure (Lowther 2005: 180). The two remaining burials, for which body position could be determined, were laid prone (Lowther 2005: 176-7). The burials were predominantly earth-cut graves, a few of which contained evidence for coffins (evidenced by nails in two graves, but predominantly through the survival of wood and wood staining), shrouds (only two, identified via the aforementioned 'parallel sided' body position) and support stones positioned by the head and alongside the body (Lowther 2005: 178-80). No cist burials were recovered (Lowther 2005: 180) and there was no surviving evidence of grave covers or markers. However, the absence of the latter may be a consequence of severe truncation of the site (Lowther 2005: 181).

The osteological data from these two sites was acquired from the published skeletal analysis undertaken by Anderson *et al.* (2006: 503-39). Disturbance of the graves and the poor preservation of the skeletal material recovered from Wearmouth and Jarrow means estimating the actual number of individuals present in the osteological sample was problematic (Anderson *et al.* 2006: 482).

2.4.7 Llandough

The Llandough cemetery is located upon an escarpment overlooking the estuary of the River Ely, 3.5 km from the centre of Cardiff (Holbrook and Thomas 2005: 1). The 19th-century church of Saint Dochwy currently occupying the site overlies a large monastic burial ground. Radiocarbon dates indicate burials within the early-medieval cemetery commenced by the mid-7th century and continued until the closure of the monastery in the late 10th or early 11th century (Holbrook and Thomas 2005: 1). Excavations at the monastic cemetery in 1994 revealed a total of 814 articulated and 212 disarticulated skeletons (Holbrook and Thomas 2005: 9). The majority of burials were supine extended, although, one individual was laid upon its right side and four burials were flexed. A single prone burial was also recovered (Holbrook and Thomas 2005: 13). Legs were predominantly extended. Eight burials had their legs crossed at the ankle and one adult burial had right leg flexed and left leg extended. A further fourteen burials exhibited slightly flexed or bowed legs, which the authors of the report ascribe to 'post-burial settlement' (Holbrook and Thomas 2005: 16). The most common arm position was for both to be extended along the body, however sixteen additional combinations of arm positioning were also observed and recorded (Holbrook and Thomas 2005: 16-18).

All the burials at Llandough were single inhumations in earth-cut graves, save for a few multiple interments. Nails and corroded iron fragments, possibly coffin nails, were recovered from twenty-seven graves and interpreted as evidence for coffins. However, this interpretation is tenuous because only one of these graves produced more than two nails (Holbrook and Thomas 2005: 27). Nonetheless, the absence of nails does not necessarily indicate an absence of a coffin. It could simply mean that wooden dowels were used instead of nails in the coffin construction. Organic staining was observed in the base of nine graves, which was substantial enough in each case to suggest the presence of a wooden coffin, although no nails were recovered (Holbrook and Thomas

2005: 27). A 'vertically-pitched limestone slab' foot marker was observed in one grave, and forty graves contained 'burial pebbles' (Holbrook and Thomas 2005: 35). Iron knives recovered from 8th – to 11th – century graves within this cemetery appear almost certainly to have been deliberately deposited during burial (Holbrook and Thomas 2005: 33-4). Nine burials exhibit 'hunching' of the shoulders which has been interpreted as evidence for the possible use of shrouds or, alternatively, of the body being 'tightly packed' within a coffin (Holbrook and Thomas 2005: 27). Due to difficulties encountered in phasing and dating the burials in the Llandough cemetery the 801 skeletons sampled from Phases I, II *and* III (*c.* 640 – 1024) (Holbrook and Thomas 2005: 44, 88) are included within the comparative analyses in this thesis. All the osteological data included within this thesis derives from the published summary report on the skeletal remains and Loe's unpublished PhD thesis (Loe 2003; Loe and Robson-Brown 2005: 42-51).

2.4.8 Ailcy Hill, Ripon

The cemetery on Ailcy Hill, Ripon (North Yorkshire) is located approximately 200m to the east of Ripon Cathedral. The cemetery is located upon an escarpment near to the point of convergence of the rivers Urea and Skell (Hall and Whyman 1996: 65). The cemetery dates from the early 7th to late 9th or early 10th centuries (Hall and Whyman 1996: 99). Three arbitrary phases of development of the cemetery were assigned based on the physical relationships between the graves. Phase 1b consisted of 12 inhumation burials, nine of which produced *in-situ* skeletons and additional disarticulated remains. It has been interpreted from the mix of male, female and immature skeletons recovered from Phase 1b that these burials represent the burial ground of a local community (Hall and Whyman 1996: 83-4, 120). Phase 2 consists of 10 *in-situ* inhumation burials, nine of which contain male remains (the sex of the remaining individual was undeterminable). This transition from mixed to single-sex burials indicates the site was adopted for burial by a monastic institution in the 7th century (Hall and Whyman 1996: 83-4, 120). Phase 3 consists of three graves dating to the 8th and early 9th century deliberately placed between Phase 2 burials (Phase 3a) and two graves which truncate Phase 2 burials and date to the 9th or possibly 10th century (Phase 3b). Phase 3a appears to be a continuation of the Phase 2 burials. Phase 3b, which includes multiple interments including sick individuals, has been interpreted as representing a later use of the site for deviant or 'outsider' burials (Hall and Whyman 1996: 76, 124).

The graves excavated from phases 1a to 3b were predominantly orientated west-east The orientation of the Phase 3 burials was determined by the spaces available between, and orientation of, the pre-existing Phase 2 interments. However, one burial was aligned east-west and there are remnants of two north-south aligned graves. The burials were primarily supine-extended with variations in the upper body, arm and leg positions. The predominant form of burial was a single interment within an earth-cut grave. However, there is one instance of a multiple burial from Phase 3b containing three adult males (Hall and Whyman 1996: 78, 93). Iron furnishings such as nails, hinge straps, corner brackets and locks have been interpreted as evidence for wooden coffins and domestic chests (Hall and Whyman 1996: 99) within at least four and possibly up to nine graves (Hall and Whyman 1996: 76). The limited evidence for disturbance and inter-cutting within the Phase 2 burials suggests they were clearly defined, indicating the presence of above-ground grave markers (Hall and Whyman 1996: 76).The only example of grave goods recovered during excavation was a knife blade associated with burial 1019 (Hall and Whyman 1996: 110). The twenty-seven *in-situ* skeletons recovered from Phases 1 to 3b documented in the Hall and Whyman report (1996) will be used as a case study with which to compare the Black Gate skeletal assemblage.

2.4.9 Raunds Furnells

Raunds Furnells was a rural cemetery located in the middle Nene Valley east of the town of Higham Ferrers in Northamptonshire. The cemetery is located approximately 58 m from the head of the valley of Raunds Brook, a three kilometres long minor tributary (Boddington 1996: 5). The cemetery and settlement underwent full-scale excavation between 1977 and 1984 (Boddington 1996: 1). The cemetery dates from the 10th century when ditches were cut to define a churchyard around a small field church, initially established in the late 9th or early 10th century, adjacent to a rectangular enclosure containing a series of regularly arranged buildings. The initial burials were located immediately adjacent to the church, and expanded to the north, south and east for a further two centuries (Boddington 1996: xii). It is believed interments within the cemetery ceased shortly after the construction of a second larger church, which replaced the original small field church (Boddington 1996: xii).

The burials were predominantly supine-extended, with the arms next to or resting upon the pelvis and legs fully extended, however, it was recorded in 16 instances that the hands were 'clasped' upon the pelvis. The feet were crossed in six instances and in a single burial the ankles were crossed. In the majority of instances, the head either faced towards the foot of the grave or to the side. In only 25 interments, the head was faced skywards (Boddington 1996: 37). The majority of burials were earth-cut graves; however, there is also evidence of wooden coffins and six stone coffins were recovered (Boddington 1996: 31). No shroud pins or coffin fittings were recovered (Boddington 1996: 37). More than half of the graves contained stone arrangements to protect and support the body. These stone arrangements comprised of pillow stones, earmuffs, head cists, stones over knees or next to legs, stone cist burials and stone- or rubble-lined graves (Boddington 1996: 38-45). There were deliberate charcoal inclusions within fifteen graves (Boddington 1996: 37).

Two decorated limestone grave covers were also discovered. An elaborately decorated grave cover, inscribed with a cross, was placed over a mature adult male interment located in the first area of burial adjacent to the church building (Boddington 1996: 45,106-7). This interment has been interpreted as a 'founder's grave'. The second decorated grave cover overlay the interment of an infant aged between birth and 6 months. During the later period of use of the graveyard, infants were interred in the 'eaves-drip' zone adjacent to the church walls (Boddington 1996: xii; 45). Boddington (1996: 45-6) also highlights the evidence for grave markers within the Raunds Furnells cemetery, in the form of post-holes and 'slots' at the extremities of several graves, horizontal stone covers, crosses, rough stones and vertically 'pitched' limestone in the top of the grave fill of burial (5321). A total of 363 skeletons were recovered, of which 339 were primary interments (the remaining 24 were secondary burials within graves) (Powell 1996: 113).

The osteological and burial data from Raunds Furnells included within this thesis derive from the published osteological report (Boddington 1996; Powell 1996: 113-24) and the associated microfiche (Boddington 1996: MF2). The information regarding the prevalence of dental enamel hypoplasias within the Raunds Furnells assemblage refers to work undertaken by L. Craig (2006).

2.4.10 Wharram Percy

Wharram Percy was a deserted rural medieval village site located upon a chalk plateau overlooking the springs and 'headwaters' of Settrington Beck on the Yorkshire Wolds, eighteen miles outside the medieval city of York (Bell 1987: 1; Stamper and Croft 2000: xi). Excavations undertaken between 1962 and 1973 (Harding and Marlow-Mann 2007: 9) recovered burials from the churchyard surrounding the church, which are thought to have primarily contained the lower social classes, such as the peasantry (Mays *et al.* 2008: 86). The cemetery was established in the latter half of the 10th century to serve the inhabitants of Wharram Percy and surrounding communities (Harding and Wrathmell 2008: 327).The cemetery has been dated by radiocarbon analysis to between the 10th and 16th centuries (Bayliss *et al.* 2007: 213). The cemetery was founded before the construction of the first stone church, as evidenced by the fact that the west wall foundation cut through two burials. However, there is tentative evidence that a timber church pre-existed on the site (Harding and Wrathmell 2008: 327). Only skeletons recovered from Phases 1 (950-1066) and 2 (1066-1348) are included in the comparative analysis within this thesis, including burials classified as Phase 1-2, which have been given a broad date range of between 950 and 1348. A total of 255 burials were recovered from these three phases, of which only 10 were attributed to Phase 1. A total of 78 burials were recovered from Phase 2 and the remaining 167 burials were from Phase 1-2 (Mays 2007: 78-9).

The majority of the burials were laid supine extended with five variations in the disposition of the arms (by the sides, hands on pelvis, hands crossed on the chest, arms across the waist and one arm on the body with the other by the side) (Heighway 2007: 233). The majority of burials contained a single individual, but five burials from Phases 1 and 2 contained multiple interments. These graves included one prime adult female with a four year old child; a prime adult female with a neonate 30 weeks *in utero*; a young adult male and a one year old infant; a young adult probable female with a neonate aged 42-45 weeks and a senior adult with a six year old child (Mays 2007: 85). It is difficult to identify the prevalence of different types of burial within the pre-Conquest phases of the Wharram cemetery but the types of burial present, aside from earth-cut graves, can be summarised as follows. A skeleton interred in a stone cist recovered from the south side of the church has been radiocarbon dated to between 950-1050 (85% probability). Stone grave covers dating from the 11th to 13th centuries, including a group of burials dating to the 11th century sealed by an old floor surface within the vestry, were also recovered. The graves under these covers contained upright stones at the head and feet, however, the covers did not rest on the stones but upon the top of the walls of the graves (Heighway 2007: 224-6). A proposed wooden cover is suggested in one grave based on a line of charcoal-flecked soil over a grave. These burials with grave covers and headstones were interpreted as contemporary burials of high status (Heighway 2007: 226). High status has also been presumed for a burial that had stones around the head and a bed of chalk blocks. This burial also contained iron nails suggested to have derived from a wooden cover which happened to have nails in it from a previous function (Heighway 2007: 226). There are further burials containing earmuffs, pillow stones and other stone inclusions characteristic of the 10^{th} to 12^{th} centuries.

All of the skeletal information regarding Wharram Percy derives from the volume published on the cemetery, and the appendices included within it (Mays 2007). Information regarding the demographic profile, cribra orbitalia and stature will be obtained from skeletons clearly assigned to these phases in Appendix 1: Catalogue of Burials (Mays 2007: 337-48). The remaining palaeopathological information will be taken from Appendix 2: Notes on Individual Burials (Mays 2007: 349-91) and within the body of the published report (Mays 2007).

2.4.11 Addingham

The later Anglo-Saxon cemetery of Addingham is located upon a precipitous gravel ridge above the south bank of the River Wharfe, which may have been a settlement site as far back as the Iron Age (Adams 1996: 151). Addingham is believed to be a rural cemetery associated with a minster church. Radiocarbon dating places the cemetery between the 8^{th} and 10^{th} centuries and documentary sources indicate it was an estate of the Archbishop of York at that time (Adams 1996: 151; Mason 1996: 153). The cemetery probably served the small monastic community associated with the archiepiscopal residence present there by the mid-9^{th} century, but may also have attracted burials from the surrounding population (Wrathmell 1996: 187). Excavations of a part of the pre-Conquest cemetery undertaken in 1989 and 1990 revealed 55 graves, of which 45 contained human remains. The excavated area of the Addingham cemetery has been postulated to represent less than one fifth of the entire cemetery, based on the known dimensions of the churchyard boundary (Wrathmell 1996: 185-6).

All primary interments were orientated west-east and they were mainly laid supine-extended. The interments were predominantly earth-cut graves. The presence of wooden coffins is suggested by the recovery of iron nails from the fill of four graves Many of the graves were very narrow, within which the individual must have lain on their side (Adams 1996: 163), and were very closely spaced together but rarely inter-cutting, reflecting the presence of some form of grave demarcation. There is evidence for both re-opening of graves for second primary interment and multiple burials within one grave fill (Adams 1996: 165). No grave goods nor evidence for clothing and the associated accessories were recovered from any of the burials and the only recorded inclusions were flecks of charcoal (Adams 1996: 165). A total of nine graves, excavated from the north-east area of the cemetery, contained either no evidence for an inhumation burial, or just small fragments of bone (Adams 1996: 163). Adams (1996: 163) purports that it is most likely that individuals were initially interred in these graves then removed and re-buried as secondary interments in another grave, either with another individual or as single interments. The dearth of skeletal material recovered from these empty graves suggests the body would have still been articulated and, therefore, may be indistinguishable from a primary burial in the second grave (Adams 1996: 163).

The remains of 83 individuals were recovered during excavation, of which 40 were undisturbed primary interments (Adams 1996: 151), and, of these, 13 contained only 'the lower extremities' (Boylston and Roberts 1996: 173). The human bone report provided by Boylston and Roberts (1996: 173-80) provides information on the 69 adults and 14 immatures. Their report is used within this thesis to compare Addingham with the Black Gate skeletal assemblage.

2.4.12 North Elmham Park

North Elmham Park was a rural community of peasant houses clustered around a cathedral precinct. The cathedral and cemetery of North Elmham are located adjacent to the upper extent of the River Wensum in Norfolk in close proximity to Billingford where the main east to west Roman road, which traversed across Norfolk from the Fens to the east coast, crossed the River Wensum (Wade-Martins 1980: 13 -14, 281). North Elmham is located only a mile and a half away from the early Anglo-Saxon cremation cemetery of Spong Hill, which contained over 2000 cremation burials and 57 inhumations (Hills 1989).

Excavation of a restricted area of the south-west corner of the cathedral cemetery undertaken between 1967 and 1972 revealed 194 graves (Wade-Martins 1980: 185). Pottery evidence suggests that most of the cemetery is contemporary with the village settlement of Period III, which dates to the 11th century (Wade-Martins 1980: 185, 187). However, it is unlikely that the cemetery fell into disuse immediately with the relocation of the see to Thetford in 1071. It is more likely that at least a small proportion of the cemetery remained in use until the erection of the new parish church in North Elmham in the early 12th century (Wade-Martins 1980: 185). Burials near the centre of the cemetery are densely packed and inter-cut and overlie each other. The more peripheral burials were less densely packed, indicating that plots closer to the cathedral were more desirable than the more peripheral burial plots (Wade-Martins 1980: 188). The density of burials within the excavated area and postulated extent of the cemetery indicate that this cemetery may contain several thousands of burials (Wade-Martins 1980: 188).

All the excavated burials were aligned west-east and were orientated 97 degrees from true north, respecting the curve of the cemetery wall and following the orientation of the cathedral. All the burials were supine extended with arms extended straight alongside the body or crossed across the torso. The presence of wooden coffins was suggested by organic and iron staining within three graves. There is no evidence for pillow stones around the skull or support stones around the body. There is also no evidence for grave markers (Wade-Martins 1980: 188). One grave, recorded as Inhumation 10, contained the remains of an adult male with 'a grossly deformed left leg' and was located external to the cemetery wall next to the road at the entrance to the cemetery and in reverse alignment (Wade-Martins 1980: 189). Inhumation 171 was interred in the base of the proposed boundary wall or fence of the cemetery either after the wall had decayed or deliberately in this position so that the boundary structure could subsequently be re-built over him. This adult male was the 'victim of a violent death' indicated by peri-mortem sword injuries upon his head, neck and arm. Wade-Martins interpreted both individuals as social outcasts who had been deliberately segregated from the rest of the population in death (Wade-Martins 1980: 189).

The osteological data from North Elmham Park included within this thesis derives from within the text of Chapter 12: 'The Human Bones' by Calvin Wells and Helen Cayton (Wade-Martins 1980: 247-302) and the list of burials provided in Chapter 13 of the site publication (Wade-Martins 1980: 315-74). Chapter 13, also written by Calvin Wells, and the aforementioned list of burials are also used to acquire information about the burial practices at North Elmham Park.

2.4.13 St Peter's, Barton-upon-Humber

Excavations at St Peter's, Barton-upon-Humber (North Lincolnshire) undertaken between 1978 and 1984 revealed 2,750 inhumations and thousands of disarticulated skeletal remains dating from the late 10th to mid- 19th century (Waldron 2007: xvi). This thesis will concentrate on the Anglo-Saxon and Norman Phase E (950-1150), representing a Christian cemetery which was established immediately outside of a middle Saxon large sub-circular enclosure in the late 10th century (Waldron 2007: 34). The cemetery pre-dates the construction of St Peter's church as 16 graves were exhumed to allow the construction of the church foundations (Waldron 2007: 6, 29). In a number of instances, the published report is unable to distinguish between Phase E and Phase D (1150-1300) burials therefore the data from the two phases is amalgamated. In these instances, the combined data is used. The skeletal remains of 446 individuals were recovered from Phase E and 437 from the combined Phase D/E (Waldron 2007: 34).

The vast majority of burials recovered from Phase E were single interments, lain supine-extended with the arms either extended alongside the body or crossed across the pelvis, although variations did occur (Rodwell 2007: 20). There were occasional multiple interments, e.g. one Phase E grave contained two senior adult males and three immatures aged eight, seven and twelve years (Mays 2007: 159; Rodwell 2007: 20).The majority of burials were earth-cut graves orientated west-east, in alignment with the church, varying only slightly to accommodate natural features (Rodwell 2007: 18-19). From Phases D and E 40 graves (predominantly from E) contained preserved wood, evidencing coffined burial. In all the burials where construction of the coffin was visible, the predominant jointing medium was wooden pegs or dowels. These would have been a cheaper alternative to nails made from iron, which Rodwell identifies as a 'semi-precious commodity' in the late Saxon period (Rodwell 2007: 22). The burial practices and variations employed in the later Anglo-Saxon phases of St Peter's cemetery include: possible bed, board or bier burials; a single charcoal burial (also bound in a layer of 'sticky blue clay'); 37 'clay burials'; willow 'wands'; earmuffs; grass-stuffed pillows and pillow stones and a deliberately placed 3rd-century Roman coin (Rodwell 2007: 22-8). Graves were occasionally marked by post-holes. Grave F746 from Phase E, located beneath the Anglo-Saxon tower, displayed a rectangular socket for a timber 'headboard' located at the head end (Rodwell 2007: 20).

The osteological data included within this thesis derives from the published report (Waldron 2007). Data was attained from within the body of the text where possible or extracted from the burial catalogue in Appendix 2 (Waldron 2007: 133-71). All of the prevalence rates included within this thesis are based on the 446 skeletons recovered from Phase E.

2.5 Summary

The documentary sources strongly suggest, but are not conclusive evidence for, a monastic settlement in Newcastle-upon-Tyne in 1072, which had been destroyed, possibly by Viking invaders by the end of the 9th century. The location of the Black Gate cemetery within an abandoned Roman fort, upon a promontory adjacent to a river is reminiscent of other early medieval monasteries. The presence of a single stone chapel and timber structures of a similar rectangular shape and construction to buildings found at other Northumbrian monastic sites, such as Hartlepool and Whithorn (Hill 1997: 44) further suggest the presence of a monastic settlement. However, the location evidence may equally represent a trade centre and the presence of similar buildings is not conclusive evidence for a monastic institution. The documentary evidence also suggests the presence of royal estates (*Ad murum*) and residences (Pandon) and smaller local settlements (Newburn) contemporary to the Black Gate cemetery. Therefore, it is possible that the Black Gate cemetery served these populations, regardless of it being either a monastic or an ecclesiastical burial ground. The size of the cemetery suggests a much larger population than a single contemporary rural settlement; however, it may have served several populations. It is possible that even if Black Gate was associated with a monastic community, such a monastery is unlikely to have existed for the whole life of the cemetery. For example, the settlement at Flixborough (Lincolnshire) alternated between secular and monastic uses (Loveluck 2007), and at Wearmouth and Jarrow, the monastic communities disappeared but retained some ecclesiastical presence.

The grave types and variations observed within the Black Gate cemetery conform to what would be expected of later Anglo-Saxon burials, but are not specific to any settlement type. A summary of the burial practices observed within the cemeteries included within this thesis is provided in Table 2.3. The variation in grave types does imply a desire to signal social differentiation and, therefore, it seems reasonable to assume some social ranking within the contributing population.

The documentary and archaeological evidence is inconclusive regarding the nature of the Black Gate cemetery and the population that it served. To assist in the interpretation of the documentary and archaeological evidence, and lay the foundations for the bio-archaeological analysis of chapters 5, 6 and 7, the following chapter places the Black Gate cemetery into the wider context of the mortuary behaviour and settlement types characteristic of the later Anglo-Saxon period.

Site	Coffin	Chest	Rubble Cist	Stone Cist	Pillow Stones	Ear-muffs	Head-Cist	Stone Coffin	Charcoal	Tile-Lined	Mortar/ crushed chalk lined	Grave Marker	Bed/ Bier	Clay burial	Willow wand
Black Gate	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	✓	X	X	X
York Minster	✓	✓	✓	✓	✓	✓	?	✓	✓	?	✓	?	✓	X	X
Swinegate	✓	X	X	X	X	X	X	X	X	X	?	X	X	X	X
St Andrews	✓	X	X	X	✓	✓	X	X	X	✓	?	✓	X	X	X
St Nicholas Shambles	✓	X	✓	✓	✓	✓	✓	X	✓	✓	✓	?	X	X	X
Wearmouth	✓	X	X	X	✓	✓	X	X	X	X	X	X	X	X	X
Jarrow	✓	✓	X	X	✓	✓	X	X	X	X	X	X	X	X	X
Llandough	✓	X	X	X	X	X	X	X	X	X	X	✓	X	X	X
Ailcy Hill	✓	✓	X	X	X	X	X	X	X	X	X	✓	X	X	X
Raunds Furnells	✓	X	✓	✓	✓	✓	✓	X	A	X	X	✓	X	X	X
Wharram Percy	✓	X	X	✓	✓	✓	✓	X	X	X	✓	✓	X	X	X
Addingham	✓	X	X	X	X	X	X	X	Flecks only	X	X	✓	X	X	X
North Elmham	✓	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Barton-upon-Humber	✓	X	X	X	✓	✓	X	X	✓	X	X	✓	✓	✓	✓

Table 2.3 *Burial Practices observed at Black Gate and thirteen sites of known context (A = organic debris?)*

CHAPTER 3

THE CONTEXT OF THE BLACK GATE CEMETERY

> *An extra and complicating dimension clearly to be considered when dealing with human populations is that of the influence of social factors, whether in terms of religious components, social hierarchies or other factors* (Brothwell 1994: 136).

The purpose of this chapter is to place the Black Gate cemetery in context by detailing the mortuary behaviour and physical environment, which characterised the later Anglo-Saxon period. To interpret the health and socio-economic status of the cemetery it is important to understand the motivating factors behind the choice of cemetery in which people were interred, and the burial practices included therein, during the later Anglo-Saxon period. An understanding of the physical environment within which later Anglo-Saxon people lived will further enhance interpretation of the physical manifestation of stress upon the Black Gate skeletal remains. Therefore, this chapter also reviews the types of settlements that emerged throughout the later Anglo-Saxon period, providing a summary of the possible settlements from which the Black Gate population may have originated.

The 8^{th}-12^{th} centuries present a consolidation of the transition from simple graves containing multiple and elaborate grave goods to a greater investment into the construction of the grave and exclusion of grave goods, which commenced in the 7^{th} century. The changes in the treatment of individuals within the grave were accompanied by transformations in the physical environments and locations within which people lived and died.

The study of later Anglo-Saxon (*c.* 800-1100) burial practices has, until recently, been limited (White 1988; Boddington 1996) and impeded by two misconceptions. It has often been presumed, firstly, that later Anglo-Saxon cemeteries are unidentifiable and inaccessible for study because they are obscured by medieval and post-medieval churchyards. The second assumption is that the Church opposed the interment of grave goods with the deceased and that this subsequently resulted in a uniformity of burial practice regardless of social status. Consequently, archaeologists concluded that there was little to be gained from the analysis of later Anglo-Saxon cemeteries because the lack of grave goods would impede differentiation between graves of different social groups (Meaney and Hawkes 1970: 51; Geake 1997: 139). However, recent research (Hadley 2000a, b; 2001; 2004; 2007; Buckberry 2004; Thompson 2004; Cherryson 2005; Hadley and Buckberry 2005; MacPherson 2005; Craig 2009) has challenged both assumptions. It is becoming increasingly apparent that later Anglo-Saxon burials were not restricted to churchyard cemeteries. Furthermore, this more recent research has identified that, from the 8th century, social display was implemented via diversity in the construction of the grave and associated above ground markers, the form of burial including body position, and the location of burial within the cemetery (Buckberry 2007; Hadley 2007; Craig and Buckberry 2010).

The majority of studies of the relationship between health, status, gender and age in the Anglo-Saxon period focus on the grave goods recovered from the early Anglo-Saxon period (Geake 1992; 1997; 1999; Härke 1992; Lucy 1997; 1998; Stoodly 1999a, b; 2000; 2002). However, during the 7th to 8th centuries, that is the period immediately preceding burial in the Black Gate cemetery, there was a reduction in the inclusion of grave goods within interments, which has been termed the Final Phase in recognition that these burials represent the last phase of burial with grave goods (Leeds 1936; Buckberry 2010: 2). The Final Phase model characterised cemeteries of the 7th and 8th centuries as being located close to settlements with burials typically orientated west-east in carefully organised straight rows, with very little inter-cutting (Geake 1992: 87).

The majority of graves within these cemeteries contained few, if any, artefacts. The artefacts that were recovered were predominantly of higher quality and constituted of clothing accessories, delicate gold and garnet jewellery, knives or personal vestiges such as combs, toilet sets and amulets. There is no evidence for the weapons, elaborate jewellery (including strings of amber, crystal and polychrome beads and crystals) and sieve spoons attached to the belt, which characterised early Anglo-Saxon graves (Lucy 2000: 4, 85). Some of the 7th-century graves contained cruciform artefacts, which have been interpreted as having Christian significance (Boddington 1990: 181; Geake 1997). The interpretation of the cross-shaped artefacts as Christian follows the central theme of the Final Phase model, that the decline in grave goods and increased churchyard burials represent a rapid conversion of pagan kingdoms to Christianity (Leeds 1936; Geake 1997: 2).

There is increasing evidence that the Final Phase model does not accurately represent the changes in burial practices observed in the middle Anglo-Saxon period. For example, the model does not account for the richly furnished burials, such as that accorded to the Prittlewell Prince (Essex), which continue during this transitional period (Geake 1999; Hadley 2011: 299). It is also unlikely that the burial grounds designated as Final Phase are in fact a separate phase, it is more probable that they are associated with the constant addition and abandonment of cemeteries which occurred as part of the evolution of the Anglo-Saxon landscape. The most obvious weakness in the Final Phase model is the implication that the changes in burial practices were solely a result of the conversion to Christianity (Boddington 1990: 196). A detailed analysis of the Final Phase model is beyond the remit of this thesis but Boddington (1990) and Craig (2009) provide comprehensive discussions of this model and its flaws. The rest of this chapter focuses on the evidence for burial both within and outside of churchyards and the features that characterised those burials. Consideration is also made of the possible influences upon burial decisions during the later Anglo-Saxon period in contrast to the early Anglo-Saxon period in both England as a whole, and more specifically in northern England and Northumbria.

3.1 Types of Cemeteries and Burial Grounds Characterising Later Anglo-Saxon England

This section discusses the increased later Anglo-Saxon burial in cemeteries associated with churches, either adjacent to the church building itself or in related satellite cemeteries. It highlights the increasing association between status and the Church. This section also considers the ways in which concepts of socio-economic status and religious belief were expressed in the location and segregation of burials within later Anglo-Saxon churchyard burial grounds.

3.1.1 Churchyard Cemeteries

During the 7th and 8th centuries, cemeteries were certainly founded in association with religious communities, such as those at Ripon, Wearmouth and Jarrow (Cramp 2005). Burial in these cemeteries was initially reserved for ecclesiastics and the social elite (Hadley 2001: 34). However, these churchyard cemeteries increasingly began to include the lay community and by the 10th century many had become the principal burial location for the surrounding population (Hadley 2007: 194). A second form of churchyard cemetery also arises in the later Anglo-Saxon period, whereby cemeteries were secondary developments at newly founded churches, such as at Raunds Furnells. A third class of cemetery were newly established cemeteries including those, such as Barton-upon-Humber, which initially appear not to have had a church, but subsequently acquired one (Hadley 2007: 194).

The cohesion between churches and cemeteries in the later Anglo-Saxon period may be a consequence of the increasing value of cemeteries to churches in terms of status. A law-code issued by King Edgar (960-962) identified that the amount of tithe to be paid by the thegn, on whose land the church was located, varied between churches with and without graveyards (Hadley 2001: 36). This distinction suggests that churches with burial rites and, therefore, cemeteries were of higher status than those without. Consequently, a church could instantly elevate its status by being established upon a pre-existing functioning cemetery (Hadley 2000a: 212). The relationship between churchyard cemetery and the status of the church is evidenced by the high financial investment of constructing a later Anglo-Saxon stone church upon a pre-existing cemetery, as seen at St Peter's, Barton-upon-Humber, where burials were exhumed to prevent their destruction by construction of the church in the 10th and early 11th century (Rodwell 2007: 6).

3.1.1.1 Characteristics of Churchyard Cemeteries in the Archaeological Record

It has been observed at a number of later Anglo-Saxon sites, such as Jarrow (Lowther 2005: 186) and Barton-upon-Humber (Rodwell 2007: 30-1), that there is increased density of burials next to church buildings, possibly representing a preference for interment close to religious buildings. Burials near the centre of the North Elmham Park cemetery, adjacent to the presumed location of the cathedral, were highly concentrated, inter-cutting and overlying each other. The more peripheral burials at North Elmham Park were less densely crowded, indicating that plots closer to the cathedral were more desirable than the more peripheral burial plots (Wade-Martins 1980: 188). An overall higher density of burials in the southernmost area of excavation at Swinegate, York has been suggested to locate the church of St Benet (Buckberry 2004: 219). This church was not revealed during excavation but historical evidence suggests that St Benet's was located at the corner of Swinegate and Back Swinegate, which are located to the south of the excavation area, corresponding with the increased density of burial (Pearson 1990; Buckberry 2004: 25; 2007: 125). The prestige of burial next to ecclesiastical buildings is further evidenced by the presence of high-status burials next to churches and minsters. For example, male and female burials located immediately south of the church at Wearmouth included a burial with gold thread and a grave which was exceptionally well-marked with both head- and foot-stones. It has been suggested from this evidence that this area was reserved for particularly high-status or otherwise exceptional lay burials (Cramp and Lowther 2005: 88). Further evidence of high-status burials adjacent to ecclesiastical buildings is provided by the recovery at Raunds Furnells of the 'founder's' grave (that of the man who established the church and cemetery) and a second carved grave cover in an area 2m from the church building and close to the west doorway (Boddington 1996: 11, 36-7).

Another common hypothesis for the later Anglo-Saxon period is that un-baptised infants were often buried alongside church walls in the 'eaves-drip' location to enable them to be baptised by the sanctified water that would run off from the roof (Daniell 1997: 128; Crawford 1999: 85-9). A high density of infant burials adjacent to a church building in the 'eaves-drip' position may be a consequence of large numbers of infants dying before they could be baptised, as baptism in the Anglo-Saxon period was traditionally confined to the two Christian festivals of Easter and Whitsuntide (Orme 2001: 22). High concentrations of graves containing infants and young children in the proposed 'eaves-drip' zone located next to churches have been observed at Raunds Furnells (Northamptonshire) (Boddington 1996: xii, 45), Whithorn (Galloway) (Hill 1997: 139) and Wharram Percy (North Yorkshire) (Mays 2007: 87). Consequently, a high concentration of neonate and infant burials have been interpreted at a number of archaeological sites as indicating the presence and location of otherwise archaeologically invisible church buildings, such as at Church Walk cemetery, Hartlepool (Daniels 1999: 112) and the aforementioned lost church of St Benet at Swinegate, York (Buckberry 2007: 125).

A characteristic feature of minster cemeteries is the spatial segregation of ecclesiastical burials from those of the lay community. Bede's *Historia Abbatum* (716-31) records that monks were buried to the south of the church at Wearmouth (HAB viii;

HAB xx, Plummer 1896: 285, 372; Cramp 2005: 32), suggesting a physical division between ecclesiastical and lay burial zones. A further physical segregation of the Wearmouth cemetery was provided by a north-south orientated structure (Building B) which divided the cemetery. To the east of this structure was a cluster of exclusively male and immature interments, whereas to the west was a high density of inter-cut burials of both males and females, and immatures. It is purported that the burials to the east of the building were monks and novices (*oblates*), whereas those to the west comprised the lay population (McNeil and Cramp 2005: 84, 88). At St Mark's, Lincoln a higher number of male interments were recovered from the north of the probable church, whereas female interments were more prevalent in the south (Buckberry 2007: 122-3). Spatial segregation of the sexes was also observed at Raunds Furnells. Amongst the burials closest to the church at Raunds Furnells (Zone 1) there was a concentration of males south of the church, whereas females were located in the more peripheral areas of Zone 1 (Boddington 1996: 54-5). Male burials at Wearmouth, St Mark's, Lincoln and Raunds Furnells were preferentially buried in prestigious areas adjacent to the church (Buckberry 2007: 123). In contrast, there is no discernible segregation or zoning at Jarrow where males, females and immatures were distributed across the pre-Conquest cemetery in no distinct pattern or concentrations (Lowther 2005: 184). However, the majority of burials at Jarrow contained male (64% of the sexed adults) or immature (35% of the certain Anglo-Saxon burials) interments (Lowther 2005: 176), indicating that the burials may predominantly be associated with the brethren of the monastery and their novices.

3.1.2 Non-Churchyard Burial Grounds

Churchyard burial was becoming increasing popular with, and accessible to, the general populace in the later Anglo-Saxon period, but it has been suggested that burial was not restricted to these burial grounds alone. There were cemeteries of varying size tha contained burials of adults of both sexes and immatures, indicative of a 'normal' lay population, which appear to have had no association with a church throughout the entirety of their use. Some of these cemeteries, such as at Riccall (Yorkshire), were apparently newly founded in the later Anglo-Saxon period, while others had earlier origins, such as Bevis Grave (Hampshire), which was established in association with a pre-existing barrow (Hadley and Buckberry 2005: 127). These non-church cemeteries include a series of small, short-lived cemeteries dating to between the 8th and 10th centuries, which are visible throughout England (Hadley 2007: 198-9). These cemeteries are characterised by west-east orientated earth-cut graves, some of which contain remnants of coffin wood, with no or few grave goods, save for the occasional knife. Examples of these small burial assemblages are the burial grounds excavated at Whitton and Fillingham (Lincolnshire) and burials discovered outside the limits of the churchyard at Kilham (Yorkshire) (Hadley 2001: 37; 2007: 195).

It must be noted, that a survey of excavated church sites from across England dating from the 8th to 11th century has revealed that a number of churches of the later Anglo-Saxon period, such as St Mark's, Lincoln and St Martin's church at Wharram Percy, were in fact constructed from wood (Morris 1989: 152, Table 1). Morris (1989) lists nine sites, four of which present evidence for wooden church structures. Therefore, it is a possibility that the rareness of churches predating the 10th century and the absence of churches at some later Anglo-Saxon cemetery sites is an artefact of the limited archaeological evidence for wooden buildings, which often only survive as shallow and barely discernible post-holes. Only the larger and more important ecclesiastical buildings constructed from stone would have survived (Morris 1989: 165; Craig 2009: 90). Having said this we should remember that cemeteries without an associated church building may have been built upon land owned by a contemporary mother church and operated as a 'satellite' burial ground under the control of that church. This is the proposed case for the 10th-to 11th-century cemetery of Chimney Farm (Oxfordshire). Excavation of this site revealed approximately 2,000 inhumation burials, but no evidence of a church. The land upon which this cemetery was established was the property of, and controlled by, the minster at Bampton (Oxfordshire), which was located three miles away (Hadley 2002: 222-3) and therefore, it is most probable that Chimney Farm was a 'satellite' burial ground for the Bampton minster.

There may be late Saxon cemeteries without a church, but it needs to be acknowledged that the absence of evidence for a church does not necessarily mean that a church was not present. As has been discussed there are several reasons why a church may not be visible during excavation of late Saxon cemeteries, including the difficulties of identifying wooden churches, limited scales of excavation and the possibility that not all church land was immediately adjoining a church.

3.1.3 Execution Cemeteries

Some members of society were excluded from burial within churchyard cemeteries, resulting in separate burial grounds, in particular the cemeteries reserved for the interment of those who had been executed, such as Walkington World (Yorkshire) (Buckberry and Hadley 2007; Buckberry 2008). So-called execution cemeteries originated during the late 7th or early 8th centuries and are typically found adjacent to or upon the boundaries of shires, hundreds or boroughs and close to, or visible from, major communication routes such as roads or rivers. They are also commonly associated with mound structures, such as linear earthworks and hill forts (Reynolds 2009: 155-6, 178-9). Graves within execution cemeteries were often aligned following the physical topography of the burial location (e.g. clustered around pre-existing mounds), or were totally random in their orientation and distribution, following no discernible pattern (Reynolds 2009: 156-7).

The graves in execution cemeteries are often recorded as being 'shallow' with a depth of 0.5m or less and they occasionally contain multiple interments (Reynolds 2009: 159-60). There was also great variability in the disposition of the body in execution cemeteries including prone burials, bodies lying on their side, individuals with their hands or legs tied and some showing flexion of the hands (due to traumatic death).

There is also evidence for decapitation, 'stoned, trussed, or bound corpses', and burials containing dress fittings (Reynolds 2009: 159-76). Twenty-seven execution cemeteries have been identified as dating to the 7th to 11th centuries, containing a total of 797 burials (Reynolds 2009: 96-7). The majority of these 27 sites (26/27; 96.3%) are in southern and eastern England, with only Walkington Wold (Yorkshire) present in the north of the country (Reynolds 2009: 152). The exclusion of criminals and individuals who had not been baptised from consecrated and demarcated cemeteries has been strongly associated with the increasing control and influence of the Church, which deemed the inclusion of such individuals in consecrated ground inappropriate. This essentially created an excluded class of society (Gittos 2002: 201). However, criminals and the un-baptised were not the only people excluded from interment in consecrated burial grounds. Law-codes issued by King Edmund (939-46) and legislation passed by Aethelred II (978-1016) show that those excluded from consecrated burial included ecclesiastics who had failed to observe celibacy or who had had sexual relations with a nun, murderers, adulterers, those who had committed violent burglary and those who lacked 'legal surety' (Hadley 2001: 36).

3.1.4 Re-Use of Extant Funerary Monuments

The previous discussion has centred on the desirability of burial within burial grounds associated within churchyards or cemeteries linked to churches, even if no church was present. The exclusion of socially rejected and therefore low social status, members of societies emphasises the importance of churchyard burial to regular members of the community as well as social elites. However, it must be addressed that there is evidence to suggest that some communities, particularly associated with rural settlements, chose not to be interred in churchyard cemeteries, and that some sectors of the population that were not incorporated into churchyard cemeteries were normal members of the secular populace. Therefore, the churchyard cemeteries do not necessarily represent the entire populace. This section shows also that prior to, and at the beginning of, the later Anglo-Saxon period burial was used to assert territorial rights and socio-economic status related to land ownership and that Christianity was not the only influence upon burial practices at that time.

A large number of burial sites in England that reuse pre-existing monuments have been dated to the 7th century; nevertheless, there are some later examples (Lucy 1999: 20; Petts 2002: 44). For example, at Kemp Howe (Yorkshire) radiocarbon dates from sparsely furnished graves, which cut a Bronze-Age barrow ditch, have dated these burials to the mid-8th century (Lucy 1998: 128; Buckberry 2004: 419). Later burials associated with a Barrow, dating to the 8th and 9th century, have been observed at Bevis Grave (Hampshire) and a further example at Winwick (Cheshire) has been dated to the mid to later Anglo-Saxon period (Buckberry and Hadley 2005: 127), but these appear to be rare exceptions. These barrow cemeteries were most probably used mainly in the 7th century as a form of monumental display linking the elite members of a community to that specific location. This physical association may have been used to reinforce ancestral links and beliefs of ancestral rites and ownership (Williams 2002: 186). It is also probable that these barrow cemeteries were associated with rural settlement and that awareness of land ownership and territorial organisation were highly important to the people living within rural settlements. This hypothesis is supported by the observation that a number of these barrow burials are located on parish boundaries, away from settlement sites (Daniell and Thompson 1999: 68; Stoodley 2007). The construction of barrows and barrow cemeteries on parish boundaries implies that barrow burials may have served to demarcate competing territories up to, and possibly including, the later Anglo-Saxon period, although the later evidence is tenuous. Consequently, it has been argued by Boddington (1990: 196) and (Stoodley 2007: 160) that the evolution of the surrounding landscape was as equal, or even greater, an influence on barrow burials as religion.

3.2 Later Anglo-Saxon Burial Practices

This section considers the characteristics of later Anglo-Saxon burial practices and the influences upon them. A central theme in this discussion is the extent to which the emergence of Christianity was influential on differences seen in burial practices from the early and later Anglo-Saxon periods. Alternative instigators for the shift from plain graves containing elaborate grave goods to more elaborately constructed graves lacking grave goods are considered, such as changing concepts of social status based on age, sex and familial status, as well as changing attitudes and beliefs regarding death and the deceased.

Archaeological evidence, predominantly from the south of England, shows that burials of the early Anglo-Saxon period were either cremation or inhumation, often accompanied by elaborate grave goods. In contrast, from the first quarter of the 8th century, the deceased were almost exclusively interred supine-extended in earth-cut graves typically orientated west-east in clearly defined well organised rows. These graves contained no, or very few, grave goods. The reduction in the inclusion of grave goods was accompanied by an additional transformation in the form and construction of graves in the 8th and 9th centuries. The majority of graves remained as simple unfurnished earth-cut graves; however, the nature of the grave itself became more complex. There was an increased variability with burial of the body in wooden coffins and chests, stone cists and sarcophagi, the inclusion of pillow stones and other stones located around the body, the use of grave markers and the introduction of organic material such as charcoal within the grave (Thompson 2002: 229; Buckberry 2007: 118-19).

Discussions on the development of burial practices throughout the Anglo-Saxon period tend to focus on southern England. However, the situation in Northern England differed to some extent, with documentary and archaeological evidence showing a near absence of cremation burials in the 5th and 6th century north of the Humber estuary

(Bede HE I, 22; Craig 2009: 50-1). Furthermore, elaborate stone cist burials have been recovered from 5th-century cemeteries at Cornforth, Copt Hill and Houghton-le-Spring (Cramp 2005: 27) and at the early-medieval monastery at Portmahomack (Carver 2004) and Hallow Hill, St Andrews (Fife) (Proudfoot 1996) in eastern Scotland (Groves 2010: 119). These stone cists contained supine-extended interments but lacked the elaborate grave goods that characterised the pre-Christian cemeteries in the south of England. The 'Christian' characteristics of these stone 'long cist' burials, and lack of early Anglo-Saxon cremation burials, have been suggested to indicate an uninterrupted growth of Christianity in the north of England from the Roman period (Morris 1983: 28-33; Blair 2005: 16-17; Craig 2009: 50-5).

The plain nature of burials and lack of cremation burials in Northern England may indicate an earlier influence of Christianity than in the rest of the country. However, it must be acknowledged that Christianity was not the sole influencing factor upon the changes in burial practices observed in later Anglo-Saxon England. The following section will discuss additional evidence in support of the influence of Christianity on later Anglo-Saxon burial practices, and then address the other possible factors, which determined mortuary behaviour at that time.

3.2.1 Evidence for the Influence of Christianity upon Later Anglo-Saxon Burial Practices

There was a noticeable shift towards plain, unadorned burials with an absence of grave goods corresponding with the conversion to Christianity by the 5th century in northern England and the 7th century in southern England (Reynolds 1999: 23; Williams 2006: 44). The majority of interments of the later Anglo-Saxon period were, as in the Black Gate cemetery, orientated west-east. Such body disposition is in accordance with the Christian principle of corporeal resurrection. The idea of resurrection of the body on the Day of Judgement is fundamental to Christian beliefs, with the act of burial being a symbolic re-enactment of Jesus' death. Accordingly, the individuals in most Christian burials are interred supine with their heads to the west so that they can sit up, then stand, to face God in the east at the time of their resurrection on the Day of Judgement (Davies 1997: 113; Parker Pearson 1999: 8). However, it must be acknowledged that west-east orientated graves were common in the early Anglo-Saxon period prior to 'conversion'. West-east orientated graves with no grave goods are present in the archaeological record from the mid-7th century (Geake 1992: 86; Hoggett 2007: 29) alongside numerous west-east orientated graves including grave goods, suggesting that such alignment is not necessarily synonymous with Christianity.

The cessation of cremation burials in favour of inhumation in the middle Anglo-Saxon period is often interpreted as representing Christian influences upon burial (Lucy 1997: 5; Hoggett 2007: 31), a view supported by a similar termination occurring among Christian populations of the late Roman period (Hoggett 2007: 31). The process of cremation opposes the Christian ideal of resurrection because it destroys the physical body, preventing corporeal resurrection on the Day of Judgement. Williams argues that pagan beliefs centred on a process of transformation, whereby destruction of the physical body facilitated the transformation of the deceased into a new ancestral form, which was contradictory to the Christian ideal of resurrection (Williams 2002: 67). Therefore, it is feasible that the cessation of cremation burial was related to the adoption of Christianity.

The relationship between the Church, Christianity and the disappearance of grave goods has been elaborated by the widely held belief that the decline in grave goods seen in the 8th century was a consequence of ecclesiastical prohibition. However, the establishment of graves with no, or few, artefacts in the first half of the 8th century commences over a century after the main period of conversion of England to Christianity in the 7th century. Furthermore, conversion is preceded by unfurnished burials in the north of England from the 5th to 7th centuries (Reynolds 1999: 23). This discrepancy does not necessarily discount Christian influence, as it may indicate a gradual transition and phasing out of grave goods. The continued occasional inclusion of grave goods in 7th-century interments may represent the adaptation and incorporation of traditional practices into Christian doctrine, easing the transition to Christianity by not excluding familiar practices from which people sought comfort (Carver 2003: 4). Alternatively, the inclusion of grave goods may not have actually been in conflict with Christian doctrine. If grave goods were personal items or indicators of social identity, rather than symbols of religious affiliation, their use was not in conflict with early Christian doctrine (Buckberry 2004: 10), evidence of which is provided by burials on the continent. For example, Daniell and Thompson (1999: 76) draw attention to the Christian Franks who were buried with as much wealth and elaboration as is observed in early Anglo-Saxon graves in England. Furthermore, many 7th-century proposed pagan burials contain artefacts with Christian symbolism, such as the gold foil crosses excavated from the richly furnished burial chamber at Prittlewell (Essex) (Geake 1999; Blair 2005: 230-3; Hadley 2011: 299). The juxtaposition of elaborate grave goods and Christian iconography is further evidenced by an elaborate Anglo-Saxon necklace recovered from a grave at Desborough (Northamptonshire) dating to the 'Christian period' of the 7th century. This necklace was made from gold and garnet cabochon pendants and gold beads and had a gold and garnet cross in its centre (Owen-Crocker 1986: 94-5; Geake 2002: 149). The juxtaposition of elaborate and expensive materials with the Christian symbol of the cross indicates that the two were not necessarily regarded as being in conflict in Christian doctrine, undermining the argument that the reduction in grave goods was prohibited by the Church.

The interment of the deceased in graves containing stones enclosing the head and the body, rubble cists and graves containing preservative charcoal deposits in the 9th and 10th centuries indicates a desire to protect the body to facilitate its resurrection. Daniell (1997: 180) identifies that that the later transition from these protective burial practices to plain burials in the 12th century correspond with a shift in the focus of Christianity from resurrection and the Day of Judgement to a greater emphasis on the concept of Purgatory, whereby the fate of the soul was more important than that of the body. These correlations between burial practices and changes in religious ideology appear to indicate an influence of Christianity on decisions made for burying the deceased.

A predominant argument against the Church being mainly responsible for the decline in grave goods and changes in burial practices observed in the middle Anglo-Saxon period is that the Church did not introduce any specific legislation regarding the 'form' of the burials of the laity for several centuries after 'conversion'. The earliest record of any such legislation concerns the evidence for soul-scot – a burial tax collected by the minster church, which is first documented in the 9th century (but not codified until the early 11th century). It is not until the 10th century that there was legislation to protect mortuary payments and to restrict access to burial in consecrated ground (Reynolds 1999: 103-4; Hadley 2001: 35-6; Hadley and Buckberry 2005: 122). Furthermore, there is no mention in the contemporary written record of the Church imposing restrictions on burial form. Indeed, the sheer diversity of burial rites implies significant secular influence (Hadley 2001; 2004; 2010: 467-75). However, the majority of surviving historical documents were written by, for and about the ecclesiastical and secular elites, excluding a large proportion of the population who were experiencing religious changes (Hoggett 2007: 29). The absence of discussions regarding burial within the historical documents may also indicate that pagan burial practices were deemed insufficient a threat to the influence of the Church to warrant their eradication (Morris 1983; Hoggett 2007). However, the exclusion of an activity or topic from the historical texts does not necessarily equate with an actual absence of discussion and debate (Hoggett 2007: 29).

Even if the Church did not explicitly forbid the deposition of grave goods, the demise of grave goods from the 8th century may, nonetheless, be closely associated with the development of churchyard burial (Hadley 2001: 17). It seems feasible that the decline in grave goods may represent a shift towards investment into the church and securing a churchyard burial to signify an elevated status of the deceased rather than placing items of wealth or indicative of social status within the grave (Crawford 2004: 95). An increased clerical influence upon mortuary practices and the increased status associated with burial adjacent to churches in the later Anglo-Saxon period may have been the impetus for increasing burial within cemeteries associated with churches. The increased status associated with burial within Christian sites and the desire of lower status members of society to emulate the behaviours of the elite and project their own ideals of their own status and prestige may have been an additional impetus for Christian interment (Blair 2005: 241). In such contexts, investment may have been placed in securing churchyard burial rather than in depositing movable wealth in the grave.

In summary, it is probable that Christian doctrine did impart some influence upon burial provisioning in the later Anglo-Saxon period, but maybe not to the extent suggested by the Final Phase model. It seems likely that other factors were also responsible, examples of which will now be considered.

3.2.2 Alternative Factors other than Christianity for the form of Later Anglo-Saxon Burial Practices

It is unlikely that Christianity was the sole factor responsible for the decline and disappearance of grave goods within Anglo-Saxon burial. It is more probable that several factors were involved, including political, social and economic influences (Boddington 1990: 190; Geake 1997: 135-6; Hadley 2000b: 153; Hadley 2009: 467). Boddington suggests that the decline in conspicuous display of grave goods within burials may also have been a consequence of an active conservation of resources, the circulation of moveable wealth and changes in hereditary law or changes in burial costume (Boddington 1990: 188-90; Williams 2006: 44). The uniformity and decline in regional variation in grave goods has also been attributed to continental influences. Geake (1997; 1999) demonstrates that identical costume fixtures were found across all the Anglo-Saxon kingdoms in the 7th and early 8th centuries, arguing that many of them derived their inspiration either from earlier Romano-British material or from contemporary Byzantine practices. The social elites would have had privileged access to foreign books and travel and, consequently, may have adopted the plain unadorned burials emerging on the continent as a medium to display their cultured and well-travelled lifestyle to others. Alternatively, the onset of taxation has been blamed for the decline and cessation of grave-goods within burials from the 7th century, resulting from the diversion of wealth from the grave into death duties (Carver 1989: 157; Daniell and Thompson 1999: 76; Hadley 2009).

A further explanation for the decline in grave goods in the later Anglo-Saxon period is that this period was characterised by increasingly stratified social hierarchies. A direct consequence of this is that identifying an individual's gender became less important than signifying elite social status. Therefore, what were previously common strongly male-associated grave goods, such as weapons, became symbols of high socio-economic status, which resulted in a reduction of their number (Stoodley 1999a: 103-6; Hadley 2004: 303-5; 2011: 294).

The reduction, and finally loss, of grave goods cannot be explained solely as a response to conversion to Christianity. Not only does Christian doctrine not specifically oppose the inclusion of grave goods, but there are also several other factors which could be equally responsible for the decline. Therefore, it is erroneous to directly equate a lack of grave goods with Christianity, an error that has constrained research into Anglo-Saxon burial practices in the past. Some of the theology associated with Christianity did affect the treatment accorded to an individual after death in the later Anglo-Saxon period, but attitudes towards the dead were also undergoing a stage of transition based on changing social constructs of the living, which will now be discussed.

The later Anglo-Saxon period sees a decline in the importance of age and gender in the choice of burial practices. Sex diagnostic artefacts often accompanied skeletal remains in the early Anglo-Saxon period. Weapons (spears, shields and occasionally swords) and tools (seaxes and axes) were typically interred with adult males. Spears were found in graves containing adolescents aged between eleven and sixteen years at Berinsfield (Oxfordshire) (Boyle *et al.* 1996: Crawford 1999: 158) possibly demonstrating a similar status recognised between adult and adolescent males in the early Anglo-Saxon period. Dress accessories and jewellery (brooches and necklaces) and domestic symbols (keys, girdle hangers, amulets and spindle whorls) were predominantly interred with females (Stoodley 1999a: 99, 101; Taylor 2001: 148). Grave goods specific to females, such as girdle hangers and chatelains were typically only interred with females aged 12-14 years and older (Crawford 1999: 47). Women of childbearing and childrearing age ('the third stage of their lifecycle') were accorded higher status burial in the early Anglo-Saxon period, in the sense that they were buried with a greater number of grave goods than mature and older women who had passed the viable age of childbearing (Stoodley 2000: 466). Cemeteries also included graves containing no grave goods or 'gender neutral' artefacts such as knives and belt buckles which were interred with both sexes (Lucy 1997; Stoodley 1999a: 101). These 'gender neutral' and unfurnished graves were predominantly associated with immatures, under the age of fifteen and older adults aged forty years and older (Lucy 1997), thus indicating that age, as well as gender, were influential upon the grave-goods assemblages in the early Anglo-Saxon period. The limited grave goods that were included in later Anglo-Saxon burials were predominantly jewellery and dress accessories, coins, combs, and small knives, with occasional miscellaneous inclusions such as tweezers (Hadley and Buckberry 2005: 137; Hadley 2009). Detailed summaries of the limited grave goods found at later Anglo-Saxon burial sites are provided in Hadley (2009: Figures 23.1- 23.4).

The decline in gender-specific grave goods in the middle Anglo-Saxon period appears to coincide with a general decrease in the importance of age and gender in the burial ritual (Stoodley 1999a; Hadley 2004). There are, however, exceptions. For example, the interment of males of high social standing, such as kings and members of religious communities such as bishops, were often buried within churches and churchyards by the 10th century, before churchyard burial became more accessible to the masses (Hadley 2002: 210; 2004). Examples of the preferential burial of these wealthy and influential males in churchyards before the 10th century in northern England are found at York, Ripon, Wearmouth and Lindisfarne (Hadley 2002: 210). Also, within some lay communities there was a propensity to look to men to make claims to land, power and family status, using burial location and the provision of elaborate above-ground markers, examples of which are present at Chester le Street (Durham), York, Ripon and Kirby Hill (Yorkshire) (Hadley 2004: 315-19). In some instances, males were accorded burial in elaborate coffins, signifying their high status in the community (Hadley 2011: 294).

In the early Anglo-Saxon period, the provision of status goods excluded the very old and young or those without social, economic or political influences. In contrast, later Anglo-Saxon burial practices indicate that no demographic group were excluded from high status burial. Firstly, the use of more elaborate coffins and grave markers is found in all age categories, including the young and elderly (Ayers 1985: 18-19; Bruce-Mitford 1997; Samuels 1998; Buckberry 2007). Secondly, greater care appears to have been accorded to infant burials (Crawford 1999: 87-9; Hadley 2004: 309), as is evidenced by 'eaves-drip' burials of infants and the use of stone sarcophagi and cists in immature burials at Raunds Furnells (Boddington 1996: 40, 45). Furthermore, excavations of later Anglo-Saxon cemeteries have revealed higher numbers of infants and young children, aged up to 5 years, than cemeteries dating to the early Anglo-Saxon period (Hadley 2010: 109). Hadley (2010: 109) draws attention to the fact that infant and young child burials of the later Anglo-Saxon period are often found in distinctive locations, such as the aforementioned 'eaves drip' burials at Raunds Furnells and within churches. An example of the latter is present at Burnham (Lincolnshire), where the infant burials are the sole interments within the church building (Coppack 1986: 39). The decline in age- and gender-related influences on the provisioning of grave goods and burial practice seems to correspond with an increase in the provision of burial practices based upon family status from the 8th century. It is suggested by Hadley (2001; 2004) that there were major social transformations in the late Anglo-Saxon period, whereby family status and social hierarchies became important influences upon burial practices. There was a diminished emphasis on age and gender-distinctive grave assemblages, previously restricted to prime-age adults who conveyed a greater social and economic influence by being of childbearing and marriageable age and physically capable, and of an age, to work. Instead, there was an increased emphasis on uniformity in burial practices denoting social status for all family members, regardless of age or sex (Hadley 2004: 311-13). The increased influence of family status is further indicated by the clustering of distinctive grave types of individuals of every age category within cemeteries, as is seen at York Minster (Phillips 1995: 76-7). Four domestic chests, dating to the 9th century, were recovered during excavations at York Minster. These chest burials – containing the remains of an adolescent, a young adult male, a middle-aged female and an elderly male – were found in a close group, inter-cutting each other. The interment of these chest burials appear to have occurred over several decades. The burial of these four individuals in such a specific fashion and in such a concentrated locality over a prolonged period has been interpreted as suggesting that these burials are inter-connected in some way, possibly a family group (Kjølbye-Biddle 1995: 488-9; Phillips 1995: 83-4; Hadley 2004: 311-12).

The social elite sought to mark the graves of their kin in increasingly elaborate and distinctive ways in the later Anglo-Saxon period. This resulted in a greater diversity of burial practices in high-status cemeteries such as York Minster relative to lower status cemeteries (Buckberry 2007: 11, 125). A further strategy employed by the aristocratic laity to display their wealth and social status was to bury their kin in the same burial grounds and churches as bishops and kings, such as at Whitby. However, there is no direct evidence that this is common practice before the 10^{th} century (Hadley 2000a: 214-15; 2002: 210; 2004: 306).

Buckberry (2004), in her study of later Anglo-Saxon cemeteries of Yorkshire and Lincolnshire, suggests that mourners were more likely to bury older individuals in a more elaborate grave. A conclusion reached from this observation is that those who were accorded more elaborate graves belonged to elite social groups predisposed to an increased longevity of life through preferential access to resources and better living conditions (Buckberry 2007: 123-4). The distribution of elaborate graves throughout all age categories, but predominance amongst senior adults (aged 45 years and older) suggests that elaborate burial was 'more appropriate' for, but not the sole reserve of, elderly members of later Anglo-Saxon society (Buckberry 2007: 125).

Differences in the burial practices of the later Anglo-Saxon relative to the early Anglo-Saxon traditions can also be attributed to changes in attitudes towards death and the physical remains of the deceased, as is mentioned previously. Williams (2006: 144), and Daniell and Thompson (Daniell and Thompson 1999; Thompson 2002) hypothesise that cist burials were intended to either constrain or imprison or, alternatively, protect the corpse or soul. The use of preservative materials such as charcoal was implemented to prevent corruption of the body to guarantee salvation of the deceased. The practice of preserving the body after death is consistent with the concept of corporeal resurrection, which was an increasingly popular belief in the later Anglo-Saxon period. Evidence for the popularity of such ideology is provided by the

10th–century imagery in Aelfric's *Homilies* where the emphasis is on the transformation of the mortal remains of an individual on the Day of Judgement (Thompson 2002: 237; Cherryson 2007: 139).

During the later Anglo-Saxon period, people were becoming increasingly familiar with the physicality of death. The subsequent reduction in the fear of the dead may have been influential in the changes in burial practice observed throughout this period. The later Anglo-Saxon period sees an increase in the disturbance and displacement of the dead, with a number of later Anglo-Saxon cemeteries exhibiting high frequencies of inter-cutting burials and disturbance of primary interments. For example, at Barton-upon-Humber at least 25 graves were exhumed to prevent their destruction by the primary foundations of the church (Rodwell and Rodwell 1982: 294). At least nine graves in the western part of the Addingham cemetery were empty, whereas burials further to the east contained more than one adult individual (Adams 1996: 161-7; 181-4), indicating preferential burial near to a specific, as yet unidentified, focal point which was not attainable until a period of delay after their initial interment (Hadley 2011: 302-3).

Typically, the inter-cutting of graves is attributed to pragmatic factors such as confinement of the burial area and longevity of use of the cemetery area (Boddington 1990: 197; Cramp and Lowther 2005: 78). Consequently, Cherryson (2007: 138) observes that inter-cutting should have been more common in urban cemeteries where the higher density of the contributing population would be more likely to exceed the available space within consecrated burial grounds. However, as is seen at St Peter's, Barton-upon-Humber this was not necessarily the case. Truncation of earlier graves may indicate that their position was never originally demarcated or that the original marker had been lost over time, along with the knowledge of the precise location of the grave or graves (Drinkall and Foreman 1998: 337; Craig 2009). However, an alternative hypothesis for the increased inter-cutting of graves in the 9th and 10th centuries is that the disturbance of the corpse had become a less disturbing concept. This reduced fear may have resulted from the increased proximity of burial grounds and settlements due to the increasing trend for churchyard burials, which would decrease peoples' apprehension associated with the dead (Thompson 2004: 86). The evidence for increased density and inter-cutting of burials in supposedly prestigious areas such as next to the church (Wade-Martins 1980:188; Cramp and Lowther 2005: 88) or *Ad sanctos* ('next to the saints') in the most holy places within churchyards (Effros 2010: 59), suggests the desire for such high-status interment prevailed over the disgust and fear of disturbing the dead. Alternatively, the 'prospective memories of salvation' superseded the 'retrospective memories' of earlier graves (Williams 2006: 114).

3.3 Summary

Overall, there are a wide range of theories and hypotheses that have been applied to Anglo-Saxon cemeteries to try to explain the changes that occur in burial practices throughout this period. It has been established that the introduction of Christianity did have an impact upon later Anglo-Saxon burial practices, as did alternative factors such as family relationships, redistributions of wealth and an increasingly stratified society. It is hoped that a detailed study of the location and nature of the Black Gate mortuary practices relative to the health, age and sex of the deceased will provide new information on late Anglo-Saxon burial practices and enhance the current understanding of the impact of socio-economic factors on the manner people treated their dead.

3.4 Later Anglo-Saxon Settlement and Urbanisation

To enable a reliable interpretation of the type of settlement the Black Gate cemetery may have served, it is important to understand the types of settlement that existed during its period of use. This section considers the size of the population that inhabited

England in the later Anglo-Saxon period, the degree of urbanisation and the specific settlement types characterising this period.

3.4.1 Population Increase throughout the Anglo-Saxon Period

McEvedy and Jones (1978: 41) estimated the population of England as being approximately 600,000 people in the 7th century, increasing to 1.5 million in 1000 then 1.75 million by the time of the Norman Conquest; however, it is unclear from where these figures derived. Roberts and Cox (2003: 163) cite the figure of 600,000 for the 7th century population of England but no other more recent estimate for population size at that time was identified during the literature search for the current study. A number of authors have argued that the withdrawal of the Romans from England in 410 resulted in the abandonment of the majority of Roman towns and an overall decline in the number of urban settlements in the 5th to 7th centuries (Vince 1994: 109; Loseby 2000: 330-1). The low population figure cited for the 7th century has been ascribed to low fertility and high mortality rates associated with the social disruption and recurrent epidemics resulting from the withdrawal of the Romans and the collapse of the Roman economy (Dyer 2002: 26). However, by the time of the Domesday survey in 1086 the population had recovered from the aftermath of the Roman withdrawal and increased to between 1,500,000 and 2,000,000 people (McEvedy and Jones 1978: 41; Reynolds 1999: 57; Roberts and Cox 2003: 263). In the rare cases where actual numbers of inhabitants are documented in the historical texts the numbers provided are often questionable, and in some cases highly improbable. The anonymous author of the *Life of St Oswald*, writing at the end of the 10th century, describes York as a 'metropolis of the whole Northumbrian people' with a population of over 30,000 adults. Children and adolescents (*parvulis et. pubertini*), were excluded from his calculations (James 1995: 11). However, the Domesday survey implies that there were a maximum of approximately 2,000 houses in York in 1086, which would have been insufficient to house the 30,000 adults claimed within the *Life of St Oswald* (James 1995: 12). It must be noted when reviewing such evidence that the Domesday survey contains a number of inaccuracies and discrepancies. Not only does it exclude the far north of England it only records the heads of households. It also omits significant elements of the population at the time, such as the garrisons of the new castles, the clergy of abbeys and cathedrals and their servants (Darby 2003: 32). The number of properties and people within large towns such as London and Winchester (Hampshire) and small towns such as Coventry (Worcestershire) and Tonbridge (Kent) were barely represented and they were not accorded the detailed systematic survey applied to the rural manors (Dyer 2002: 94; Griffiths 2003: 97). In some instances, hundreds of households were omitted. For example, the Domesday survey lists fewer than 150 households and burgage properties in Gloucester whereas a survey conducted between 1096 and 1101, only ten to fifteen years later, indicates the presence of over 600 properties (Dyer 2002: 94). Nevertheless, although the actual number of inhabitants and true number of rural and urban settlements cannot be known for certain, there is a definite increase in the population and intensification of economic activity in England from the 9th century onwards (Griffiths 2003: 98). The presence of established urban sites by the late 11th century is evidenced by the 112 places mentioned in the Domesday survey that were identified as towns based on their large population size and the use of the descriptive terms *civitas* or *burgus* (Griffiths 2003: 98). Of these 112 places, 17 contained at least 2,000 people while York, London and Winchester each had populations exceeding 10,000 inhabitants (Dyer 2002: 62).

3.4.2 Concepts of Urbanisation and Settlement in the Later Anglo-Saxon Period

> *In 1066, apart from the possibility of Durham, there were no towns north of the Tees but within two centuries the region had been transformed by the development of village markets, small towns and the rise of Newcastle* (Kermode 2000: 659).

What defines an urban settlement in the Anglo-Saxon period has long been a contentious issue amongst scholars. To assist in the identification of towns within the archaeological record, Martin Biddle (1976: 100) proposed a twelve-point list of criteria, which included the presence of defences; a planned street system; one or more markets; a mint; legal autonomy; a role as a central place; a relatively large and dense population; a diversified economic base; plots and houses of 'urban' type; social differentiation; complex religious organization; and a judicial centre. However, there is much debate, not least by Biddle himself (Biddle 1976: 100), as to how many of these characteristics must be identified before a place can be confidently classified as a town. Scull (1997: 271-2) has argued that 'uncritical' application of 'institutional and morphological' criteria, such as those proposed by Biddle, would categorise non-urban settlements, such as ecclesiastical centres, in the 7th and 8th centuries as towns. An alternative approach to defining urban settlements and towns in the past, pioneered by Susan Reynolds (1977) and consolidated by Ambrosiani (1988: 63), is to focus on the more social, cultural and economic attributes. Both scholars defined towns as densely populated, permanently occupied, non-agricultural settlements. These towns would have specialised non-agrarian economies, which were sustained by agricultural produce from an external supplier (Reynolds 1977; Ambrosiani 1988: 63; Clarke and Ambrosiani 1991: 3; Scull 1997: 272).

Recent historical and archaeological research has identified a range of small-scale towns which held no specific legal or constitutional status but provide evidence for a wide range of occupational activities which would have made them important contributors to the production and trade of craft merchandise, suggesting they would have been an integral part of England's urban framework (Astill 2009: 256). England underwent a series of economic and social changes in the 7th to 9th centuries, which provided the foundations upon which an urban revival occurred in the 8th to 10th centuries. This urban revival is increasingly visible in the archaeological record from the late 9th century onwards via settlements with organised street-layouts of domestic and administrative buildings and evidence for non-agrarian specialist craft production such as metalworking and glass manufacture (Biddle 1976: 141; Loseby 2000: 321; Blair 2005: 263). Such evidence has been found at the urban settlements at Southampton, Ipswich, London and York (Scull 1997: 277-80). The intensification of urbanisation from the 9th century is also visible in the north of England in the increased economic activity suggested by the greater output of the Danelaw mints, particularly Chester (Astill 2009: 265). Coins from these mints have been found in hoards throughout England, such as that from the Stamford hoard (Lincolnshire), which dates to approximately 900 (Astill 1991: 110).

The consensus is that the main transition to town living occurred from the later 9th century. However, estimates based upon information within the Domesday survey indicate that only between 7 and 10% of the population of England inhabited towns by the time of the Norman Conquest (Dyer 1985: 92; Hinton 1990: 115; Scull 1997: 272-3). By calculating the total number of burgesses, houses and men recorded in the 112 boroughs listed in the Domesday survey a figure of 20,000 people is attained. This is approximately 7% of the total recorded population (Dyer 1985: 92). There are obvious inaccuracies in this calculation caused by problems with consistency of terminology used throughout the Domesday survey and the inclusion of slaves as heads of households (the same as villeins and burgesses) whereas slaves are in fact individuals, not heads of households, overestimating the rural population figures (Dyer 1985: 92). Overall, the number of people living in towns from the 9th century did increase, but this transition was nominal when considered in terms of real population numbers. If the estimation that less than 10% of the population inhabited towns by the Norman Conquest is correct it could be suggested that there were very few towns and those that existed contained a reasonably dense population of inhabitants.

3.4.3 Types of Settlement Characterising Later Anglo-Saxon England

The terms 'urban' and 'rural' are increasingly applicable to the later Anglo-Saxon period; however, they are not as distinguishable from each other as they are for the more heavily populated late- and post-medieval periods. The following section summarises the types of settlement known to have existed in Anglo-Saxon England.

3.4.3.1 Proto-Urban Settlements

'Proto-urban' is a term used by a number of authors (e.g. Scull 1997; Ayers 2000; Lilley 2002; Barrett *et al.* 2004; Draper 2008; Ayers 2011) to describe new forms of settlement which were arising in Britain from around the 7th century and continued to emerge throughout the later Anglo-Saxon period. These proto-urban settlements exhibited characteristics of later towns, such as sustaining a resident non-agrarian population. However, these settlements lacked the level of complexity or were of insufficient size to be accurately described as a town. A number of proto-urban towns have been identified solely on their subsequent development into 'fully-fledged' towns (Scull 1997: 272). However, such retrospective identification is flawed because the development of proto-urban settlements into towns was not inevitable (Scull 1997: 272). Examples of proposed proto-urban settlements, which have been identified retrospectively, are Brandon and Burnham in Norfolk (Ayers 2000: 62) and later examples, such as the 12th-century market site of Witham (Essex) and the small 11th–

century settlement of scattered buildings, which preceded the larger urban settlement of Hartlepool in 1250 (Dyer 2003: 89, 110).

3.4.3.2 Wics and Emporia

In the 7th and 8th centuries, larger settlements, commonly classified as *wics* or *emporia*, arose on the coasts of north-west Europe. One of the main functions of these settlements was to import luxury goods such as fine wine, foods and pottery to distribute to wealthy secular and ecclesiastical elites in the local region (Griffiths 2003: 83). Examples include *Eoforwic*, *Hamwic* and *Lundenwic*. These sites were densely populated and had specialised functions, such as craft production, and regular street layouts indicative of urban settlement. The sedentary population of *Hamwic* in 800 has been estimated at between 2,000 and 3,000 people based on the number of graves recovered from several cemeteries associated with it (Hinton 2000: 220-1; Griffiths 2003: 83). *Hamwic* and *Eoforwic* have provided evidence for several non-agrarian production activities including the working of iron, copper-alloy, bone, antler, leather and glass alongside weaving, potting and butchery (Kemp 2001: 93; Morton 2001: 91). In contrast to rural settlements of this period, there is little evidence for agricultural production within these settlements (Scull 1997: 274; Dark 2000: 130). Therefore, *wics* essentially fulfilled the definition of a town as a *densely populated, permanently occupied, non-agricultural settlement with a specialised non-agrarian economy sustained by agricultural produce from an external supplier* (Reynolds 1977; Ambrosiani 1988: 63; Clarke and Ambrosiani 1991: 3; Scull 1997: 272).

Wics were a short-lived phenomenon. By 800 most had declined as centres of overseas trade, with only Ipswich surviving past the 9th century (Scull 1997: 274; Griffiths 2003: 83).The decline of the *wics* is generally believed to be a direct consequence of the detrimental impact of Viking raids on North Sea trade (Griffiths 2003: 83). An example of the damaging impact of such attacks is the rapid decline of *Hamwic* after the Viking raid in 840 (Ottaway 1992: 127).

3.4.3.3 Continuity of Roman Walled Towns

It has been suggested that some Roman towns, such as Canterbury (Kent) continued to function with no interruption between Roman and Anglo-Saxon occupation (Clarke and Ambrosiani 1991: 10-15; Draper 2008: 245). There is, however, no archaeological evidence for continuous occupation at any of these Roman walled towns. The presence of over forty sunken-feature buildings at Canterbury, dating from the 5th to 7th century and indicators of artisan activity, such as the recovery of a 5th-century fire-steel (Brooks 1988: 103), indicate some form of activity within Canterbury throughout this period. However, this does not confirm continuous inhabitation from the withdrawal of the Romans, as there is an evident hiatus in activity at Canterbury indicated by the lack of cultivation of the 'dark soil' overlying abandoned Roman structures. Nonetheless, the shortest period between the abandonment of the last Romano-British building radiocarbon dated to approximately 425 to 430 and the construction of the earliest Anglo-Saxon *grubenhäuser* in approximately 450 suggests that the hiatus may only have been for about 20 to 25 years and possibly even less, i.e. one generation (Brooks 1988: 107; Loseby 2000: 340).

The absence of evidence for 'cultural interaction' between the Romans and Anglo-Saxons, such as the exchange of market goods – e.g. pottery, coins, tools etc.—further undermines an argument for continuity (Brooks 1988: 108). It is most probable that if these Roman urban centres continued into the 5th century it was on a much reduced scale, serving a predominantly administrative or religious function and coinciding with a decline in the levels of occupation, which would have made these settlements indistinguishable from their rural counterparts (Vince 1994: 109; Reynolds 1999: 38). The majority of Roman walled towns re-emerged as major later Anglo-Saxon towns in the 6th and 7th century, with no evidence for continuity through the 5th century. The later ecclesiastical centres that were established within the walls of former Roman towns from the end of the 6th century sustained resident non-agrarian populations, but were of insufficient size and economic, social and jurisdictional complexity to be considered urban. Therefore, they have been identified as 'proto-urban' and as the focal point for the emergence of urbanism in the later Anglo-Saxon period (Scull 1997: 272; Lilley 2002: 7).

3.4.3.4 Monastic Sites

A network of minster churches, often originally monastic communities, emerged during the 7th and 8th centuries varying from large-scale urban minsters, such as York Minster to small churches located within aristocratic estates, such as at Addingham (Yorkshire) (Adams 1996; Richards 2000: 135, 137). Each of these religious communities, or minsters, housed a number of priests who ministered to its members (Bassett 2006: 119). It is probable that the bishops, priests and deacons based in monasteries were actively engaged in pastoral work within the surrounding population rather than simply serving the monks, nuns and other clergy of the monastic community itself (Pryce 2003: 147). These monastic sites began to flourish in the 7th century then gradually declined in both size and wealth towards the 10th century (Blair 2005: 247). The 8th century has indeed been called 'the Age of the Minsters' in acknowledgement of the emergence and prosperity of minsters and the associated *wics* during this period (Hindley 2006: 178).

The larger monasteries of the 7th and 8th centuries, such as Wearmouth and Jarrow, may have served and accommodated the largest concentrations of people in the Anglo-Saxon landscape. For example, Bede states in the *Historia Abbatum* (716-731) that 600 brethren remained at the twin monasteries of Wearmouth and Jarrow when Abbot Ceolfrid departed in 716, and a further 80 left with him (*HA, 18*: Plummer 1896: 382). Documentary sources from the later Anglo-Saxon period suggest that monastic sites were regarded as towns at the time and this is not just a retrospective categorisation by scholars. Blair discusses the synonymous use of the terms minster and town within a text dating to 798, which reads that "King Offa had transferred 'Cookham minster and many other towns' from Wessex to Mercia" (Blair 2005: 250).

Monastic sites were often established and controlled by secular elites, such as royal households and major landowners. Consequently, the monasteries and minsters accumulated a large amount of material wealth, which made them a desirable target for Viking raiders in the 9th century. This situation was worsened by the coastal location of monasteries such as Tynemouth, Hartlepool, Whitby, Lindisfarne, Wearmouth and Jarrow, which made them vulnerable to attacks from the sea and consequently led to their apparent abandonment in the 9th century (Richards 2000: 137).

Monastic communities served as 'mother-churches' for territories which corresponded to secular administrative units, such as are reflected in the boundaries of 10th-century hundreds, and they often became boroughs from the late 12th century (Pryce 2003: 147; Astill 2009: 262). These minster settlements were responsible for the pastoral care of the surrounding locality, providing baptism and burial for the laity (Richards 2000: 137). The larger scale pastoral care provided by minsters is conveyed by both documentary and archaeological evidence. Firstly, the large number of individuals documented at some of the monastic and minster sites cannot all feasibly represent 'choir monks' destined to become priests and nuns (Blair 2005: 255). Secondly, large areas of land were provided to supply sustenance for the minster or monastic sites. For example, Bede in his *Historia Abbatum* (716-731) describes how Benedict Biscop obtained seventy hides from King Ecgfrith with which he founded his minster at Wearmouth (Plummer 1896, *VBAH,* I. 364-387; Foot 1990: 49). Blair (2005) suggests that the appearance of *wics* coincided with the emergence of complex monastic sites. Indeed, monastic sites formed the focus for nucleated settlements which subsequently evolved into small towns in the 10th and 11th centuries, examples of which are St Albans (Hertfordshire), Abingdon (Oxfordshire) and Bury St Edmunds (Suffolk) (Griffiths 2003: 96). These towns were characterised by a triangular market place lined with burghage plots and were established outside the main gates of the monastery or abbey (Haslam 1985: 50; Pallister *et al.* 2000: 160; Richards 2000: 137-8).

3.4.3.5 Burhs

A series of *burhs*, some of which were fundamentally fortified towns, emerged in the late 9th and early 10th century. The main source of information regarding *burhs* in the later Anglo-Saxon period is the Burghal Hidage, which is a list of thirty-three major fortified *burhs* compiled between *c.* 911-914 (Reynolds 1999: 87). *Burhs* were royal fortresses, which were strong-points and refuges, as well as emerging urban centres. They were established by the West Saxon King Alfred and his son Edward to resist the Vikings in Wessex and to extend their power northwards throughout the midlands, East Anglia and Lincolnshire (Rollason 2003: 257; Draper 2008: 245). A number of these fortified *burhs* were new constructions initiated in the 9th century, whereas others were refortifications of Roman settlements (Reynolds 1999: 86). Reynolds (1999: 88-9) acknowledges two types of *burh*: those that served a single function of defensive fortification (e.g. Southampton and Burpham) and others, which performed several functions (e.g. Winchester and Oxford). The latter 'burghal towns' contained markets, minster churches and royal accommodations and sometimes became the administrative foci for shires, such as Warwick, which was the administrative centre for Warwickshire (Rollason 2003: 257-8). These 'burghal towns' also exhibited a regularised street layout characteristic of towns (Reynolds 1999: 89-91). The more urbanised *burhs* were a phenomenon predominantly of the south of England (Reynolds 1999: 88).

The building of *burhs* did occur in Northumbria during the early to mid-10th century but was restricted to the south-west extremity of the region. Rollason (2003: 258) suggests that these *burhs*, such as those located at Chester, Eddisbury and Runcorn in Cheshire (constructed in 907, 914 and 915 respectively), were solely defensive in function to maintain areas already secured by the West Saxons and to defend north-west Mercia against Viking incursions from across the Irish Sea. This view is supported by Bassett (2011: 15), who identifies Runcorn and Eddisbury as part of a series of defensive *burhs* constructed to prevent Vikings raiders from sailing up the rivers Clwyd, Dee and

Mersey. Rollason argues that, save for the aforementioned mints at Chester, the Northumbrian *burhs* have yet to produce any archaeological evidence that they possessed the administrative and urban functions of their more southerly counterparts (Griffiths 2001: 176-7; Rollason 2003: 258). However, such an interpretation based on negative evidence must be treated with caution as only limited excavation of both Runcorn and Eddisbury has been undertaken to date (Varley 1950; Griffiths 2001: 176; Bassett 2011). The lack of surviving archaeology at Runcorn limits the possibility of any further insight being attained even from further excavation (Griffiths 2001: 176-7). In contrast, excavations of the Castle Ditch hillfort located near Delamere in central Cheshire has been identified as being connected with the Eddisbury *burh*, and has produced evidence for settlement and industrial activity in the form of huts and a loomweight. Further excavation of the Castle Ditch site, however, is needed to provide dating evidence which will determine if these activities correlate with the proposed date of occupation of the Eddisbury *burh* (Griffiths 2001: 175-6).

Anglo-Saxon Northumbria was directly at risk from Viking invaders. It is documented in the Anglo-Saxon Chronicle that the Vikings first attacked York in 867, which was subsequently under Scandinavian rule for sixty years afterwards and Torksey (Lincolnshire) was used as the winter quarters by Vikings in 872 (Ottaway 1992: 147, 155). The monasteries of St Peter and St Paul at Wearmouth and Jarrow were also attacked and destroyed in Viking raids in 869-70 (Cramp 2005: 34). Therefore, it is feasible that a *burh* in the location of the Black Gate may have been constructed with a defensive purpose as its primary function.

3.5 Summary

The period of use of the Black Gate cemetery coincides with significant changes in the ideological and physical landscape. Interment within burial grounds, previously reserved for secular and religious elites, either adjacent to or within land associated with the Church, became the norm, although not universal, by the 10th century. The heavily gender and age biased grave goods of the early Anglo-Saxon period were replaced by social display facilitated by the form and construction of the grave. The investment of greater wealth in the construction of stone cists and the inclusion of supportive or protective stones was used to display family wealth incorporating all family members (i.e. the old and young, males and females). Display of wealth shifted from the confines of the grave towards investment in churches and monasteries.

The period sees a transformation in the landscape from small, dispersed settlements towards the establishment of trade centres, defensive settlements, concentrated settlements associated with monasteries and minsters and large-scale towns. Indeed, from the 9th century there is a notable increase in urbanisation, which may have resulted in differential health profiles between the urban, monastic and rural settlements. The rest of this thesis seeks to create a health and burial profile for the Black Gate population and to compare this data to the early medieval period as a whole and the aforementioned comparative sites. The intention is that placing the Black Gate data into the wider archaeological context will enhance our current knowledge not only of one particular cemetery, but of later Anglo-Saxon life and death in general, particularly in the north and how the religious and environmental factors impacted upon the lives of these people.

CHAPTER 4

BLACK GATE PALAEOPATHOLOGY: MATERIALS AND METHODOLOGY

The purpose of this chapter is to outline the methodology used to identify and quantify the expression of health indicators within the Black Gate cemetery. It commences with an exploration into the nature of the skeletal assemblage, that is the demographic profile of the cemetery population and the preservation of the skeletal material. This is to enable the identification of any biases in the data, which may result from selective burial practices or poor preservation of the skeletal elements. This will be followed by a summary of the ageing and sexing methodologies utilised in this project and the identifying criteria for each palaeopathology within the health indicator categories of non-specific stress, non-specific infection, dental health and biomechanical stress. The chapter concludes with an outline of the statistical methods used in chapters 5, 6 and 7 to identify the relationship between health and cultural status and settlement type in the Black Gate cemetery and the thirteen comparative sites.

4.1 The Black Gate Cemetery: Skeletal Assemblage Preservation and Composition

An important aspect of this research was to identify how well preserved the Black Gate material is in order to account for any bias that may occur in the distribution of the different sexes and age groups or the prevalence rates of pathologies affecting the teeth and bones. For example, poor preservation of infant remains can lead to an under-representation of their demographic profile in cemetery populations. If levels of preservation are not considered when such under-representation of skeletal remains is observed, it is easy for their absence to be interpreted as evidence that the infants were excluded from the cemetery, suggesting selective burial practices. This problem is highlighted in Buckberry's (2000) study of the effects of taphonomy on the archaeological record throughout the Anglo-Saxon period. Her analysis revealed under-representation of immature remains in cemeteries located on acidic sands and gravels, which are poor preservers of human bone. Indeed, from the total assemblage of eighty-three individuals excavated from the 10th- century cemetery on the gravels at Addingham (Yorkshire) (Adams 1996; Boylston and Roberts 1996: 175) only the fragmentary remains of three immatures aged under five years of age were recovered. In contrast, Buckberry notes twenty-three immatures under five years of age (22.5% of the 102 individuals excavated) were recovered in 'fair' preservation from the clays of the 8th-to 12th -century cemetery at Castle Green, Hereford (Buckberry 2000). Furthermore, 142 immature skeletons were recovered from the clay and limestone natural of Raunds Furnells, one of the largest samples recovered from a late Anglo-Saxon cemetery to date (Boddington 1996).

Within the present study, the degree of preservation and completeness was recorded for each skeleton. This enabled crude counts of the number of each elements surviving, and whether that element was preserved well enough for any pathologies to be observed. This information was later translated into crude, true and absolute prevalence rates (definitions of which are provided below) for the pathologies under analysis, which can be compared with the contemporary sites outlined in Chapter 2. The method for establishing the levels of preservation of the Black Gate skeletal assemblage and the subsequent assessment of preservation will now be discussed. This will be followed by an account of the methodology used to determine the age and sex of each individual within the skeletal assemblage. The age and sex data collected for Black Gate will be used to create an overall mortality profile of the entire assemblage and a demographic profile and life table will be created to calculate average life expectancy at birth (e_o).

Life tables for archaeological populations constructed from osteological data have been criticised on a number of methodological and theoretical grounds. A synopsis of the range of criticisms of the application of life tables to archaeological populations is provided by Wood *et al.* (2002: 129-31). Here it is sufficient to note briefly that the general problems are that life tables assume that past populations were 'stationary', with no migration, while expecting constant schedules of fertility and mortality, which resulted in a stasis of population growth and decline (Wood *et al.* 1992: 344; Wood *et al.* 2002: 130). Life tables assume that age-specific mortality remains constant throughout a person's life, regardless of their age (Chamberlain 2006: 27-8). Such an assumption is problematic when dealing with human populations, which are essentially a dynamic entity exposed to various extrinsic stimuli, which determine a person's chance of survival. The ageing methods utilised are variable in their accuracy and often the central value of an age range is used creating inaccuracies which, when coupled with the inconsistencies between skeletal physical and chronological age, can have a knock-on effect on the accuracy of subsequent calculations involved in creating the life table (Chamberlain 2009: 280-1). The fixed age intervals used within life tables requires all individuals to be incorporated into one of the age intervals, even when their age cannot be determined to such a degree of accuracy and traverses two or more age categories. This can skew data and produce inaccurate and misleading results. Archaeological skeletal assemblages are typically quite small, providing samples that are insufficient numbers to calculate life tables accurately (Wood *et al.* 2002: 129-30). For example, in this study three assemblages – York Minster, Ailcy Hill and Addingham – comprise less than 100 articulated individuals. Furthermore, taphonomic processes and differential levels of preservation can affect the presence of different age groups within a skeletal assemblage, creating false representations of the actual population (Chamberlain 2009: 283). The life tables presented within this thesis were intended purely to provide a comparison between Black Gate and the thirteen comparative skeletal assemblages alongside several other morbidity and stress indicators. They were not expected to provide a definitive analysis of population structure, mortality and morbidity on their own.

4.1.1 The Black Gate Cemetery: Skeletal Assemblage Preservation

Within this thesis, 'preservation' refers to how well the bone has survived the taphonomic processes of decay and external environmental factors, such as soil type and the presence of microorganisms within the soil (Bell *et al.* 1996). To quantify the level of preservation within this assemblage the completeness of the surviving skeletal elements and the overall condition of the bones was assessed. *Completeness* refers to the percentage of the skeleton surviving and *condition* is the extent that erosion, abrasion and post-mortem damage has affected the skeleton. The completeness was recorded numerically as a percentage of the complete skeleton recovered. The percentage of surviving skeletal elements was divided into four categories (0-24%; 25-49%; 50-74%; 75-100%). To quantify the condition of each skeleton, the standard Institute of Field Archaeologists criterion for recording cortical bone erosion and abrasion was utilised (McKinley 2004: 17). Definitions of the seven different grades of surface condition of the bones are listed below and illustrated in Figure 4.1:

0. Surface morphology is clearly visible with fresh appearance to bone and no modifications.
1. Slight and patchy surface erosion.
2. More extensive surface erosion (e.g. through root action) than grade 1, with deeper surface penetration.
3. Most of the bone surface affected by some degree of erosion (by root action); general morphology maintained but detail of parts of surface masked by erosive action.
4. All of bone surface affected by erosive action; general profile maintained and depth of modification not uniform across whole surface.
5. Heavy erosion across whole surface, completely masking normal surface morphology, with some modification of profile.

5+. As Grade 5, but with extensive penetrating erosion resulting in modification of profile.

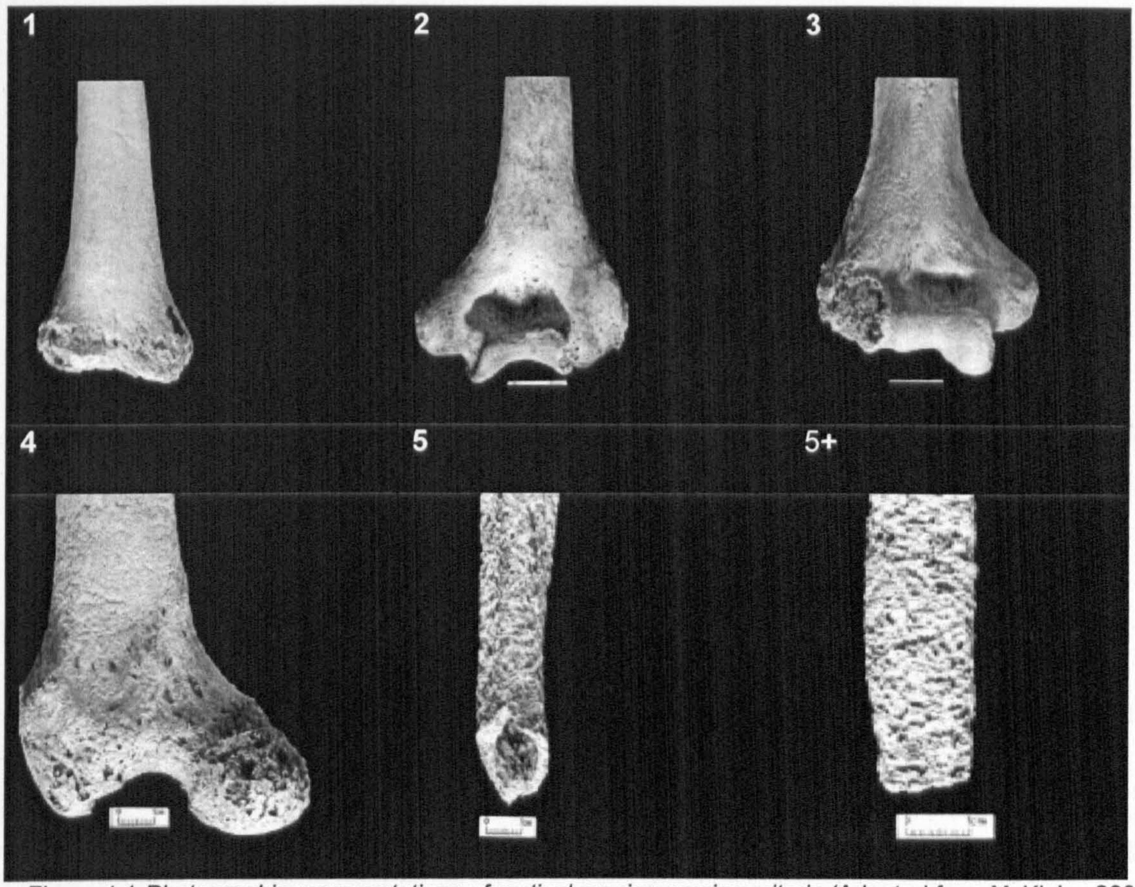


Figure 4.1 *Photographic representations of cortical erosion scoring criteria* (Adapted from McKinley 2004: 17)

An additional preservation criterion was employed, whereby each skeleton was assigned a rating of *Destroyed*, *Poor*, *Good* or *Excellent*. Though these nominal categories are subjective, the intention is to provide the reader with an overall impression of the condition of the cortical bone of the skeleton overall. This is important because, aside from cortical erosion, post-mortem damage, fragmentation and staining from organic materials, both within the surrounding natural geology and the grave itself, can affect each bone. Each of these factors can impede the identification of pathology, and sex- and age-diagnostic characteristics. For example, the shaft of the bone may have Grade 0 cortical erosion but may have abraded or fragmentary joint ends, which would inhibit analysis of degenerative joint disease. Therefore, in the present survey, the overall condition of the bone for the entire skeleton would have been recorded as Poor. In addition, for this thesis, all analysis of the Black Gate skeletal assemblage was undertaken by the author; therefore, although these categories may be subject to inter-observer error if applied by other osteologists to other assemblages, they provide a reasonably accurate interpretation of the varying levels of preservation amongst the skeletons interred within the cemetery. The information was recorded on a modified version of the recording forms used by the Global History of Health Project, headed by Richard H. Steckel (Ohio State University) and Jerome C. Rose (University of Arkansas), and co-ordinated in Britain by Charlotte Roberts (University of Durham).

4.1.2 Ageing and Sexing Methodology used to Determine the Composition of the Black Gate Assemblage

Adults, including adolescents (individuals aged 12-17 years), were aged by developmental and degenerative changes to the teeth and bones. Degenerative changes to the physical morphology of the pubic symphysis (Todd 1921; Suchey and Brooks 1990), auricular surface (Lovejoy *et al.* 1985), sternal rib ends (Isçan *et al.* 1984; Yoder *et al.* 2001) and occlusal surfaces of the teeth (Miles 1962) were analysed to provide an informed estimation of each individual's age at death.

Immatures were aged by ontogenetic changes to their skeleton and dentition. Dental development is primarily controlled by genetics making it less susceptible to environmental influences such as periods of malnutrition and infection than skeletal growth and development and is, therefore, considered to be the most accurate indicator of age at death in immatures (Hillson 2000; Bennike *et al.* 2005: 736). Consequently, where possible, age at death for immature remains was estimated from stages of dental calcification, root extension, tooth eruption and apical closure of the tooth root (Anderson *et al.* 1976; Moorrees *et al.* 1963; Smith 1991). Epiphyseal fusion (Krogman and Isçan 1986; Bass 1995; Schwarz 1995) and diaphyseal long bone length (Anderson *et al.* 1964; Maresh 1970; Gindhart 1973; Fazekas and Kósa 1978; Scheuer *et al.* 1980; Hoppa 1992; Scheuer and Black 2000) measurements were used to supplement the dental age estimate and as a substitute when no teeth survived. The development of the *pars basilaris* of the occipital bone and *pars tympani* of the temporal bone (Scheuer and Black 2000) were also employed to estimate age at death in neonate and infant remains.

Miles' (1962) dental attrition charts and Hoppa's (1992) diaphyseal long bone estimates were both methods developed from the analysis of Anglo-Saxon material from Breedon-on-the-Hill (Leicestershire) and Raunds Furnells (Northamptonshire) respectively. Therefore, they were the best methods to apply to the contemporary Black Gate skeletal material in conjunction with dental development.

Within this thesis, the term 'immature' refers to individuals of a skeletal age below 18 years of age at death. 'Adult' refers to any individual including and over the skeletal age of 18 years at death. In some cases, an individual has been assigned the 'adult' age category with no further sub-division into a more specific age category. This was necessary due to poor preservation or condition of a skeleton preventing an accurate assessment of that individual's age, save for to identify that they were over 18 years of age. The age categorisations used throughout this thesis are presented in Table 4.1. However, it must be noted that these are arbitrary biological categorisations, which may not reflect chronological age and have no relevance in a cultural and social context. For example, the Anglo-Saxon law codes demonstrate that the age at which children legally become adults rises from 10 years in the 7th century to 12 years in the 10th century (Crawford 2000; Kamp 2001: 4).

Age Category	Age Range
Foetal	<0
Neonate	Birth-1month
Infant	1-12 months
Young Child	1-5 years
Older Child	6-11 years
Adolescent	12-17 years
Adult	18+ years
Young Adult	18-25 years
Prime Adult	26-35 years
Mature Adult	36-45 years
Senior Adult	45+ years

Table 4.1 *Age categories utilised in the analysis of the Black Gate skeletal assemblage*

Sexing of adults was predominantly determined from sexually dimorphic characteristics of the skull and pelvis (Buikstra and Ubelaker 1994). Each skeleton, where possible, was assigned a sex category of either male (M), probable male (M?), female (F) or probable female (F?). Individuals who lacked the sexually dimorphic areas necessary for sex determination, or did not display strongly male or female characteristics were recorded as 'unknown'. Wherever possible, metric measurements were taken of the vertical diameter of the femoral and humeral heads, and these were used for determining the sex of an individual (Stewart 1979: 100). A number of metrical and morphometrical methods for determining the sex of immature remains have been developed (Schutkowski 1993; Molleson *et al.* 1998; Loth and Henneberg 2001). However, the reliability of such methods has been called into question and even though they show correlations between the predicted and actual biological sex of the immature individual these relationships are rarely statistically significant (Mays and Cox 2000; Scheuer and Black 2000: 15; Vlak *et al.* 2008). Consequently, it was decided not to assign biological sex to the immatures within the Black Gate assemblage as the methodologies could not be relied upon to provide accurate sex designations. Therefore, when using any osteological methods which distinguished between the sexes upon immature remains, the male and female results were combined and the full range of values used.

Immature skeletal remains are regarded as a more sensitive indicator of environmental stress than those of biologically more mature adults (Lewis 2007). This sensitivity is due to the continued growth of immature remains and the physiological response of the developing skeleton to intrinsic and extrinsic environmental changes, such as periods of nutritional stress and exposure to respiratory irritants and infectious disease, and their reliance on the care and provisioning of others (Lewis 2007). Unfortunately, there is often a shortage of immature skeletal material recovered from excavations, not only from the late Anglo-Saxon period, but from the majority of archaeological excavations of cemeteries, of varying topography, locality and time periods. Aside from the preservation issues discussed previously, the absence of infant skeletal remains may be the consequence of cultural practices. For example, it has been suggested that lower levels of immature skeletal remains may be accounted for by the burial of immatures away from the cemetery. For example, two infants were recovered from rubbish pits at *Hamwic* and the remains of infants were recovered from the foundations of several sunken featured buildings at West Heslerton (Hamerow 2006: 14). The burial of infants near to, or within, boundary ditches has also been recorded for the sites of West Stow and Wharram Percy (Hamerow 2006: 12). However, in the late Anglo-Saxon period, there is consistent evidence for the inclusion of immature interments within burial grounds containing adult remains (e.g. Raunds Furnells and Norwich Castle (Ayers 1985). Conversely, there is also evidence for the segregation of immature burials in early medieval cemeteries. At Fishergate, 76% of the under-fives were recovered from the western third of the excavated area, including a group of infants (Stroud 1993: 254). Furthermore, a high proportion of infant burials at Raunds Furnells were found adjacent to the church in the 'eaves-drip' location (Boddington 1996: xii, 45).

The majority of contemporary cemeteries provide remains from less than 50 immatures, many of which are in poor condition. These sample sizes are too small to enable any reliable interpretative statistical analysis. In contrast, the sample of aged immature skeletal remains recovered from the sandstone till, or boulder clay (Nolan 2010: 155) of the Black Gate cemetery consists of 202 individuals. These 202 immatures make up 31.4 % of the total assemblage. Consequently, the immature component of the Black Gate population is substantial enough for statistical analyses to be applied to the prevalence of health indicators. Thus, not only is this site of utmost importance overall, the immature population is of great significance in its own right in the context of the study of late Anglo-Saxon cemeteries.

4.2 Palaeopathology Methodology

> *The pathology of a group of people ... reflects ... the environment in which they live, the geographical and climatic influences which bear on them, the pressure of competing or co-existent forms of life, their behaviour in the environment ... pattern of dress, houses, tools, weapons ... the study of the accidents and diseases which afflict a people can reveal more about their living circumstances than any evidence except the most detailed written descriptions based on direct observation* (Wells 1964: 17-19).

To understand the quality of life experienced by the contributing population of the Black Gate cemetery a number of health indicators were studied. Health indicators are the manifestation upon the skeleton and dentition of the physiological response of the body to extrinsic environmental insults (Goodman *et al.* 1988: 177; Duray 1996: 275). These external influences include mal- and under-nutrition, inclement weather, unhygienic or overcrowded living conditions, physical activity and pollution of the air and water supply. These, in turn, result in metabolic diseases such as rickets and scurvy, fevers, respiratory infections, intestinal parasites, diarrhoea, degenerative joint disease, allergic reactions and bacterial and viral infections (Selye 1973; Ribot and Roberts 1996: 67; Mays 1998: 158; Goodman and Martin 2002: 12). The extent to which the individual is affected by these environmental stressors results from a combination of factors, such as the biologically determined level of resistance related to age, sex and socio-economic and cultural influences (Goodman *et al.* 1988: 172) (Figure 4.2).

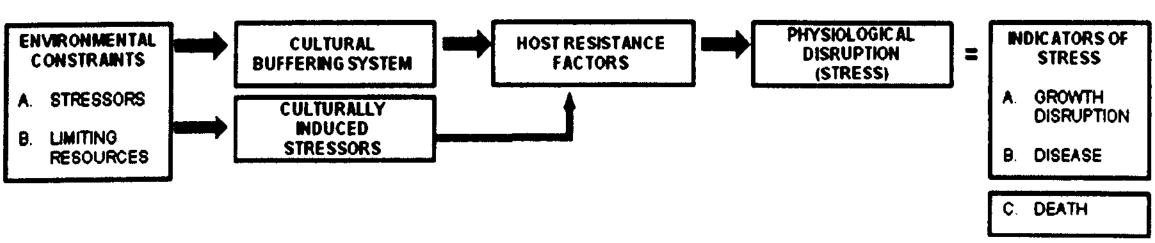


Figure 4.2 *The relationships between environmental and biological insults and the expression of physiological stress (adapted from Goodman et al. 1988: 172 Figure 2)*

Environmental stress observed in the Black Gate assemblage was divided into two separate categories: non-specific environmental stress and biomechanical stress. Non-specific environmental stress was studied by observations of the disruptions in immature growth and the subsequent impact upon adult stature (Brothwell 1994; Maat 2005; Giannecchini and Moggi-Cecchi 2008) and the expression of cribra orbitalia, porotic hyperostosis (Stuart-Macadam 1991; Facchini 2007; Djuric *et al.* 2008) and dental enamel hypoplasias (King *et al.* 2005; Halcrow and Tayles 2008). Biomechanical stressors imposed upon the skeleton during life were assessed by the prevalence of degenerative joint disease and trauma.

The main health indicators employed in this thesis are non-specific infections and dental pathologies. Evidence of non-specific infection throughout the skeleton, particularly upon the long bones, gives a general impression of the state of health of an individual at their time of death (Weston 2008), whereas specific infections can be more directly associated with particular living conditions and activities. For example, maxillary sinusitis can be used to infer the presence of respiratory irritants and infection (Boocock *et al.* 1995; Lewis *et al.* 1995; Roberts 2007). Dental pathologies such as calculus, dental caries, abscesses and ante-mortem tooth loss are good indicators of the oral health and hygiene, diet and general health status of an individual or population (Goodman and Rose 1990; DeWitte and Bekvalac 2010). Metabolic conditions such as rickets and scurvy are direct indicators of dietary stress or underlying health conditions (Ortner and Mays 1998; Brickley and Ives 2006; Lewis 2010) and, therefore, were utilised as a further indicator of the overall health of the Black Gate skeletal assemblage. The skeletal health indicators employed within this study and whether they were investigated on the adult or immature remains, or both, are summarised in Table 4.2

For each skeletal health indicator a brief explanation of its aetiology will be presented with a discussion of how it can enhance our knowledge of the health and lifestyle of an individual and a population as a whole. This explanation will be followed by a description of the methodology and criteria utilised to record each indicator. Where possible, the recording criteria are adapted from texts where photographic and diagrammatic examples are provided of the health indicator under consideration. The intention of this approach was to standardise the recording system and reduce any inter- and intra-observer errors that can occur from misinterpretation of ambiguous terminology such as 'slight', 'moderate' and 'severe'. Standardised recording of each attribute using illustrations or photographic images will help to ensure that this project can be used for comparative osteological analysis with other archaeological sites in the future.

Skeletal Health Indicators	**Adult**	**Immature**
Growth and Development		
Immature Growth Rates		*
Adult Stature	*	
Non-Specific Stress		
Cribra Orbitalia/Porotic Hyperostosis	*	*
Dental Enamel Hypoplasias	*	*
Non-Specific Infection		
Tibial Periosteal New Bone Formation	*	*
Maxillary Sinusitis	*	*
Dental Health		
Calculus	*	*
Caries	*	*
Dental Abscesses	*	*
Ante-Mortem Tooth Loss	*	*
Skeletal Biomechanical Stress		
Degenerative Joint Disease	*	
Trauma	*	*

Table 4.2 *Skeletal indicators of health analysed within the Black Gate cemetery assemblage. (Italicised pathologies are included within analysis of comparative sites and burial practices in Chapters 6 and 7)*

Typically, in palaeoepidemiological and clinical studies the prevalence of a specific condion is quantified by calculating a crude prevalence (the number of cases as a proportion of the total population) or true prevalence (the number of cases divided by the total number of elements affected) (Waldron 1991, 1994:45, 54; Robets and Cox 2003; Brickley 2006: 65; Bourbou 2009: 224). This thesis maintains the common meaning of crude prevalence rate. However, due to the variability in quality of data available from the comparative literature, the true prevalence is calculated as the number of affected individuals as a proportion of the number of individuals upon whom the pathology could be recorded if it was indeed present, i.e.

Skeletal True Prevalence Rate (TPR):

Number of skeletons affected / total number of skeletons with one or more recordable skeletal element available for analysis

Dental True Prevalence Rate (TPR):

Number of skeletons affected / total number of skeletons with one or more teeth (or sockets).

To enable comparisons with chronologically similar sites of known context, each attribute analysed was categorised into the following categories devised for this project:

Total Population Prevalence (TPP)

Total number of skeletons affected / total number of adult and immature skeletons analysed.

Immature Prevalence (IP)

Total number of immature skeletons affected / total number of immature skeletons analysed.

Adult Prevalence (AP)

Total number of adult skeletons affected / total number of adult skeletons analysed.

4.2.1 Indicators of Environmental Stress: Growth and Development

4.2.1.1 Immature Growth as an Indicator of Environmental Stress

Skeletal growth rates in a population are influenced by a number of factors, the most influential of which are nutrition and disease and socio-economic status (Lunn 2000: 152-3; Scheuer and Black 2000: 5; Lewis 2002b: 211; Mays *et al.* 2009: 410). Growth can only occur if there is a surplus of the body's resources beyond the levels required to maintain the body in a state of equilibrium (Hillson 1991: 53). Consequently, under- or mal-nutrition or the re-allocation of resources to enable the immunological response of the body to environmental insults and disease will result in retarded growth. Cultural influences and socio-economic status can both influence growth rates both positively by protecting the individuals from immunological insults and disease and providing preferential diets conducive to growth, and negatively by exposure to disease though poor sanitation or restricting the diet and therefore reducing the necessary dietary components vital for growth. Environment principally affects growth between birth and approximately 3 years of age. Environmental stress may also impact upon pre-natal ontogenetic development, when the size of the developing foetus can be directly affected by the activities, health and nutrition of the mother (Saunders and Barrans 1999: 183; Collins 2007: 453). Reduced birth weight and retarded growth in the first few years of life have been linked to reduced adult stature, impaired adult health and a reduction in longevity of life (Steckel *et al.* 2002a: 144; Pfab *et al.* 2006). If the Black Gate contributing population derived from a surrounding rural population one might expect, for example, a child aged eight years old would have a similar femoral diaphyseal length as a child of the same age interred in a contemporary rural cemetery assemblage, such as Raunds Furnells. In contrast, a difference between the average diaphyseal long bone lengths between children from these two populations may be indicative of differences in environment, nutrition or exposure to disease. If the Black Gate population were experiencing severe environmental and nutritional stress, it would also be expected that age estimates based on diaphyseal length would consistently provide younger ages than the dental age estimate.

To determine any effects environment, nutrition or disease may have had on the immature growth rates in the Black Gate assemblage, skeletal growth profiles comparing dental age with diaphyseal long bone length were created. Dental development is less sensitive to external environmental factors than diaphyseal length and is, therefore, the more reliable indicator of age at death. Consequently, retarded long bone length in relation to dental age is regarded as a helpful indicator of environmental stress (Cardoso and Garcia 2009: 137). The skeletal growth profile was constructed by plotting the stage of dental development and calcification (Anderson *et al.* 1976; Moorrees *et al.* 1963; Smith 1991), and therefore dental age, against the diaphyseal length of the femur. Femoral diaphyseal lengths were utilised because the femur is the most rapidly growing long bone and, therefore, will exhibit inconsistencies in growth more evidently than other long bones (Feldesman 1992; Mays *et al.* 2008: 86). Measurements were only made of the diaphyseal lengths of the femoral bones on which the epiphyses have not fused, therefore representing bones that were still growing at the time of death.

4.2.1.2 Adult Stature as Indicator of Environmental Stress

Genetics and heritability predominantly determine final attained stature in adults. However, environmental and socio-economic factors also have a strong influence (Giannecchini and Moggi-Cecchi 2008: 284). Inadequate nutrition and infectious disease, or a synergistic interaction between the two, are the most common causes of poor growth in human populations (Lunn 2000; Mays *et al.* 2008: 85), inhibiting an individual's ability to achieve their maximum potential height (Robb *et al.* 2001: 216). Consequently, adult stature is perceived as a good indicator of the general state of nutrition of individuals and populations in the past. One would expect similarity in stature between populations from similar economic, health and environmental backgrounds. Therefore, comparison of the overall average adult stature of the Black Gate population with contemporary later Anglo-Saxon urban, monastic and rural cemeteries may provide insight into the environmental and social background of the cemetery. An intra-cemetery comparison between the stature of individuals interred in elaborate graves and those interred in plain earth-cut graves within the Black Gate cemetery may reveal if there are different economic, nutritional or health backgrounds between individuals buried with contrasting levels of grave provision.

Estimates of adult stature followed the calculations from long bone length measurements for white males and females provided by Trotter and Gleser (1952), as these categories would be nearest to the later Anglo-Saxon European population. Measurements were made of the maximum length of the left femur, unless the left element was absent, in which case the maximum length of the corresponding right femur was substituted. When the sex of the individual was unknown, the average of the values calculated for males and females was recorded. Only individuals of discernable age and sex were included within the results documented in chapters 5 to 7, to enable sexual dimorphism to be identified.

4.2.2 Indicators of Environmental Stress: Non-Specific Stress

4.2.2.1 Cribra Orbitalia and Porotic Hyperostosis

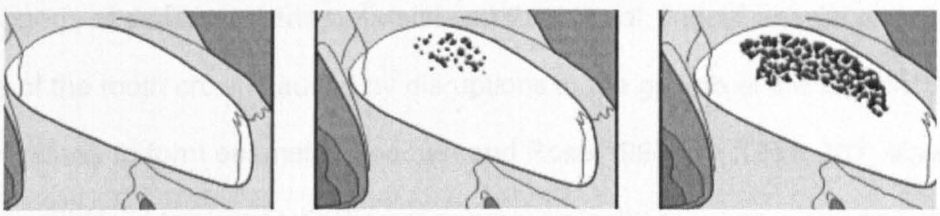
Cribra orbitalia and porotic hyperostosis are porous lesions observable upon the orbital and cranial vault bones respectively (Angel 1966; Stuart-Macadam 1985; 1987a, b; 1989; 1992). The most commonly suggested aetiology for these porotic lesions is iron deficiency anaemia, which causes hyperplasia of the bone marrow to stimulate the production of red blood cells (Stuart-Macadam 1992; Grauer 1993; Steckel *et al.* 2002a, b; Djuric *et al.* 2008). This widely held belief that cribra orbitalia and porotic hyperostosis are resultant from iron deficiency anaemia has, however, come into question in recent years, with suggestions that genetic anaemias and depleted maternal B12 reserves and parasitic infections may be responsible (Wapler *et al.* 2004; Walker *et al.* 2009: 119). Genetic anaemias are rare in modern day Northern Europe and it can therefore be inferred that they were also uncommon in this region in the past Therefore, it appears most likely that cribra orbitalia and porotic hyperostosis are a consequence of a nutritional deficiency, whether it is of iron or vitamin B12. Such depletion may result from mal- or under-nutrition or insufficient uptake of such nutrients from a sufficient diet due to the body's natural defence against chronic diarrhoeal disease and parasitic infections. Such acute and chronic infections may stimulate the immune system to withhold nutrients, particularly iron, from invading micro-organisms as a defence mechanism (Holland and O'Brian 1997; Bennike *et al.* 2005: 738; Walker *et al.* 2009: 113). It is probable that an increased prevalence of diarrhoeal and parasitic infections in the past resulted from unsanitary living conditions or a compromised immunological response system (Palkovitch 1987; Stuart-Macadam 1989; 1992; Piontek and Kozlowski 2002; Walker *et al.* 2009). It has been claimed that related individuals exhibit a higher susceptibility to iron deficiencies (Angel 1966; Stuart-Macadam 1985; 1987a, b; 1989), which is more probably a consequence of increased exposure to the same pathogens through living in the same locality in close proximity in unhygienic and overcrowded conditions than the suggested developmental relatedness.

Parasitic infections are evidenced within the early medieval urban settlements at St Andrew's, Fishergate and Coppergate in York by the presence of preserved parasite eggs in archaeological deposits. A number of faecal deposits recovered from Period 3 at St Andrew's, which dates from the late 7th to mid-9th century, contained moderate to high concentrations of eggs from the intestinal tract parasites *Trichuris trichiura* (whipworm) and *Ascaris* sp. (maw worm) (Allison *et al.* 1996: 87-91). Further evidence for both *Trichuris trichiura* and *Ascaris* parasite eggs has been found in 90% of rubbish deposits analysed from York and within cesspits, on yard surfaces and even on building floors at Coppergate (Addyman 1989: 257). It is probable that the transmission of parasitic infection and other infections will rise in frequency as the number and density of people within an area increases (Walker *et al.* 2009: 115). Therefore, one would expect an increase in the prevalence and severity of cribra orbitalia and porotic hyperostosis in more densely populated urban areas than in rural settlements if they are indeed symptomatic of parasite infections.

Several researchers have linked anaemia to either gender or social status. For example, Bullough and Campbell (1980: 319) claimed that in the Anglo-Saxon period life expectancy in women was reduced due to iron deficiency resulting from menstrual bleeding, frequent childbearing – although there is no available information on birth intervals in the Anglo-Saxon period – and a predominantly cereal based diet. If this is so, a higher prevalence of cribra orbitalia and porotic hyperostosis would be observed in females in the Black Gate assemblage of childbearing age (i.e. adolescent to prime adults). A study on the relationship between health and burial practices at Raunds Furnells has revealed that individuals buried without elaborate grave markers or covers exhibited higher prevalences of cribra orbitalia than individuals interred in graves accorded with such elaboration (Craig and Buckberry 2010: 135).

To record and classify the prevalence and severity of cribra orbitalia within the Black Gate assemblage stages 0 to 3 of the criteria described by Steckel *et al.* (2006: 13) were utilised. The recording categories (shown in Figure 4.3) are as follows:

0. No orbits present for observation
1. Absent with at least one recordable orbit
2. A cluster of mostly fine foramina covering a small area (≤1 cm^2)
3. Substantial area (> 1 cm^2) covered by small and/or larger foramina with a tendency to cluster together



1 2 3

Figure 4.3 *Coding criteria for cribra orbitalia (Steckel et al. 2006: 13)*

Porotic hyperostosis was scored using stages 0 to 3 of the criteria described by Steckel *et al.* (2006: 13-14). The recording categories (shown in Figure 4.4) are as follows:

0. No parietals present for observation
1. Absent with at least one recordable parietal
2. Presence of slight pitting or severe parietal porosity
3. Gross parietal lesion with excessive expansion and exposed diploë

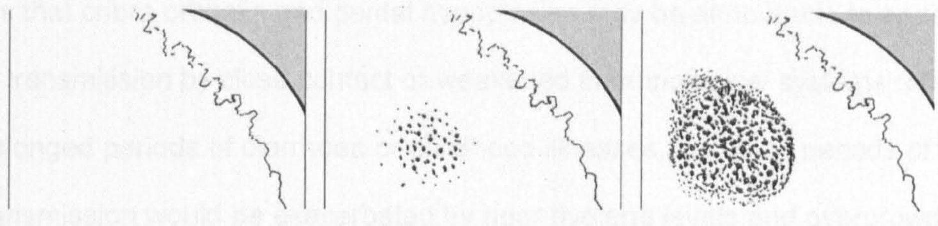


Figure 4.4 *Coding criteria for porotic hyperostosis (Steckel et al. 2006: 13-14)*

Cribra orbitalia and porotic hyperostosis lesions were recorded for both immature and adult skeletal remains. To enable comparisons to be made with other studies on Anglo-Saxon skeletons (such as Powell 1996) both the crude prevalence rates (calculated using the total number of individuals present) and true prevalence rates (calculated using the number of individuals with observable orbits and parietal, frontal or occipital bones present) were recorded.

4.2.2.2 Dental Enamel Hypoplasia (DEH)

Hypoplasias or hypoplastic enamel defects (Hillson 1996: 165) are localised transverse lines or bands of depressed enamel visible on the buccal, lingual, mesial and distal surfaces of the tooth crown caused by disruptions in the growth of the organic matrix that mineralises to form enamel (Goodman and Rose 1990: 59; 1991: 281; Mays 1998: 158). Disruptions in the mineralization of enamel typically occur as a non-specific physiological response to an extrinsic environmental stressor such as periods of disease or nutritional deficiency. The enamel hypoplasia forms on the area of the crown developing at the time the physiological stress occurs and is, therefore, indicative of the age at which the stressor is experienced. Consequently, enamel hypoplasias represent periods of disruption of enamel formation in individuals aged between one and seven years of age (or up to approximately thirteen years if the third molar is incorporated into the analysis) (Ogilvie *et al.* 1989; Mays 1998: 156). Dental hypoplasias have been shown to be more prevalent in younger siblings of individuals affected by acute diarrhoeal disease than in a population as a whole, as is the case with cribra orbitalia (Infante and Gillespie 1974; King *et al.* 2005). This relationship suggests that cribra orbitalia and dental hypoplasias may be attributable to endemic disease transmission by close contact or weakened immunological systems resulting from prolonged periods of diarrhoea or childhood illnesses, including periods of fever. Such transmission would be exacerbated by poor hygiene levels and overcrowding. Therefore, DEHs may be possible indicators of unhygienic or crowded living conditions. Research has shown that the severity of systemic disturbance is equivalent to the quantity of missing enamel (Suckling *et al.* 1986; Hubbard *et al.* 2009). Therefore, one would expect that a population experiencing greater physiological stress would experience not only a larger number of individuals exhibiting enamel hypoplasias, but also that individuals within a stressed population would experience a greater number, of linear enamel hypoplasias per tooth than individuals from a less stressed population (Palubeckaite *et al.* 2002). The age at which interruption of enamel formation occurs can be determined from the stage of development of the tooth crown at the time of disruption (Goodman and Rose 1991; Reid and Dean 2000). Determining the age of disruption of enamel formation will allow identification of the developmental stages at which individuals experienced the greatest levels of physiological stress. For the adult dentition, the sex of the individual will be taken into consideration to see if any patterns can be inferred about the health of males and females. However, for immature skeletons sex is rarely identifiable so it is not possible to identify any sexual variation in the prevalence and severity of dental enamel hypoplasias or the age of an individual at the time the enamel defects occur amongst immatures.

To calculate the prevalence of dental enamel hypoplasias in the Black Gate assemblage the number of enamel hypoplastic defects on all the available incisors and canines was recorded. To quantify the severity of dental enamel hypoplasia in a concise format the coding criteria for hypoplastic lesions provided by Steckel *et al.* (2006: 15-16), adapted from Schultz (1988), was utilised (Figure 4.5):

0. Tooth not present or unrecordable owing to wear or other causes
1. No linear enamel hypoplasia
2. One hypoplastic line present (can be felt with your fingernail)
3. Two or more hypoplastic lines present

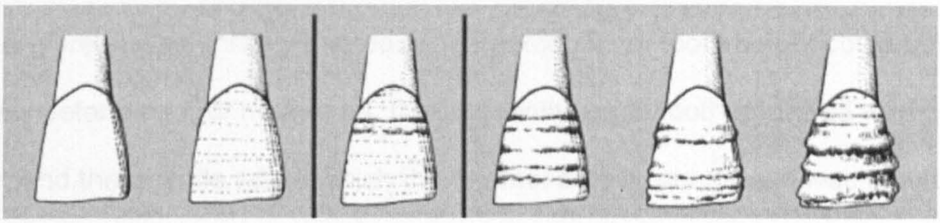


Figure 4.5 *Coding criteria for severity of dental enamel hypoplasia (Steckel et al. 2006: 15-16)*

To calculate the individual's age at the time of enamel disturbance, the method of Reid and Dean (2000) was followed. All measurements were taken with Biltema© digital callipers with a precision of 0.01mm and accuracy of ±0.03mm. The distance from the cemento-enamel junction to the occlusal margin of the linear enamel hypoplasia was measured on the labial surface of the tooth crown of the incisors and canines. To prevent mis-identification of perikymata (transverse lines of incremental growth resulting from normal enamel apposition) or enamel defects resulting from localised trauma as dental enamel hypoplasias, only transverse lines forming a continuous band around the tooth crown and into which the tip of a dental probe can be inserted were recorded. Worn teeth, with no surviving occlusal enamel, were excluded from calculations of dental enamel hypoplasia age at formation. This did reduce the sample size somewhat, but enabled comparisons of age estimations between the Black Gate and other studies and reports that had utilised the methodology of Goodman and Rose (1985).

Reid and Dean (2000) calculated, from light microscopy studies, the timing of anterior tooth growth to compensate for the lack of visible surface enamel formation during the first year of life, and the variable rates of both tooth growth and enamel. Consequently, Reid and Dean divided the tooth crown height of the four anterior teeth into ten equally spaced percentiles (Reid and Dean 2000: 138).

The current study of the Black Gate assemblage depended on macroscopic analysis of DEH; therefore, it was unlikely that each 10th percentile of tooth height could be accurately determined, or measured. Consequently, each tooth analysed was divided into four, and the quartile within which the enamel defect had formed was recorded. The age groups represented by each quartile are displayed in Table 4.3.

Tooth	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Maxillary central incisor	1.1-1.7	1.7-2.4	2.4-3.65	3.65-5.0
Maxillary lateral incisor	1.8-2.3	2.3-2.9	2.9-3.9	3.9-5.1
Maxillary canine	1.7-2.3	2.3-3.0	3.0-4.05	4.05-5.3
Mandibular central incisor	1.0-1.4	1.4-2.0	2.0-2.8	2.8-3.8
Mandibular lateral incisor	1.0-1.4	1.4-2.1	2.1-3.05	3.05-4.2
Mandibular canine	1.5-2.15	2.15-3.1	3.1-4.55	4.55-6.2

Table 4.3 *Age ranges represented by each quartile of the anterior dentition (adapted from the 10th percentile values of Reid and Dean 2000: 138)*

4.2.3 Indicators of Environmental Stress: Non-Specific Infection

4.2.3.1 Tibial Periosteal New Bone Formation (TPNB)

Periosteal new bone formation is a skeletal response to extrinsic or intrinsic pathological stimuli upon the periosteum, which is the outer membrane of connective tissue covering the external non-articular surfaces of a bone (Roberts and Manchester 1995: 127-9; Weston 2008: 48-9; Waldron 2009: 115). Periosteal new bone formation is commonly referred to in the palaeopathological literature as periostitis (Belcastro *et al.* 2007; Slaus 2008) or osteoperiostitis (Lambert and Walker 1991; Buzon and Judd 2008). However, within this study the phrase periosteal new bone formation will be used in preference to periostitis or osteoperiostitis, because these latter terms imply an inflammatory origin indicative of systemic infection, which is not necessarily the underlying process causing the new bone formation.

Roberts and Manchester (1995: 127-9), Larsen (1997: 83-4) and Steckel *et al.* (2002a: 146) attribute the main cause of periosteal new bone formation to the haematogenous spread of bacteria, such as *Staphylococcus*, *Streptococcus* and *Pneumococcus*, from a primary site of infection, such as the ear, nose, throat and chest, to a secondary locus, commonly the tibial shaft. The superficial nature of the anterior tibia also makes it susceptible to direct infection from severe and chronic skin lesions which may spread into deeper tissues, and eventually the bone surface (Roberts and Manchester 1995: 127-9). These are likely common causes of periosteal new bone formation, however, numerous other pathological aetiologies have been suggested including trauma, varicose veins and minor inflammations within the soft tissues of the body; underlying metabolic conditions and non-specific and specific infections, such as syphilis, and haematomas (Roberts and Manchester 1995: 127-9; Loe and Robson-Brown 2005: 51; Waldron 2009: 116). It has also been argued that periosteal new bone formation can be generated by any friction, pressure or mild stress upon the periosteum (Weston 2008: 49). Consequently, drawing any definite conclusions from the presence of periosteal new bone formation in isolation must be done with caution. Nonetheless, TPNB has been commonly utilised as an indicator of health and the body's ability to respond to infection throughout the past, including the later Anglo-Saxon period (Lee 1995: 563-4; Powell 1996: 120; Loe and Robson-Brown 2005: 51). The abundance of comparative information available means this health indicator, regardless of the aetiology of the lesions, is important within the present study because it shows the body's ability to respond to irregularities within it, whether they are infectious, inflammatory or traumatic in origin.

When identifying new bone formation resulting from inflammatory reactions, infection and stress in immature skeletal remains there is the problem of physiological periostitis. Physiological periostitis, also known as 'reactive periostitis', refers to the overproduction and consequent deposition of immature disorganised bone, macroscopically identical to periosteal new bone formation, upon the cortical surface of long bones as part of the normal appositional and ontogenetic growth process (Anderson and Carter 1994; Scheuer and Black 2000: 24; de Silva *et al.* 2003: 1124). The most commonly affected elements are the humerii, tibiae and femora of infants aged 1 to 6 months. Therefore, when recording new bone formation, one has to be careful to distinguish whether it is a normal developmental bone physiology or inflammation, infection, trauma or a reaction to an underlying disease.

The prevalence of non-specific infection in the Black Gate assemblage was analysed by recording the location and manifestation of all new bone formation present on both the adult and immature remains. However, the new bone recorded for infants below three years will not be included in the final analysis to avoid confusion of pathological periosteal new bone formation and physiological new bone. New bone formation on the long bones was scored using the criteria for osteoperiostitis proposed by Steckel *et al.* (2006: 30-1), with each long bone being assigned a grade of 0 to 7 (Figure 4.6) corresponding with the following descriptions:

0. Element not recordable or available
1. No osteoperiostitis present
2. Markedly accentuated longitudinal striations
3. Slight, discrete patch or patches of reactive bone involving less than one quarter of the long bone surface
4. Moderate involvement of the periosteum, but less than one-half of the long bone surface
5. Extensive periosteal reaction involving over half of the diaphysis, with cortical expansion and pronounced deformation
6. Osteomyelitis (infection involving most of the diaphysis with cloacae)
7. Osteoperiostitis associated with a fracture

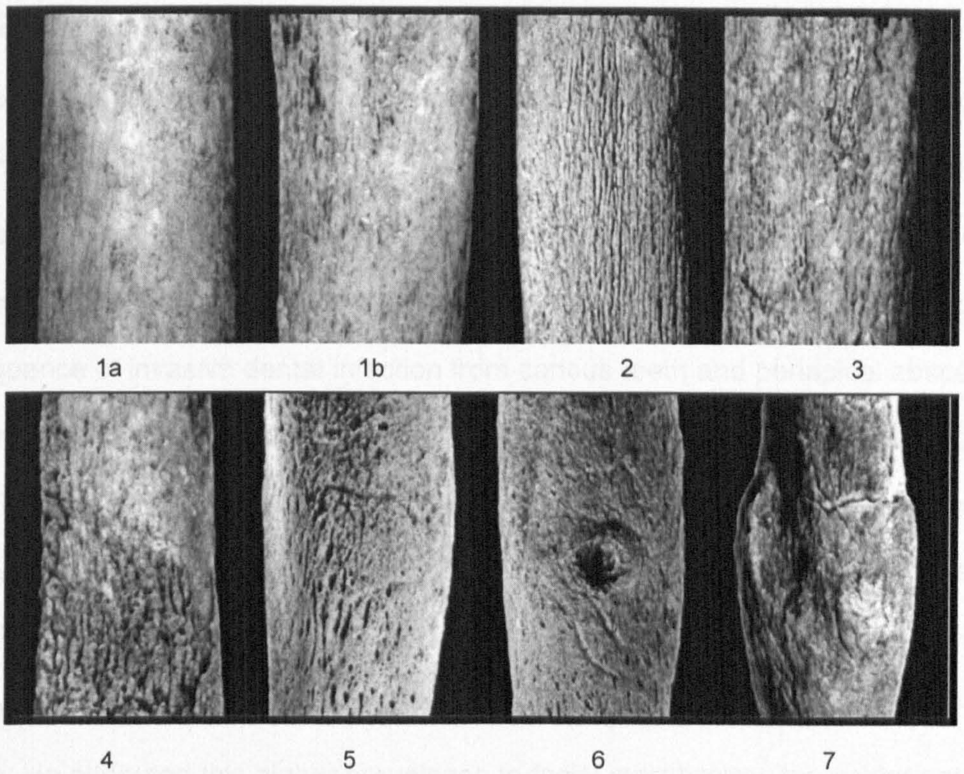


Figure 4.6 *Periosteal new bone formation stages (Steckel et al. 2006: 30-31)*

Only the new bone formation present on the shafts, and not the articular surfaces, of each skeletal element was recorded to prevent confusion with new bone forming in response to inflammation from arthritis and other degenerative joint disease. To enable the prevalence of TPNB in the adult remains of the Black Gate assemblage to be compared with published material from other collections (e.g. Lee 1995; Powell 1996; Lewis 2002a; Buckberry 2004) it was recorded on a present or absent basis. The crude and true prevalence rates of TPNB were calculated. The crude prevalence rate represents the number of individuals within the total population affected. In contrast, the true prevalence rate represents the number of individuals with at least one tibia who exhibit periosteal new bone formation.

The scoring criterion for TPNB describes the type but not severity of the lesion. Due to the many different manifestations that periosteal new bone formation can present, it is not possible to quantify the severity of lesions.

4.2.3.2 Chronic Maxillary Sinusitis

Infection of the maxillary sinus is primarily caused by upper respiratory tract infections but can also result from allergies, air pollution, pollutants and irritants associated with the internal and external environment encountered daily, poor hygiene and congenital predisposition (Lewis *et al.* 1995; Roberts 2007: 795). Maxillary sinusitis can also be a consequence of invasive dental infection from carious teeth and periapical abscesses discharging through the floor of the maxillary sinus cavity (Boocock *et al.* 1995; Lee 1995; Roberts 2007: 794, 801). Several studies have identified links between maxillary sinusitis and living conditions, in particular poor ventilation in living quarters (Wells 1977; Boocock *et al.* 1995; Roberts *et al.* 1998). Calvin Wells documented a higher prevalence of maxillary sinusitis in the Anglo-Saxon period than previous or later periods. He attributed this higher prevalence to facial morphology, the colder and damper climate and an increase in respiratory irritants from agricultural processing of cereals, metalworking and textile production and indoor pollution from the presence of hearths, indoor cooking and poor ventilation (Wells 1977; Boocock *et al.* 1995; Merrett and Pfeiffer 2000; Roberts 2007: 795). Other research has revealed that both rural and urban communities in the later Anglo-Saxon period were predisposed to maxillary sinusitis, but urban communities exhibited a higher prevalence than their rural counterparts (Roberts 2007: 795, 803-4). By analysing the prevalence of chronic maxillary sinusitis within the Black Gate skeletal assemblage inferences could be made about the living and working conditions of the population as a whole. Further detailed analysis into the prevalence of maxillary sinusitis within different components of the population such as adults and immatures, males and females and people provided with elaborate burial rites may provide information on the different conditions encountered by different demographic and socio-economic groups. Further analysis of the prevalences observed in the different sites of known context can enhance the current understanding of the aetiology of maxillary sinusitis and its subsequent expression in the archaeological record.

To preserve the surviving Black Gate skeletal material, analysis was limited to those sinuses exposed by post-mortem damage. Due to the incomplete development of the maxillary sinus in infants and younger children (Lewis 2002a: 37), recording of maxillary sinusitis was restricted to individuals aged over three years. Maxillary sinusitis was recorded as absent or present using the diagnostic criteria and photographs provided by Boocock *et al.* (1995: 486-9), shown in Figure 4.7. The presence of dental palaeopathologies which may impact upon the maxillary sinus were also recorded to enable the relationship between dental health and sinus infection to be determined.

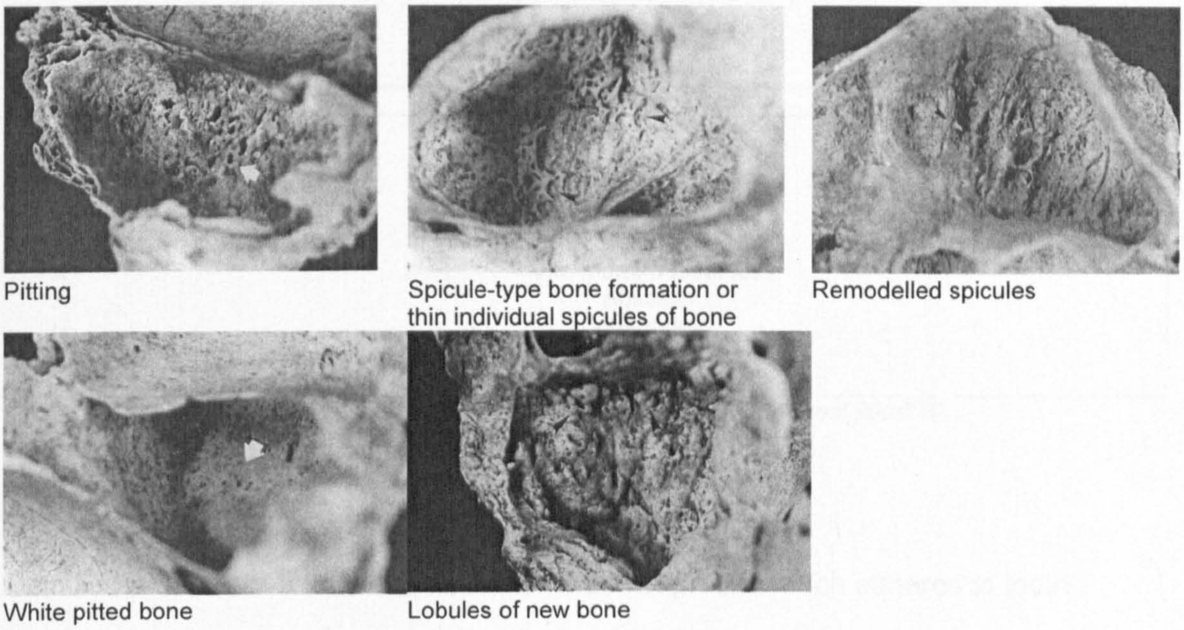


Figure 4.7 *Manifestations of maxillary sinusitis (adapted from Boocock et al. 2005: 486-489)*

4.2.4 Indicators of Environmental Stress: Dental Health

Dental palaeopathologies can be used as quantifiers of oral health in skeletal assemblages, providing valuable evidence for diet, general health, oral hygiene, food preparation techniques and cultural behaviours (Fields *et al.* 2009: 42-3; Meller *et al.* 2009: 287). Two forms of dental palaeopathologies are observable in the Black Gate skeletal assemblage i.e. infectious dental diseases – calculus, dental caries and dental abscesses – and degenerative dental modifications – ante-mortem tooth loss and occlusal attrition (Roberts and Manchester 1995: 44-5). The infectious dental pathologies are most informative about oral health and diet, whereas degenerative dental pathologies provide information on activity and age-related changes to the occlusal surface of the teeth. However, infectious and degenerative dental pathologies are mutually dependent processes (Roberts and Manchester 1995: 44-5). For example, ante-mortem tooth loss can occur from age-related recession of the alveolar bone surrounding the teeth but can also be a reaction to periodontal disease resulting from a build-up of calculus deposits on the teeth.

The dental notation employed in this thesis is adapted from Connel (2004: 8) and is summarised in Table 4.4:

Symbol	Dental Condition
/	Post-mortem loss
C	Caries
NP	Not present
E	Erupting
K	Calculus
X	Ante-mortem tooth loss
A	Abscess
U	Unerupted
PE	Pulp exposed
-	Alveolus and tooth absent

Table 4.4 *Dental notation categories (adapted from Connel 2004: 8)*

4.2.4.1 Calculus

Calculus is a matrix of mineralised bacterial dental plaque which adheres to tooth (supragingival) and root (subgingival) surfaces (Roberts and Manchester 1995; Lieverse 1999). Calculus deposits can harbour pathogenic bacteria, such as *Actinobacillus actynomycetemcomitans*, which can induce bone loss resulting in alveolar bone resorption and tooth decay symptomatic of periodontal disease (Delgado-Darias *et al.* 2006: 664). The durability of calcified calculus deposits means they are frequently recovered in the archaeological record (Hardy *et al.* 2009: 250). Therefore, calculus is a useful means for estimating the prevalence and degree of periodontal disease in any given extinct population. The aetiology of dental calculus is unconfirmed but its formation is believed to be facilitated by an alkaline oral environment, often associated with a protein-rich diet (Hillson 1996; Lieverse 1999) and poor oral hygiene (Hardy *et al.* 2009: 250). Regular and sufficient oral cleansing or self-cleaning dietary practices which detach dental plaque from the teeth prevent the accumulation of plaque biofilms, and their subsequent mineralise into plaque and calculus (Hardy *et al.* 2009: 250). Therefore, differences observed in the frequency and severity of dental calculus between individuals and populations can reveal differences in diet, oral activities and levels of oral hygiene.

The extent of dental calculus formation was recorded using the diagrams presented in Figure 4.8 taken from Brothwell (1981: 155):

0. Unrecordable
1. No calculus
2. Slight calculus build-up
3. Medium calculus build-up
4. Considerable calculus build-up

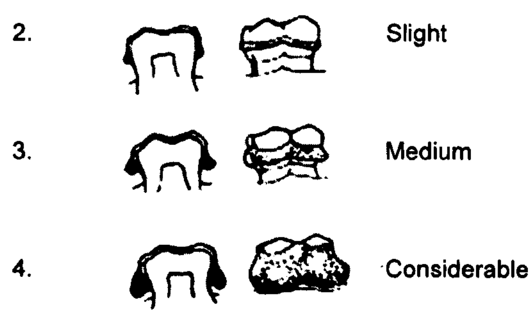


Figure 4.8 *Diagrammatic representations of variations in severity of dental calculus formation (adapted from Brothwell 1981: 155)*

4.2.4.2 Dental Caries

Dental caries is an infectious disease, which causes demineralisation and destruction of the dental enamel. The localised fermentation of food sugars, especially sucrose, by acid forming bacteria within dental plaque demineralises the enamel to form carious lesions (Lukacs 1989: 265; Roberts and Manchester 1995: 45). The appearance of carious lesions varies according to the stage of the disease, ranging in severity from initial white opaque areas and brown discoloured spots to clearly observable cavities (Liebe-Harkort *et al.* 2010: 525). The acids within the dental plaque, which demineralise the dental enamel, are believed to mainly be a response to fermentable carbohydrates present in the diet (Liebe-Harkort *et al.* 2010: 525; DeWitte and Bekvalac 2010: 343). Indeed, several studies show a positive correlation between the prevalence of carious lesions and the adoption of more carbohydrate-rich diets (Delgado-Darias *et al.* 2006; Temple and Larsen 2007; Keenleyside 2008). However, aside from the impact of carbohydrate consumption, several other environmental and biological factors may pre-dispose an individual to the expression of carious lesions. These factors include trace elements within the food and water supply (fluoride), pathogenic agents, oral hygiene, the shape and structure of the teeth and hormonal influences upon the biomechanical composition of saliva and saliva flow (Roberts and Manchester 1995: 45-6; Lukacs and Largaespada 2006).

All adult and immature teeth within the Black Gate assemblage were examined and the number of teeth affected with carious lesions recorded. The number of carious lesions an individual possesses was used to quantify the prevalence of the condition. The severity of each carious lesion observed are recorded as 'small', 'medium' or 'large'. 'Small' lesions are barely discernible perforations of the enamel surface, up to 2 mm in diameter; 'Medium' lesions cover up to 50% of a single surface of an enamel crown and 'Large' lesions cover over 50% of a single enamel crown surface (Lukacs 1989: 267).

4.2.4.3 Dental Abscesses

Dental abscesses predominantly manifest as a consequence of periodontal disease (Roberts and Manchester 1995: 50) or dental caries (Marsh and Martin 1999: 131). However, they may also derive from localised trauma to the tooth or surrounding soft tissue and ante-mortem tooth loss (Ogden 2008b: 51). The accumulation of dental plaque displaces the soft tissue surrounding the tooth creating a periodontal pocket, within which micro-organisms accumulate causing inflammation of the soft tissue. The resultant pus drains from the infected area through the alveolar bone forming a periodontal abscess cavity near to the alveolar margin. This abscess cavity is often referred to as an apical abscess in the palaeopathological literature (Roberts and Manchester 1995: 50; Dias and Tayles 1997). Necrosis of the dental pulp, predominantly related to infection or exposure of the pulp chamber to the oral environment due to destruction of the protective dental enamel and dentine from dental caries, attrition or trauma, also results in the accumulation of pus either within the pulp chamber and root canal or around the root of the tooth. The accumulation of pus can subsequently lead to a periapical abscess at the apex of the root which drains through a sinus penetrating the thin alveolar bone of the maxilla or mandible (Roberts and Manchester 1995: 50; Dias and Tayles 1997: 548, 551; Marsh and Martin 1999: 131; Dias *et al.* 2007: 620).

Many of the proposed dental abscesses within the palaeopathological literature are actually symptomless periapical granulomas or periapical cysts (Dias and Tayles 1997; Ogden 2008a, b). A periapical granuloma is a mass of granulation tissue (a proliferation of fibroblasts and endothelia cells) permeated with inflammatory cells. The granuloma develops as a response to chronic infection and often stimulates osteoclastic activity creating a bony cavity, the walls of which are smoothed by the osteoblast activity of the fibroblasts contained within the granuloma. A periodontal cyst is a subsequent, but not inevitable, development of a periapical granuloma whereby the granulation tissue of the latter is replaced by fluid surrounded by a layer of epithelial tissue lining the walls of the cavity (Dias and Tayles 1997: 549). The differential criteria for granulomas and cysts provided within the palaeopathological literature are that a granuloma is no larger than 3mm in diameter, whereas all larger smooth-walled cavities greater than 3mm in diameter are cysts (Dias and Tayles 1997: 551; Dias *et al.* 2007: 626). The difference between periodontal granulomas and cysts and chronic dental abscesses is difficult to determine macroscopically. However, dental abscesses lack the lining of epithelial cells characteristic of cysts and, therefore, have porous walls which enable a blood supply (Ogden 2008b: 54). Furthermore, a chronic abscess has a clearly defined margin of rounded or thickened remodelled bone resulting from prolonged seepage of pus, whereas both granulomas and cysts are often exposed by post-depositional taphonomic damage, resulting in a sharp edge to the cavity (Ogden 2008b: 53-4).

A high presence of periapical granulomas and cysts and abscesses within a population may indicate a lowered immunological response system (Dias and Tayles 1997: 548), which in turn may result from both poor health and nutrition, but also high environmental stress levels. Consequently, the study of the prevalence of these dental voids can be used to determine the level of dental disease and environmental stress within the Black Gate cemetery. None of the comparative sites utilised in this study differentiate between the different forms of periapical voids and all the reports were written prior to 2007 when publications began to highlight the differences. Therefore, it is probable that all periapical voids have been recorded as dental abscesses. Within this study periapical granulomas and cysts were distinguished from chronic abscess voids during recording using the diagnostic features described above. However, they will be grouped together as 'dental abscesses' within the text and analysis because they all represent an immunological response to infection, and to enable comparison with the prevalence of dental abscesses available for the comparative sites. Dental abscesses are recorded on a present or absent basis along with which tooth is affected. The number and size of dental abscesses an individual possesses will be used to quantify the severity of the condition.The severity of each dental abscess will be scored using the following dimensions of the diameter of the externally visible sinus:

0. No alveolar bone available for analysis
1. Alveolar bone present, no abscess sinus observed.
2. Small (<3mm)
3. Medium (3.0mm-6.9mm)
4. Large (equal to or greater than 7.0mm) (Lukacs 1989: 271).

4.2.4.4 Ante-Mortem Tooth Loss (AMTL)

Ante-mortem tooth loss is often associated with periodontal disease. However, it can also be attributable to dental caries, abscesses and high levels of dental attrition resulting from increasing age or heavy occupational dental wear (Clarke and Hirsch 1991; Cucina and Tiesler 2003: 2). Lukacs (2007: 157-8) summarises the four main causes of AMTL as variations in dietary consistency, nutritional deficiency diseases, cultural or ritual ablation and trauma. Therefore, AMTL can inform about not only the prevalence of periodontal disease, but also the effects of ageing, diet and occupational use of the teeth and cultural traditions. There is very little evidence of trauma overall, let alone facial trauma, amongst the Black Gate skeletons and none of the tooth loss is associated with evidence of trauma. Consequently, the AMTL observed in the Black Gate assemblage is most likely to be a consequence of variations in dietary consistency, nutritional deficiency diseases, the level of periodontal disease and the effectiveness of the immune system of the population at overcoming dental infections. The levels of AMTL in association with levels of occlusal attrition can also inform us of the levels of masticatory stress experienced by the people buried in the cemetery.

AMTL was recognised in this study by resorption and secondary bone growth sealing empty alveolar sockets indicating that the crypt is remodelling, or has remodelled, following the loss of a tooth during life (Freeth 2000: 231). The crude and true prevalence rates were calculated to provide the most detailed profile of AMTL in the Black Gate assemblage for comparison with the contemporary sites. The number of teeth an individual has lost ante-mortem was used to quantify the severity of the condition.

4.2.5 Indicators of Environmental Stress: Skeletal Biomechanical Stress

4.2.5.1 Degenerative Joint Disease (DJD)

The gradual deterioration of the joints is an inevitable consequence of the ageing process (Roberts and Manchester 1995: 99); however, there are several contributing factors affecting its instigation and severity. These factors include biological sex, obesity, trauma, genetic predisposition, congenital malformations, biomechanical stress, physical activity (Jurmain and Kilgore 1995; Rogers and Waldron 1995; Ortner 2003; Weiss and Jurmain 2007; Rojas-Sepulveda *et al.* 2008) and bipedal locomotion (Knüsel *et al.* 1997; Jurmain 2000; Weber *et al.* 2003). Degeneration of the joints is recognisable by porosity, osteophytosis and new bone growth on the joint surfaces of the synovial joints and symphyseal articulations between the vertebral bodies, malformation of the normal joint contour and eburnation, the latter of which is pathognomic of osteoarthritis (Buikstra and Ubelaker 1994: 122-3; Waldron 2009: 25-7). Degenerative joint disease manifests within the vertebral column as osteophytosis, osteochondrosis, degenerative changes of the intervertebral articular processes and costovertebral articular surfaces, and ossification of the supraspinous and longitudinal ligaments and *Ligamentum flava* (Buikstra and Ubelaker 1994: 122-123; Hukuda *et al.* 2000: 110).

Osteoarthritis, the most commonly observed degenerative joint disease in palaeopathological assemblages, has often been used in the literature as an indicator of comparative physiological stress within and between populations and of the type of subsistence economy and lifestyle they experienced (Jurmain 1990; Croft *et al.* 1992; Rojas-Sepulveda *et al.* 2008). However, within the older site reports used for comparison with Black Gate there is often no distinction made between osteoarthritis and non-specific DJD and the diagnostic criteria for determining osteoarthritis is not always described. Consequently, it is not possible to determine the prevalence of osteoarthritis and DJD as separate conditions or if osteoarthritis is in fact osteoarthritis as currently defined, by the presence of eburnation i.e. polished areas on joint surfaces (Rogers and Waldron 1995: 13). Consequently, the prevalence rates of all degenerative changes of articular surfaces are combined and documented within this study.

The degeneration of the appendicular articulations of the shoulder, elbow, wrist, hand, hip, knee, ankle and foot joints (ADJD) were scored using the criteria and diagrams provided by Steckel *et al.* (2006: 32-3) which are adapted from Schultz (1988). These diagrams, shown in Figure 4.9, represent Grades 0 to 4, which are described as:

0. Joint not available for observation.
1. Joint shows no evidence of pathological changes.
2. Slight marginal lipping (osteophytes less than about 3mm) and slight degenerative/productive changes present (left hand column: less than 50%, right hand column: more than 50%). May include some porosity.
3. Severe marginal lipping (osteophytes greater than about 3mm) and severe degenerative/productive changes present, white area: eburnation (left hand column: less than 50%, right hand column: more than 50%). May include substantial porosity.
4. Complete or near complete (more than about 80%) destruction of articular surface (margin and face), including ankylosis.
5. Joint fusion (synostosis).

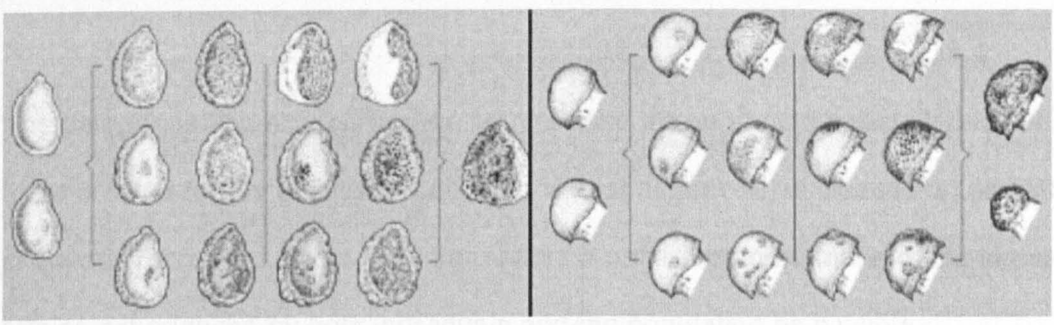


Figure 4.9 *Stages of appendicular degenerative joint disease (adapted from Steckel et al. 2006: 32)*

Degenerative changes in the spine (SDJD) were recorded for each vertebra. Each component – the superior and inferior discal surfaces, the articular processes and costal articular facets – was analysed for signs of degenerative disease. The degree of osteophytosis, porosity (osteochondrosis), and eburnation were given an overall score on the following scale:

0. Element absent or unrecordable
1. Joint shows no evidence of pathological changes.
2. Slight
3. Moderate
4. Severe

Scores 2 to 4 correspond with Grades I to III illustrated by Brothwell (1981: 150) and the very similar Grades 1 to 3 described by Steckel *et al.* (2006: 13, adapted from Walker 2001) shown in Figure 4.10

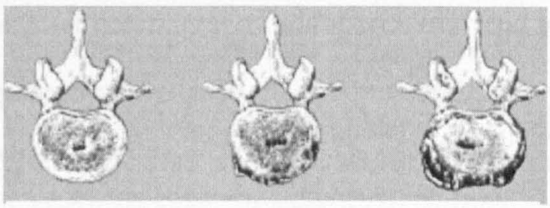


Figure 4.10 *Stages of spinal degenerative joint disease (adapted from Steckel et al. 2006: 13)*

Schmorl's nodes are excluded from the current study because, despite their strong association with degenerative joint disease (Buikstra and Ubelaker 1994; Aufderheide-Rodriguez-Martin 1998; Üstündağ 2009), they have been ascribed several aetiologies, including congenital predisposition and trauma (Üstündağ 2009).

The categories and scoring system summarised above should enable a detailed picture to be created for the distribution and intensity of degenerative disease on each of the skeletons recovered. From this information, a profile could be made of the stresses and strains experienced by both individuals and the population as a whole.

4.2.5.2 Trauma

Trauma manifests upon the skeleton in several ways, including a partial or complete break in a bone (fracture), abnormal displacement or dislocation of a bone, disruption of nerve or blood supply, osteochondritis dissecans on joint surfaces and artificially induced abnormalities in the shape or contour of a specific bone (Roberts 2000: 338). Accidental injuries predominantly manifest in the long bones and reflect the hazards associated with specific occupations and activities involved in day-to-day living (Steckel *et al.* 2002a: 146). For example, traversing rugged, mountainous terrain results in ankle and wrist injuries (Steckel *et al.* 2002a: 146), whereas high levels of physical activity are typically associated with fractures to the lower limb, distal radius, clavicles and ribs (Larsen 1997: 110). Occupational traumas derive from repetitive or sudden stresses imposed upon the skeleton during an individual's working life. For example, collapsed vertebrae are often inferred to be a consequence of carrying heavy loads (Schwartz 1995: 245). Spondylolysis – fracturing of a neural arch from the vertebral body – is often cited as a consequence of repeated trauma imposed upon the neural arch through bending and lifting associated with agricultural activities (Roberts and Cox 2003: 202). Roberts and Cox (2003) and Judd and Roberts (1999) have explored the relationship between skeletal trauma and occupational stresses associated with farming in the late Anglo-Saxon period, giving several examples, and concluded that farming posed a greater number of traumatic risks to those involved than the craft activities undertaken in the urban settlements.

All skeletal traumas, including both peri-mortem and healed fractures, observed in the Black Gate assemblage were recorded to determine any prevalence or patterns which may be indicative of occupation. Attention was paid to whether there were any differences in the prevalence rates of individuals interred in elaborate burials in comparison to those interred in plain earth-cut graves.

4.3 Data Analysis

The pathology and burial practice data were entered into a Microsoft Excel spreadsheet to enable easy manipulation of the data and analysis of the raw numbers and percentages for inter- and intra-site comparisons. To enable statistical analysis these data were transferred into SPSS (Statistical Package for Social Science) Version 16.0.

The data analyses within this thesis centred on cross-tabulation of biological and social variables, with significance testing to assess the probability of the relationship between the two. Prior to any statistical analysis a frequency histogram was created in SPSS 16.0 and a Kolmogorov-Smirnov test was applied to each variable to determine if the data are normally distributed (i.e. the distribution fits the bell-shaped normal curve in a frequency histogram) (McDonald 2008: 4). If a normal distribution was observed, the data were analysed using parametric tests. T-tests were used to compare two variables and one way ANOVA were used to investigate relationships between one ranked and one-discontinuous variable. If a non-normal distribution was observed, non-parametric tests were applied. The Chi-squared test of independence (χ^2) was used to identify basic correlations between categorical groups of data such as biological sex, pathology and burial practices. In each case, the null hypothesis was that there is no significant difference between the pathological, demographic or social variables. The threshold for rejection of the null hypothesis was set to 0.05. If the Chi-squared test result approached or reached statistical significance when using a two-by-two contingency table a Yates correction for continuity was calculated to ensure the result was significant. Due to the small number of elaborate burial types, grave types and grave variations it was occasionally necessarily, when counts for a specific variable were less than 5, to employ a Fisher's Exact test (Gould and Gould 2002). For the majority of statistical tests the degree of freedom (d.f.) value was 1. Only in instances where this was not the case the d.f. value included in the statistical summary within the text. In instances where non-normally distributed numerical values were investigated, as when comparing age distributions between comparative sites, a Wilcoxon-Mann-Whitney test was applied. This test is the most powerful test to identify if the summed ranks of individual ages are significantly different between samples (Chamberlain 2006: 44).

When employing a significance value of 0.05, 5 of every 100 statistical tests will return a significant result, even within a random data set (Robb 2000: 483). The following study addresses such false positives by interpreting the statistically significant results in relation to the trends in the data. Any statistically significant result that does not correspond with a real trend in the data is rejected.

CHAPTER 5

RESULTS OF BLACK GATE HEALTH INDICATOR ANALYSIS

The results of the osteological analysis of the Black Gate skeletal assemblage are presented in this chapter. The purpose of this chapter is to document the health profile presented by the 643 articulated skeletons, which were available for analysis. Growth rates and adult stature are assessed to determine the extent to which the living conditions experienced by the Black Gate contributing population has impacted upon skeletal growth in comparison to other sites from the Anglo-Saxon period. Adult stature will also be compared between adult males and females to determine the extent of sexual dimorphism, which may indicate disparity in the diet, health and environmental influences upon the two sexes. The true prevalence rates (TPRs) (as defined in Chapter 4) of each stress related palaeopathological condition is then documented. Comparisons will be made of the prevalence of health indicators between immatures and adults. Within the adult component of the Black Gate assemblage, the prevalence rate of each health indicator will be discussed in terms of the different age and sex categories. This will determine if there were different levels of physiological stress experienced by different members of the contributing population. The severity of the pathological lesions observed in the immature and adult assemblages will be analysed when it is feasible. The distribution and severity of ADJD, SDJD and trauma within the Black Gate assemblage are analysed to investigate if any differing physical and occupational stresses upon the skeleton had affected the rate of degeneration or resulted in specific skeletal traumas within the different age and sex categories. The prevalences observed are compared with contemporary skeletal assemblages to identify if any of the comparative sites exhibit similar levels of skeletal stress, which may indicate similarities in daily activities or occupation. The term 'Total Assemblage' refers to the combined sum of the entire adult (n = 441) and immature (n = 202) articulated skeletons which were available for analysis. The term 'Recordable

Assemblage' refers to the total number of skeletons within the Black Gate assemblage for which a specific pathological lesion could be recorded.

5.1 The Black Gate Cemetery Preservation and Assemblage Composition

5.1.1 The Black Gate Cemetery: Skeletal Assemblage Preservation

Overall preservation (Table 5.1), quantified by factors such as the extent of cortical erosion, damage to the epiphyseal surfaces and organic staining etc., was recorded for each individual.

Age Category	Grade 1 Destroyed		Grade 2 Poor		Grade 3 Good		Grade 4 Excellent	
	N	%	N	%	N	%	N	%
Pre-Infant	0	0.00	7	1.09	18	2.80	1	0.16
Infant	3	0.47	15	2.33	30	4.67	1	0.16
Young Child	2	0.31	29	4.51	36	5.60	1	0.16
Older Child	0	0.00	13	2.02	13	2.02	5	0.78
Adolescent	0	0.00	15	2.33	13	2.02	0	0.00
Young Adult	0	0.00	16	2.49	19	2.95	1	0.16
Prime Adult	2	0.31	45	7.00	41	6.38	0	0.00
Mature Adult	2	0.31	44	6.84	47	7.31	5	0.78
Senior Adult	1	0.16	66	10.26	62	9.64	4	0.62
Immature Total	5	0.78	79	12.29	110	17.11	8	1.24
Adult Total*	12	1.87	209	32.50	210	32.66	10	1.56

Table 5.1 *Degree of preservation for each age category within the Black Gate cemetery (* = adult total includes 86 adults of unknown age; N = number of individuals expressing grade of preservation; % = percentage of total assemblage of 643 individuals)*

Close to half of the total assemblage exhibited good preservation (49.8%; 320/643) and a similar percentage (44.8%; 288/643) showed poor preservation. A nominal number of skeletons fit the extreme preservation categories of *excellent* and *destroyed*, which constituted only 2.8% (18/643) and 2.6% (17/643) of the total assemblage respectively. Comparable frequencies of *poor/destroyed* (50.1%; 221/441) and *good/excellent* (49.9%; 220/441) preservation were observed amongst the adults, whereas a slightly higher frequency of *good/excellent* preservation (58.4%; 118/202) was observed amongst the immatures in comparison to the frequency recorded as *poor/destroyed* (41.1%; 83/202). Overall, the osteological information available through macroscopic analysis of the Black Gate assemblage was good, with less than 3.0% of individuals being too destroyed to provide any osteological information.

Condition	Completeness 1 0-24%		Completeness 2 25-49%		Completeness 3 50-74%		Completeness 4 75-100%		Total	
	N	%	N	%	N	%	N	%	N	%
Grade 0	2	0.31	1	0.16	1	0.16	2	0.31	6	0.93
Grade 1	38	5.91	21	3.27	22	3.27	47	7.31	128	19.91
Grade 2	60	9.33	48	7.47	39	7.47	64	9.95	211	32.81
Grade 3	39	6.07	40	6.22	34	6.22	53	8.24	166	25.82
Grade 4	34	5.29	26	4.04	19	4.04	23	3.58	102	15.86
Grade 5	16	2.49	6	0.93	3	0.93	4	0.62	29	4.51
Grade 5+	1	0.16	0	0.00	0	0.00	0	0.00	1	0.16
Total	190	29.56	142	22.09	118	22.08	193	30.02	643	103.64

Table 5.2 *Condition and completeness of skeletons recovered from the Black Gate Cemetery (N = no. of individuals, % = percentage of total population; grades of cortical erosion 0-5+ = as defined in Chapter 4)*

Within the Black Gate skeletal assemblage, slightly more than half of the skeletons (51.6%; 332/643) were less than 50% complete. Individuals recorded as 0-24% (29.5%; 190/643) and 75-100% (30.0%; 193/643) complete were essentially equally represented within the assemblage. These figures indicate a high frequency of incomplete skeletons; however more than a quarter of the bone elements were available for analysis in 70.5% (453/643) of the individuals recovered.

There was no direct correlation between the extent of cortical erosion (condition) and the percentage of the skeleton surviving (completeness) (Table 5.2). The total assemblage shows little evidence for severe cortical erosion. The high proportion of the population displaying Grade 1-3 cortical erosion (79.5%; 511/643) demonstrates the slight to moderate erosion of the skeletons within the assemblage overall. Only a nominal percentage (4.7%; 30/643) of individuals exhibited complete destruction of the cortical bone represented by Grades 5 and 5+. Consequently, cortical bone was observable for osteological analysis in a high percentage of individuals within this assemblage, reducing the risks of under- and mis-diagnosis of palaeopathological lesions. The low levels of cortical erosion seen in the least complete individuals (Table 5.2) indicates that the loss of skeletal elements was not the result of the poor preservation of the bone, as the surviving bone was in good to moderate condition. It may be inferred from this that non-taphonomic factors resulted in the incomplete skeletons recovered, such as truncation of burials by later graves or the construction of the castle and modern railway arches.

Burial Location	Grade 1 Destroyed		Grade 2 Poor		Grade 3 Good		Grade 4 Excellent	
	N	%	N	%	N	%	N	%
Compound	4	2.23	64	35.75	102	56.99	9	5.03
Area C	3	2.00	56	37.33	87	58.00	4	2.67
Railway Arches	8	2.84	155	54.96	114	40.42	5	1.77
Area D	1	5.56	10	55.55	7	38.89	0	0.00

Table 5.3 *Degree of preservation for each burial location within the Black Gate cemetery (N = number of individuals expressing grade of preservation; % = percentage of total assemblage of 629 individuals)*

The level of skeletal preservation was also recorded for each of the burial locations to identify if there would be any preservation bias in the investigation of health and burial relative to the different areas of burial within the cemetery. It is clear that the Compound and Area C included a greater number of 'good' or 'excellent' preserved skeletons than the Railway Arches and Area D (Table 5.3). However, even though a greater proportion of the burials in the latter locations were recorded as being in poor condition, it is apparent from the overall skeletal assemblage, that these individuals would still be viable for osteological analysis and recording palaeopathological lesions. Indeed, all four locations contained low frequencies of destroyed skeletons. Overall, the skeletons were sufficiently preserved in each locality to not pose any analytical problems or biases in the data recorded.

5.1.2 The Black Gate Cemetery: Skeletal Assemblage Composition

A total of 643 Black Gate skeletons underwent osteological analysis. Of these, 202 (31.4%) were immatures and 441 (68.6%) were adults. The mortality profile (Figure 5.1) showed an increase from birth peaking in the young childhood age category, followed by a reduction in older childhood, adolescence and young adulthood, and then increasing to a peak in senior adulthood.

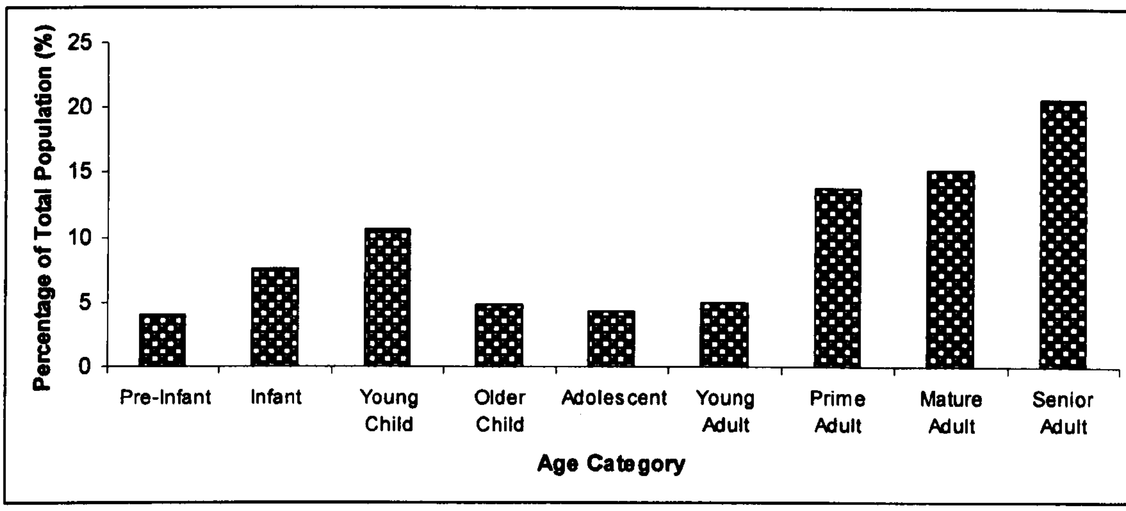


Figure 5.1 *Mortality profile of the Black Gate cemetery assemblage represented by percentage of the total population (643) (excludes 90 adults of unknown age and sex)*

Table 5.3 shows the age and sex composition of the 553 individuals for which this information was available. Within the adult population, 69.2% (305/441) were assigned a definite biological sex (Table 5.4). To maximise the numbers of individuals of known sex available for analysis, the probable males (male?) and females (female?) were pooled with the definite males and females to create simple 'male' and 'female' categories (Figure 5.2) which are used throughout the rest of this thesis. The proportion of males and females constituting the total adult population was fundamentally the same (male = 40.4%, 178/441; female = 39.2%, 173/441).

Age Category	Unknown		Male		Male?		Female		Female?		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Pre-Infant	26	4.04	-	-	-	-	-	-	-	-	26	4.04
Infant	49	7.62	-	-	-	-	-	-	-	-	49	7.62
Young Child	68	10.58	-	-	-	-	-	-	-	-	68	10.58
Older Child	31	4.82	-	-	-	-	-	-	-	-	31	4.82
Adolescent	28	4.35	-	-	-	-	-	-	-	-	28	4.35
Young Adult	0	0.00	17	2.64	2	0.31	11	1.71	2	0.31	32	4.98
Prime Adult	5	0.78	36	5.60	5	0.31	36	5.60	6	0.93	88	13.69
Mature Adult	4	0.62	39	6.07	6	0.93	43	6.69	6	0.93	98	15.24
Senior Adult	2	0.31	59	9.18	8	1.24	59	9.18	5	0.78	133	20.68
Total*	213	33.13	151	23.48	21	3.27	149	23.17	19	2.95	553*	86.00

Table 5.4 Assemblage composition (age and biological sex) of the Black Gate cemetery assemblage represented by raw numbers and percentages of the total population (643) (= excludes 90 adults of unknown age and sex)*

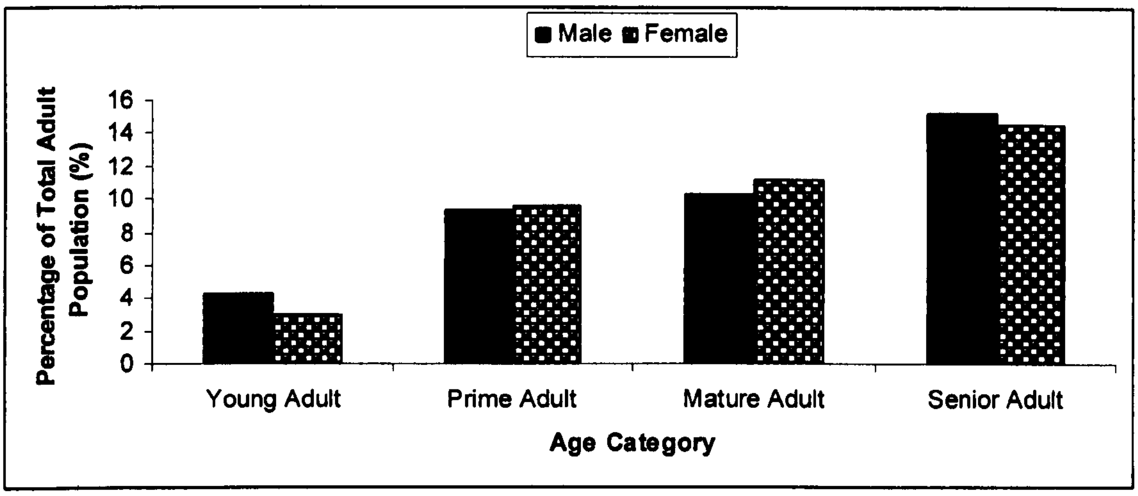


Figure 5.2 *Biological sex profiles for each adult age category within the Black Gate cemetery assemblage consolidating sex categories into male and female and excluding individuals of unknown sex (N = 340 individuals)*

5.2 Indicators of Environmental Stress: Growth and Development

The summary statistics for both immature growth and adult stature are provided in Appendix B, Tables B.1-B.4.

5.2.1 Immature Growth

Dental age and femoral diaphyseal length at death were recorded for 57 Black Gate immatures aged 0 to 15 years. Figure 5.3 shows the relationship between the mean femoral diaphyseal length and age-at-death divided into one year categories for Black Gate and equivalent data for two medieval rural sites – Raunds Furnells and Wharram Percy – and two urban sites – St Helen-on-the-Walls and Spitalfields (Lewis 2002a: 40). For the age categories where no data were available, the mean value for the age categories above and below the missing value was calculated providing an estimated diaphyseal length (Appendix B, Table B.1).

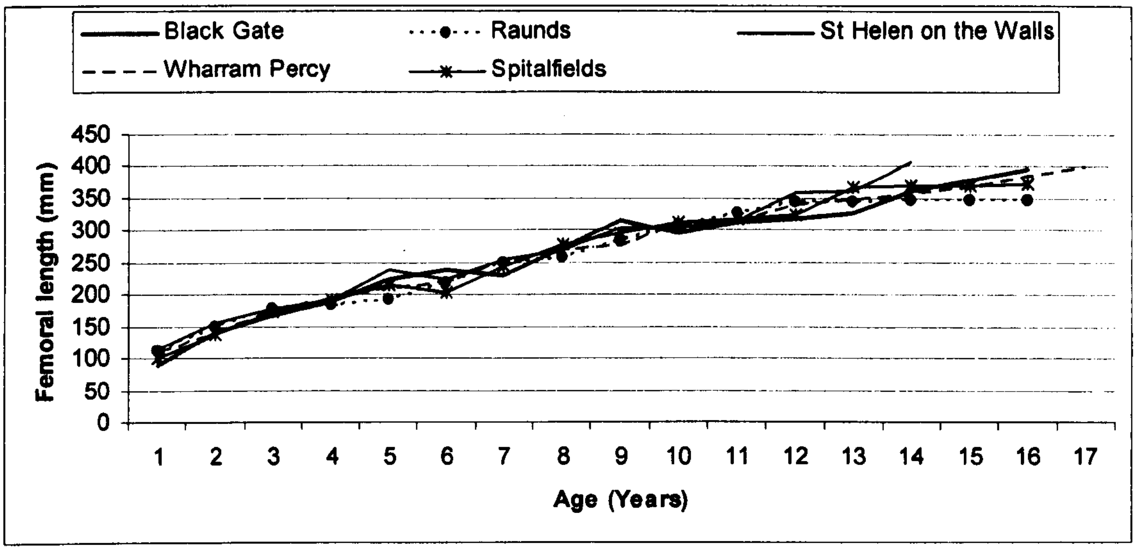


Figure 5.3 *Skeletal growth profiles: femur diaphyseal length versus dental age (adapted from Lewis 2002b: 215: Figure 5.3)*

The Black Gate immatures showed a significant increase in femoral diaphyseal length with advancing age. There were some fluctuations, resulting from the small number of individuals in some of the age categories and estimated mean diaphyseal length in others when no data were available. Comparisons of the mean femoral diaphyseal length for each age category between Black Gate and the four additional sites revealed no consistent patterns. A one-way ANOVA test showed no statistically significant difference in the mean femoral length-at-age data for each immature age category between the five sites ($F = 5.220$; $P = 0.756$) (Appendix B, Table B.3). Consequently, the Black Gate immature growth profile was indistinguishable from both rural and urban sites of the early and later medieval period and, indeed, even the post-medieval industrial site of Christ Church, Spitalfields.

5.2.2 Adult Stature

Stature calculated from femoral length was recordable for 161 of the Black Gate adult skeletons (77 male, 78 female and 6 of unknown sex). The mean adult stature was 169.9 ± 6.28 cm (with a range of 149.70-185.17 cm) for males and 161.5 ± 5.62 cm (with a range of 148.99-181.60 cm) for females. The mean adult stature for the observable adults was 165.70 ± 7.27 cm (with a range of 148.99 cm-185.17 cm). The difference in stature observed between the Black Gate males and females was statistically significant ($t = 8.768$; $P = 0.000$) (Appendix B, Table B.4).

The mean average stature estimates for the early medieval period (410-1066), including the later Anglo-Saxon period, have been calculated as 172 cm (with a range of 170-182 cm) for males and 161 cm (with a range of 152 cm-170 cm) for females, with a combined mean average stature of 166.5 cm (Roberts and Cox 2003: 195). The Black Gate stature estimates showed that the males were on average 2 cm shorter than the average for males during the Anglo-Saxon period while the females were 0.5 cm taller than the female average; nonetheless, both were within the ranges calculated for both Black Gate and the early medieval period. Thus, the male and female statures recorded for Black Gate were typical for the period. Chapters 6 and 7 provide further discussions of the relationship between stature, status and settlement type.

5.3 Indicators of Environmental Stress: Non-Specific Stress

The summary statistics for true prevalence rates and severity of the non-specific stress indicators observed in the Black Gate cemetery are provided in Appendix B, Tables B.5 to B.29.

5.3.1 Cribra Orbitalia and Porotic Hyperostosis

Within the Black Gate assemblage, 327 individuals possessed at least one orbit available for analysis of cribra orbitalia (Figure 5.4). Of these, 124 were immatures and 203 were adults. The TPR of cribra orbitalia for the total assemblage was 33.6% (110/327). The TPRs for immatures and adults were 52.4% (65/124) and 22.2% (45/203) respectively. There was a statistically significant higher true prevalence of cribra orbitalia amongst the immature assemblage when compared to the adults ($\chi^2 = 30.556$; $P = 0.000$).

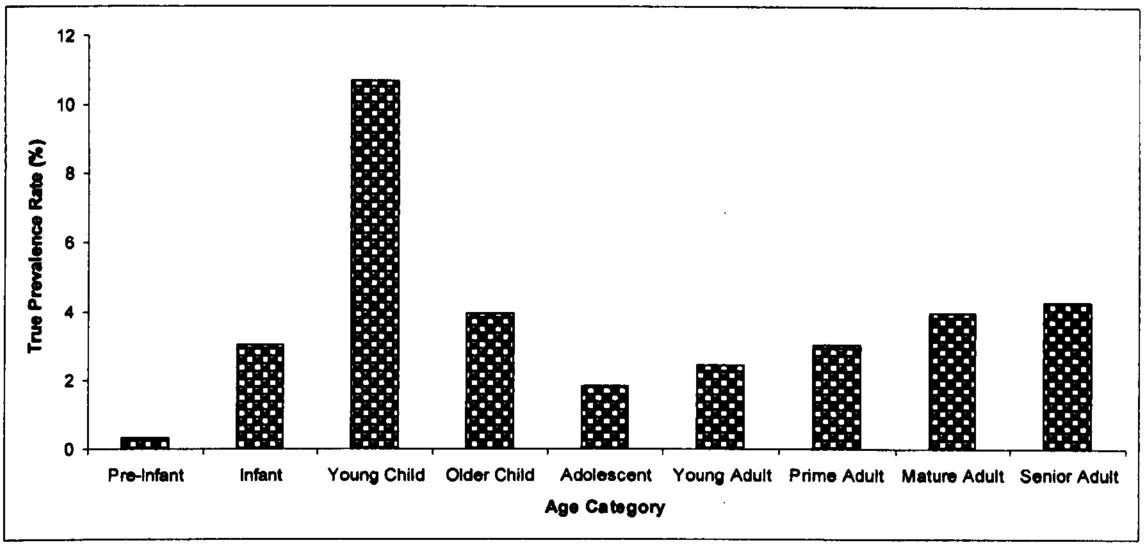


Figure 5.4 *True prevalence rates in percentages for cribra orbitalia for each age category within the Black Gate assemblage (n = 327)*

The highest TPR of cribra orbitalia for the total recordable assemblage was amongst the young child age category (10.7%; 35/327). Comparisons of the frequency of cribra orbitalia in each age group showed a significant difference (χ^2 = 4.165; P = 0.000). Figure 5.4 shows that the difference was random – created by the higher prevalence of cribra orbitalia in the young child age category – and did not result from increasing prevalence with age. The true prevalence of cribra orbitalia increased with advancing age amongst the adults (Figure 5.4). However, the increase between successive age categories was too slight to be statistically significant.

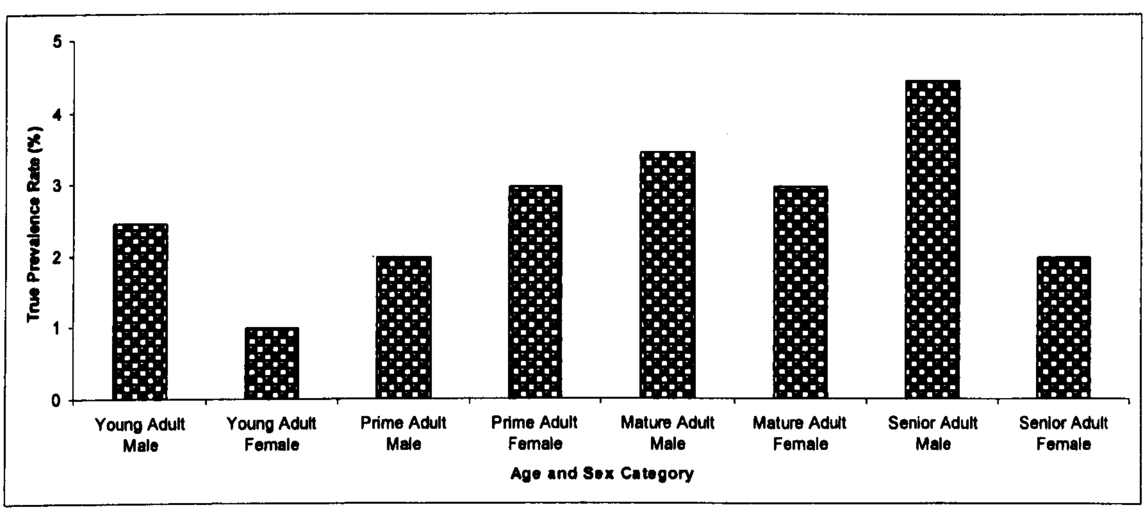


Figure 5.5 *True prevalence rates in percentages for cribra orbitalia for each adult age and sex category within the Black Gate assemblage (n = 203)*

There was no statistically significant difference in the prevalence of cribra orbitalia between males and females (Figure 5.5). There was no statistically significant difference between the sexes in increasing age categories

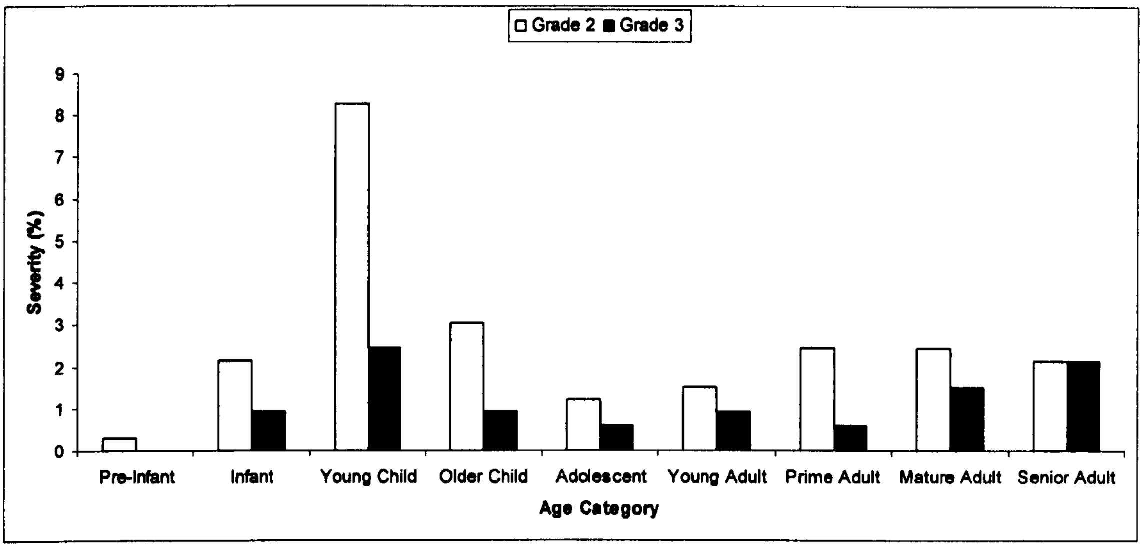


Figure 5.6 *Severity in percentages for cribra orbitalia for each age category within the Black Gate assemblage (n = 327) (Grade 2 = A cluster of mostly fine foramina covering a small area (≤1 cm²), Grade 3 = Substantial area (> 1 cm²) covered by small and/or larger foramina with a tendency to cluster together)*

Figure 5.6 shows the percentage of the recordable population in each age category exhibiting mild (Grade 2) or severe (Grade 3) cribra orbitalia. Both Grade 2 (8.3%; 27/327) and Grade 3 (2.4%; 8/327) were most frequent in the young child age category. There was no statistically significant difference in the severity of cribra orbitalia between the immature and adult remains. There was no statistically significant increase in the severity of cribra orbitalia with advancing age for either the total population or adults only.

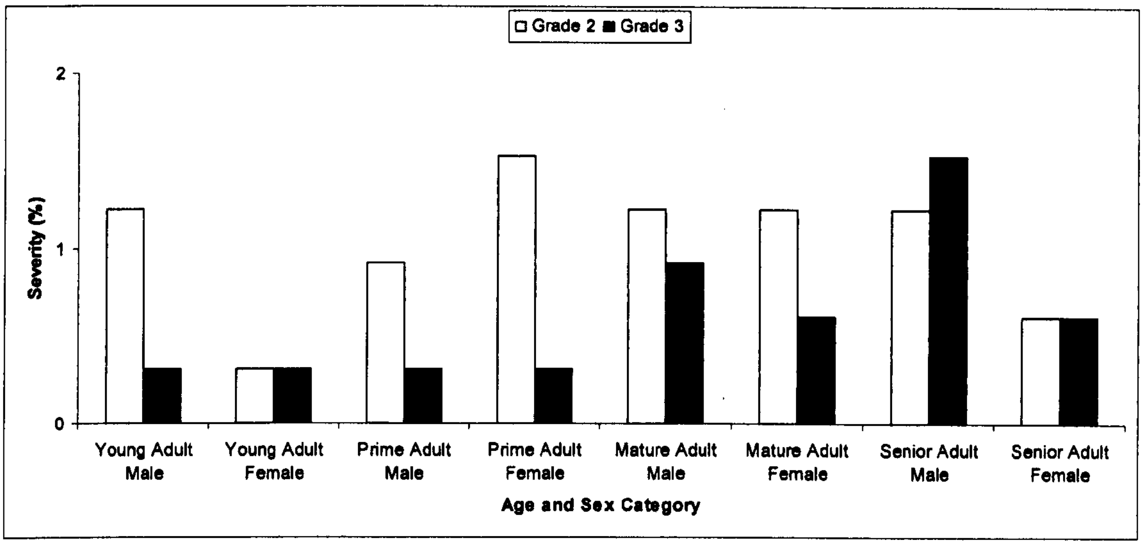


Figure 5.7 *True prevalence rates and severity in percentages for cribra orbitalia for each adult age and sex category within the Black Gate assemblage (n = 203) (Grade 2 = A cluster of mostly fine foramina covering a small area (≤1 cm^2), Grade 3 = Substantial area (> 1 cm^2) covered by small and/or larger foramina with a tendency to cluster together)*

There was no significant difference in the severity of cribra orbitalia recorded for males and females in general or within each age category (Figure 5.7).

Within the total Black Gate assemblage, 374 individuals had cranial vault bones available for analysis of porotic hyperostosis (Figure 5.8). Of these, 139 were immatures and 235 were adults. The TPR of porotic hyperostosis within the total assemblage was 6.4% (24/374). The TPRs for immatures and adults were 11.5% (16/139) and 3.4% (8/235) respectively. There was a statistically significant higher prevalence of porotic hyperostosis amongst the immature population than observed amongst the adults (χ^2 = 9.226; P = 0.002).

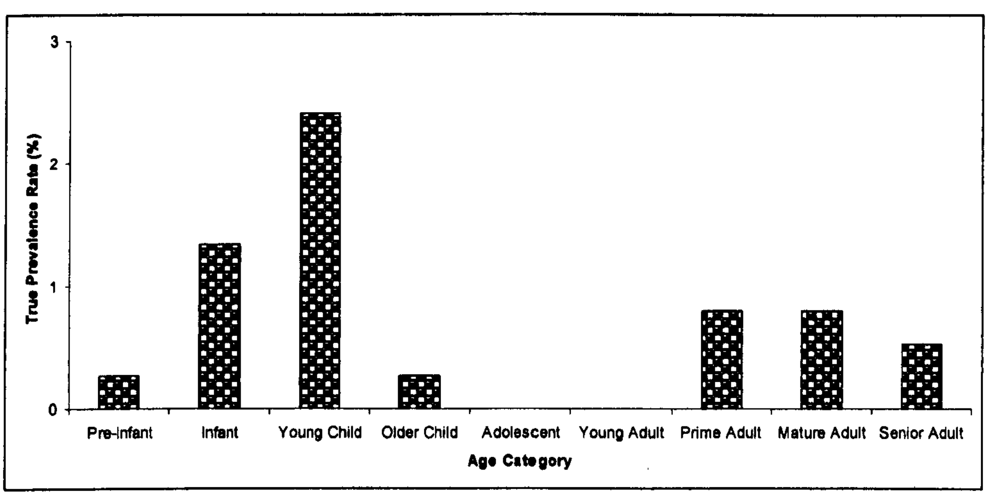


Figure 5.8 *True prevalence rates in percentages for porotic hyperostosis for each age category within the Black Gate assemblage (n = 374)*

The true prevalence for porotic hyperostosis was highest in the young child age category (2.4%; 9/374). There was a statistically significant difference in the prevalence of porotic hyperostosis in each age category from pre-infant through to senior adult age categories (χ^2 = 20.708; P = 0.008). Figure 5.8 shows that the difference in porotic hyperostosis between the age categories did not represent an increase in prevalence with advancing age. The difference was a consequence of the higher prevalence in the young child age category. There was no statistically significant increase in the prevalence of porotic hyperostosis with advancing age amongst the adults.

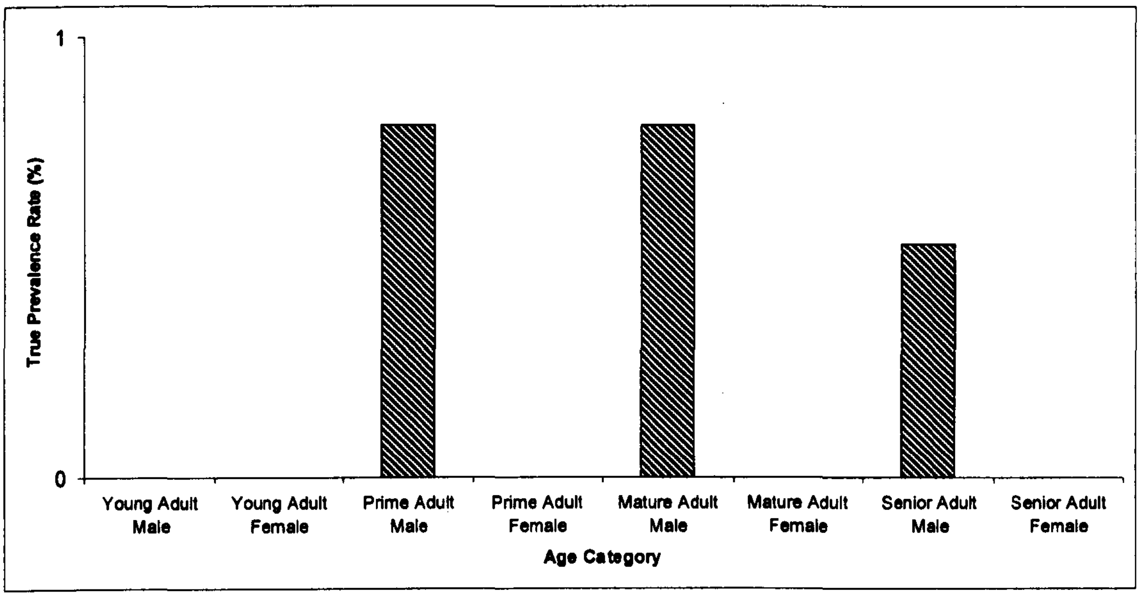


Figure 5.9 *True prevalence rates in percentages for porotic hyperostosis for each adult age and sex category within the Black Gate assemblage (n = 441)*

Figure 5.9 shows the TPRs for porotic hyperostosis recorded for each adult age and sex category. All the adults of known sex expressing porotic hyperostosis were male (2.1%; 5/235) resulting in a statistically significant difference between males and females (χ^2 = 8.294; P = 0.004). There were no recorded cases amongst the young adults, and only male skeletons exhibited porotic lesions of the parietals in the prime, mature and senior adult age categories.

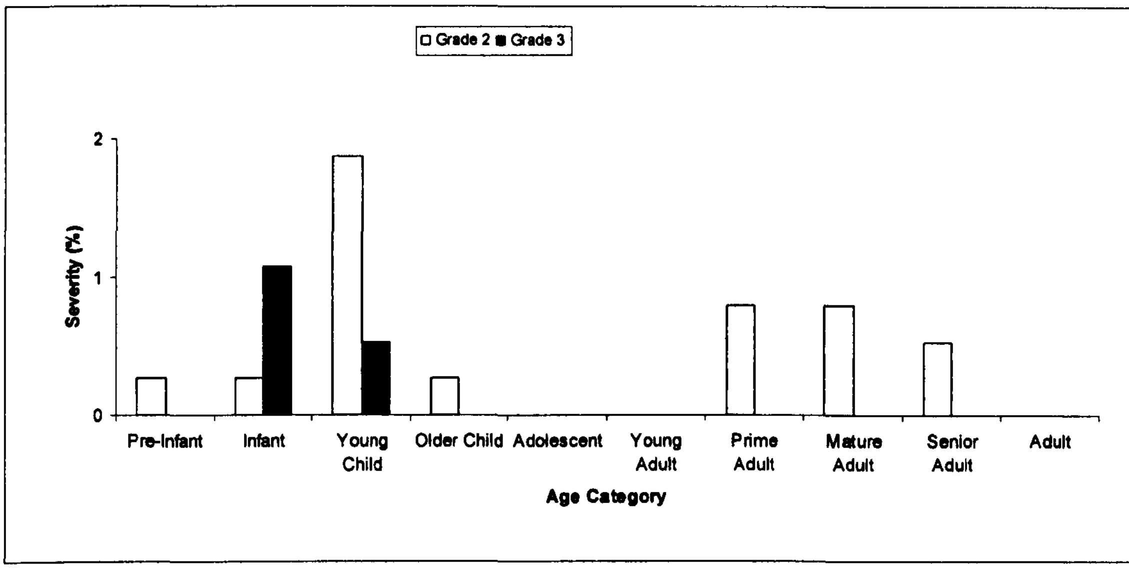


Figure 5.10 *True prevalence rates and severity in percentages for porotic hyperostosis for each age category within the Black Gate assemblage (n = 327) (Grade 2 = presence of slight pitting or severe parietal porosity, Grade 3 = gross parietal lesion with excessive expansion and exposed diploë)*

Figure 5.10 shows the percentage of individuals exhibiting mild (Grade 2) or severe (Grade 3) porotic hyperostosis in each age category. Grade 3 porotic hyperostosis was only present in the infant (1.1%; 4/374) and young child (0.5%; 2/374) age categories. No adult individuals exhibited Grade 3 lesions; therefore, the relationship between the severity of porotic hyperostosis in immatures and adults and increasing age could not be investigated.

5.3.2 Dental Enamel Hypoplasia

Figure 5.11 shows the TPRs for DEH for each age category. A total of 226 individuals possessed one or more anterior teeth suitable for analysis of DEH. Of these, 39 were immatures and 187 were adults. The TPR for the total assemblage was 54.0% (122/226). The TPRs for immatures and adults within the Black Gate assemblage were 56.4% (22/39) and 53.5% (100/187) respectively. There was no significant difference in the prevalence of DEH in immatures and adults.

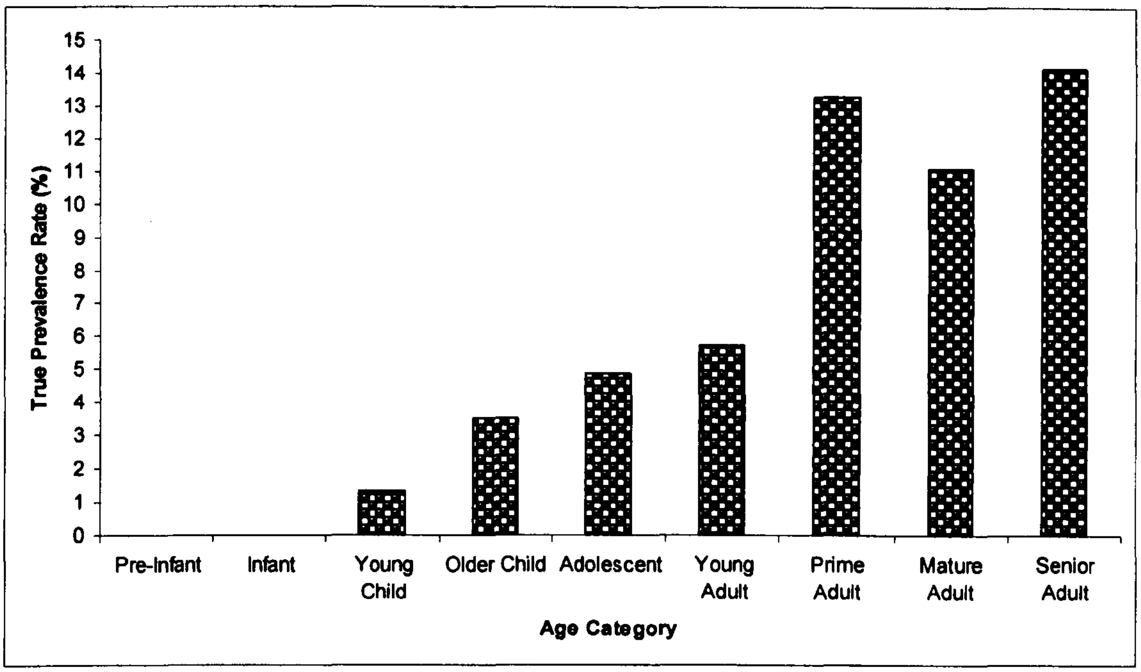


Figure 5.11 *True prevalence rates in percentages for dental enamel hypoplasia for each age category within the Black Gate assemblage (n = 643)*

The highest TPR of DEH for the total recordable population was amongst the senior adult age category (14.2%; 32/226). There was no significant increase in the true prevalence of DEH with age for the total population, or amongst adults only.

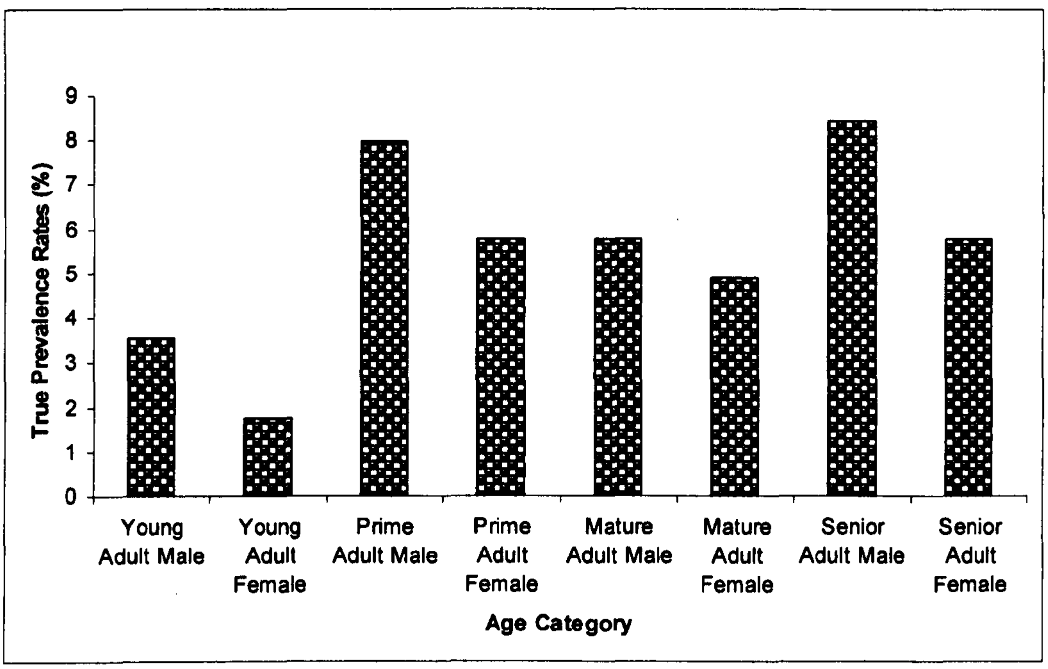


Figure 5.12 *True prevalence rates in percentages for dental enamel hypoplasia for each adult age and sex category within the Black Gate assemblage (n = 441)*

There was no statistically significant difference in the frequencies of DEH between males and females (Figure 5.12). In the young (male = 3.5%; female = 1.77%), prime (male = 8.0%; female = 5.7%), mature (male = 5.7%; female = 4.9%) and senior (male

= 8.4%; female = 5.7%) age categories there was a higher prevalence of males expressing enamel hypoplasias than females. However, these higher prevalences of DEH observed in the males were not significantly different from the female prevalences (Appendix B, Table B.24).

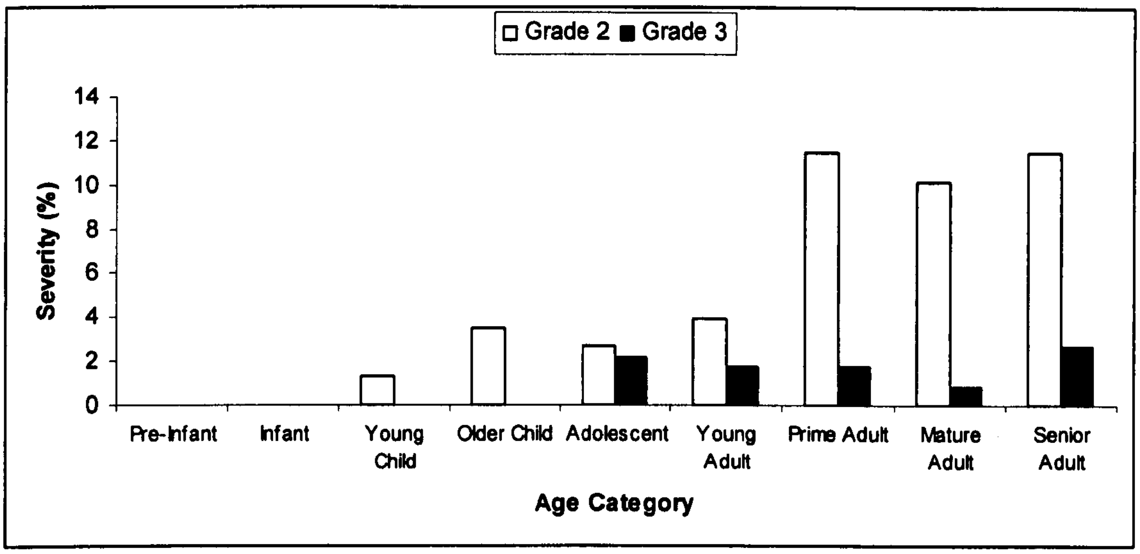


Figure 5.13 *Severity in percentages for dental enamel hypoplasia for each age category within the Black Gate assemblage (n = 203) (Grade 2 = one hypoplastic line present, Grade 3 = two or more hypoplastic lines present)*

Figure 5.13 shows the percentage of individuals exhibiting mild (Grade 2) and severe (Grade 3) DEH within each age category. The majority of individuals exhibited Grade 2 DEH manifest as a single band of disrupted enamel formation (82.8%; 101/122). The most severe cases of DEH were in the senior adult age category. There was a statistically significant higher occurrence of Grade 3 DEH amongst the Black Gate adults compared with the immatures (χ^2 = 12.860; P = 0.000). There was no statistically significant relationship between severity of DEH and advancing age for either the total population or the adult assemblage only.

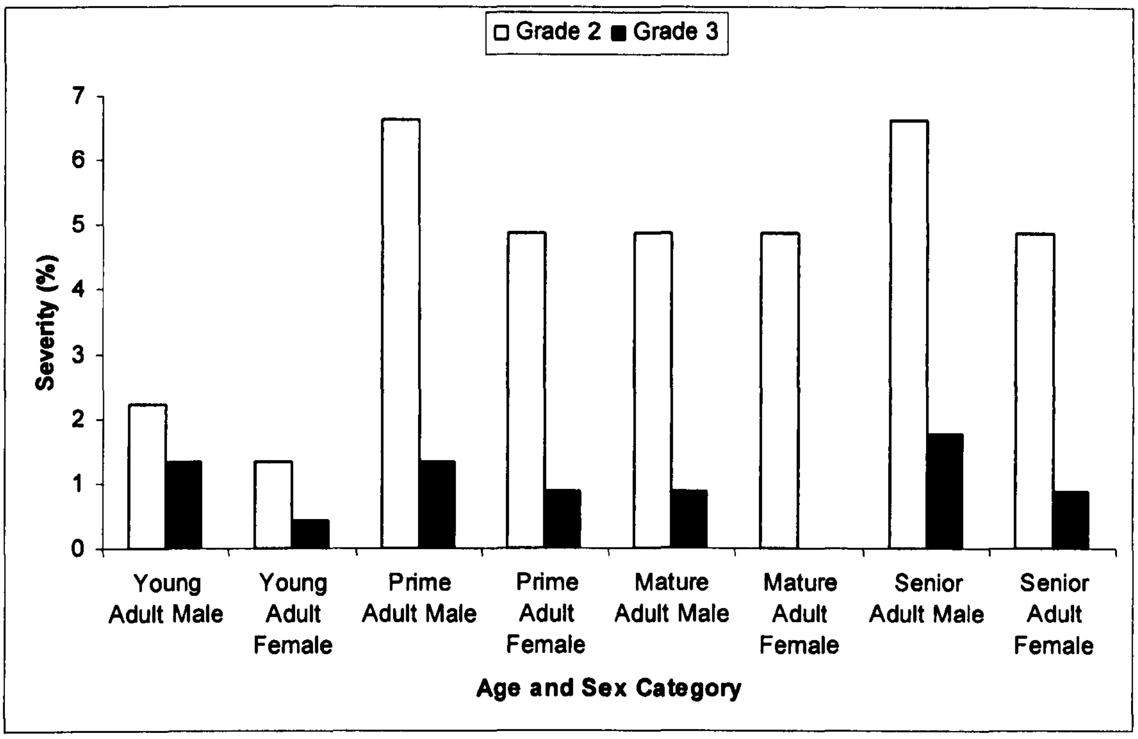


Figure 5.14 *True prevalence rates and severity in percentages for dental enamel hypoplasia for each adult age and sex category within the Black Gate assemblage (n = 203) (Grade 2 = one hypoplastic line present, Grade 3 = two or more hypoplastic lines present)*

Figure 5.14 shows the frequency of individuals expressing Grade 2 (mild) and Grade 3 (severe) DEH in each of the adult age and sex categories. The majority of individuals in each age and sex category exhibited mild DEH. There was no significant difference in the proportion of males and females exhibiting Grade 3 DEH for the total observed adult population. In all of the age categories males presented a higher frequency of Grade 3 (severe) DEH than females. This difference was, however, not statistically significant.

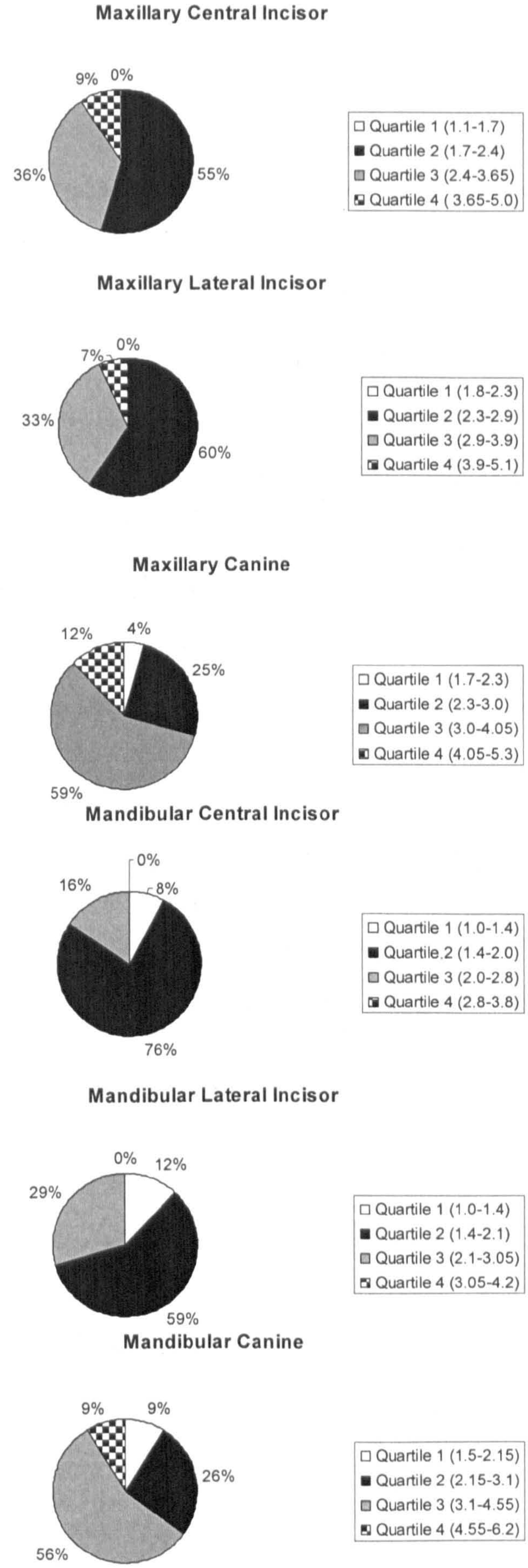


Figure 5.15 *Percentage of dental enamel hypoplasias in each age band within the Black Gate assemblage*

Figure 5.15 shows the age bands within which DEHs have manifest on the anterior dentition within the Black Gate assemblage. The second and third quartile of the anterior teeth, which show the majority of enamel defects, were mineralising during early childhood and therefore reflect dietary and physiological stresses during that developmental period. For the central and lateral incisors, the majority of hypoplasias were observed in the 2nd quartile, which provides age ranges of 1.7-2.4 years in the maxillary central incisor (55.0%), 2.3-2.9 years in the maxillary lateral incisor (60.0%), 1.4-2.0 years in the mandibular central incisor (76.0%) and 1.4-2.1 years in the mandibular lateral incisor (59.0%). In both the maxillary and mandibular canines the majority of hypoplastic defects were observed in the 3rd quartile at a prevalence of 59.0% and 56.0% respectively, providing age ranges of 3.0-4.0 and 3.1-4.5 years. The preponderance of hypoplastic defects in the 2nd and 3rd quartiles of the anterior teeth suggest the Black Gate immatures experienced the most physiological stress during the approximate age of 2-3 years.

5.4 Indicators of Environmental Stress: Non-Specific Infection

The summary statistics for true prevalence rates and severity of the non-specific infection indicators observed in the Black Gate cemetery are provided in Appendix B, Tables B.30 to B.39.

5.4.1 Tibial Periosteal New Bone Formation

Within the Black Gate assemblage, 368 individuals possessed at least one tibial diaphysis suitable for osteological analysis (Figure 5.16). Of these, 113 were immatures (aged three years or older) and 255 were adults. The TPR of TPNB for the total assemblage was 29.1% (107/368). The TPRs for immatures and adults were 24.8% (28/113) and 31.0% (79/255) respectively. There was no significant difference in the prevalence of TPNB between immatures and adults.

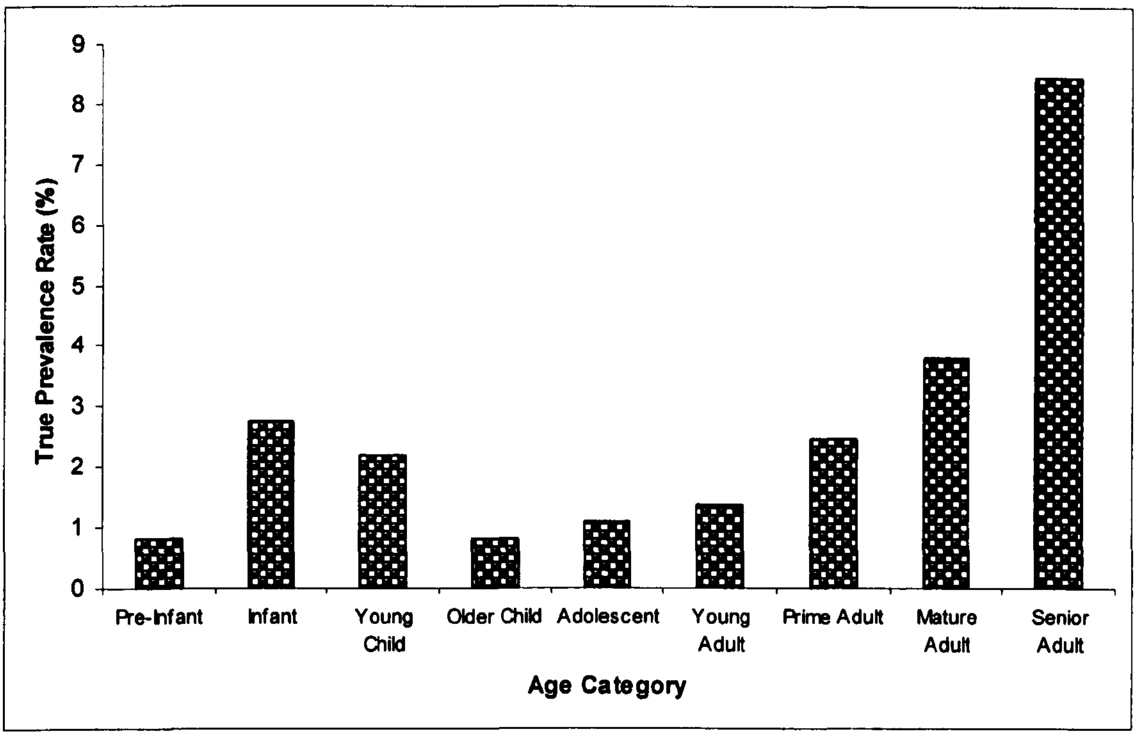


Figure 5.16 *True prevalence rates in percentages for tibial new bone formation for each age category within the Black Gate assemblage (n = 368 individuals with tibia suitable for analysis)*

TPNB was most prevalent in the senior adult age category (8.4%; 31/368). There was no statistically significant relationship between the prevalence of TPNB and advancing age for either the total population or the adults only. There was an increase in the true prevalence of TPNB with advancing age from the older child to senior adult age categories (Figure 5.16). However, due to the small incremental increase in the older child to young adult age categories this increase was not statistically significant.

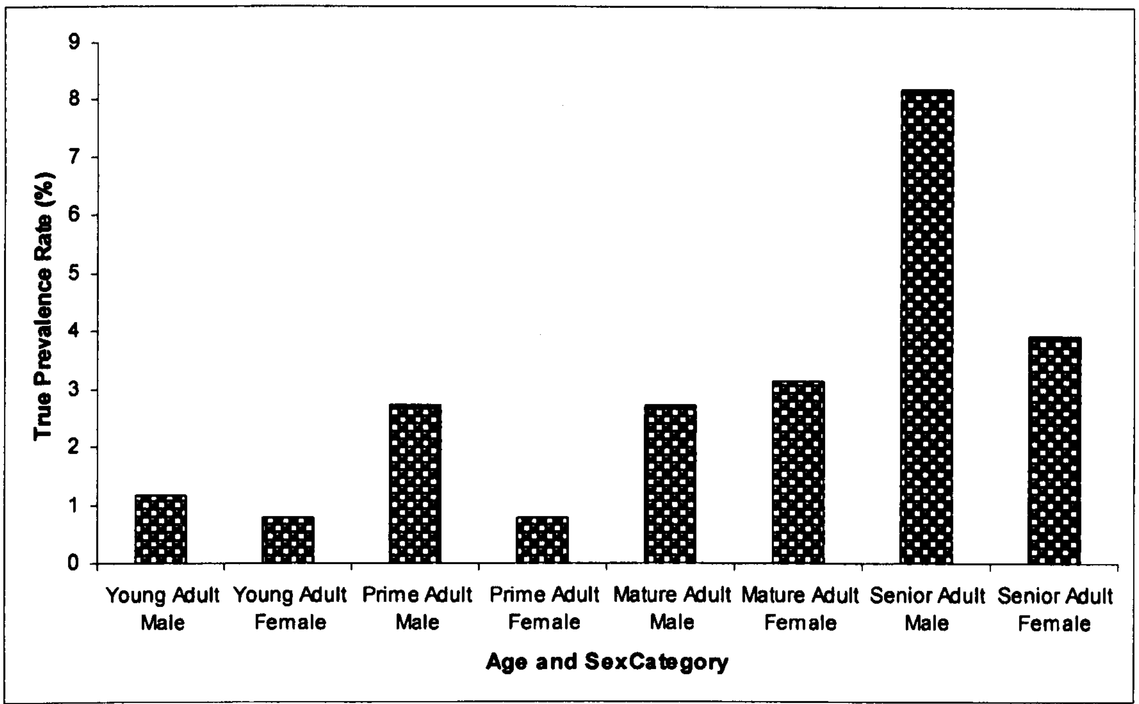


Figure 5.17 *True prevalence rates in percentages for tibial new bone formation for each adult age and sex category within the Black Gate assemblage (n = 205 individuals of known age and sex with tibia suitable for analysis)*

There was a statistically significant higher prevalence of TPNB in adult males (18.0%; 37/205) than females (11.2%; 23/205) (χ^2 = 4.591; P = 0.032) (Figure 5.17). A significantly higher prevalence of males to females amongst the senior adults exhibited TPNB (χ^2 = 5.975; P = 0.015).

5.4.2 Chronic Maxillary Sinusitis

A total of 220 individuals possessed at least one maxillary sinus suitable for analysis (Figure 5.18). Of these, 56 were immatures (aged 3 years and over) and 164 were adults. The TPR of maxillary sinusitis for the total assemblage was 33.6% (74/220). The TPRs for immatures and adults were 32.1% (18/56) and 34.1% (56/164) respectively. There was no statistically significant difference between the immature and adult TPRs.

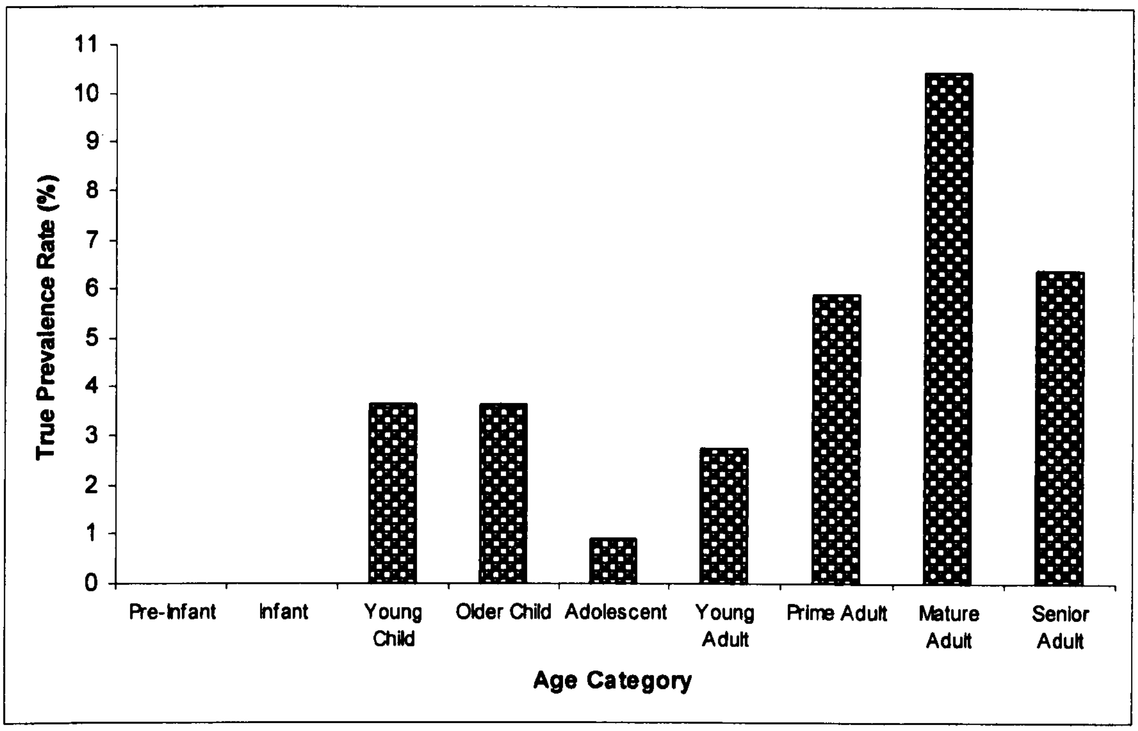


Figure 5.18 *True prevalence rates in percentages for maxillary sinusitis for each age category within the Black Gate assemblage (n = 220 individuals with recordable maxillary sinuses)*

Maxillary sinusitis was most prevalent amongst the mature adults (10.4%; 23/220). There was no statistically significant increase in the prevalence of maxillary sinusitis with advancing age for either the total population or the adult population alone.

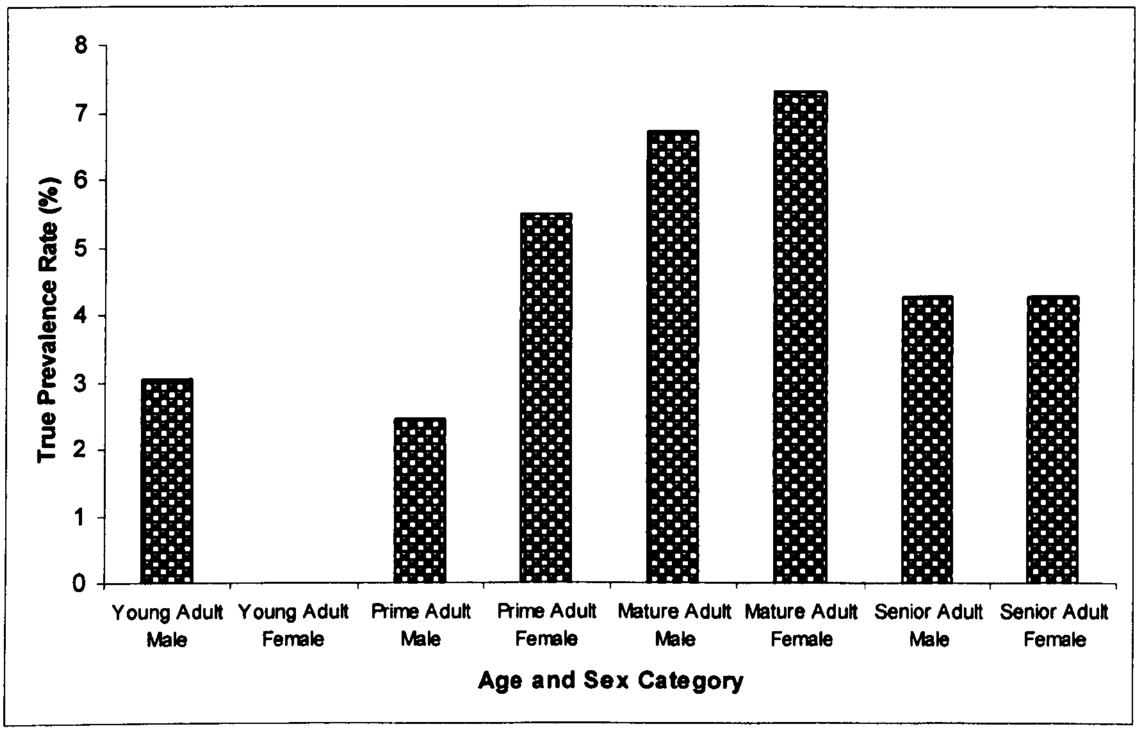


Figure 5.19 *True prevalence rates in percentages for maxillary sinusitis for each adult age and sex category within the Black Gate assemblage (n = 164 adults with recordable maxillary sinuses)*

There was no statistically significant difference in the prevalence of maxillary sinusitis observed amongst the adult males and females, either overall or within each age category (Figure 5.19).

5.5 Indicators of Environmental Stress: Dental Health

The summary statistics for true prevalence rates and severity of the dental health indicators observed in the Black Gate cemetery are provided in Appendix B, Tables B.40 to B.84.

5.5.1 Dental Calculus

A total of 290 individuals possessed one or more teeth suitable for analysis (Figure 5.20). Of these, 41 were immatures and 249 were adults. The TPR of calculus for the total assemblage was 90.3% (262/290). The TPRs for immatures and adults were 53.7% (22/41) and 96.4% (240/249) respectively. Immatures showed a significantly lower TPR compared to adults (χ^2 = 42.828; P = 0.000).

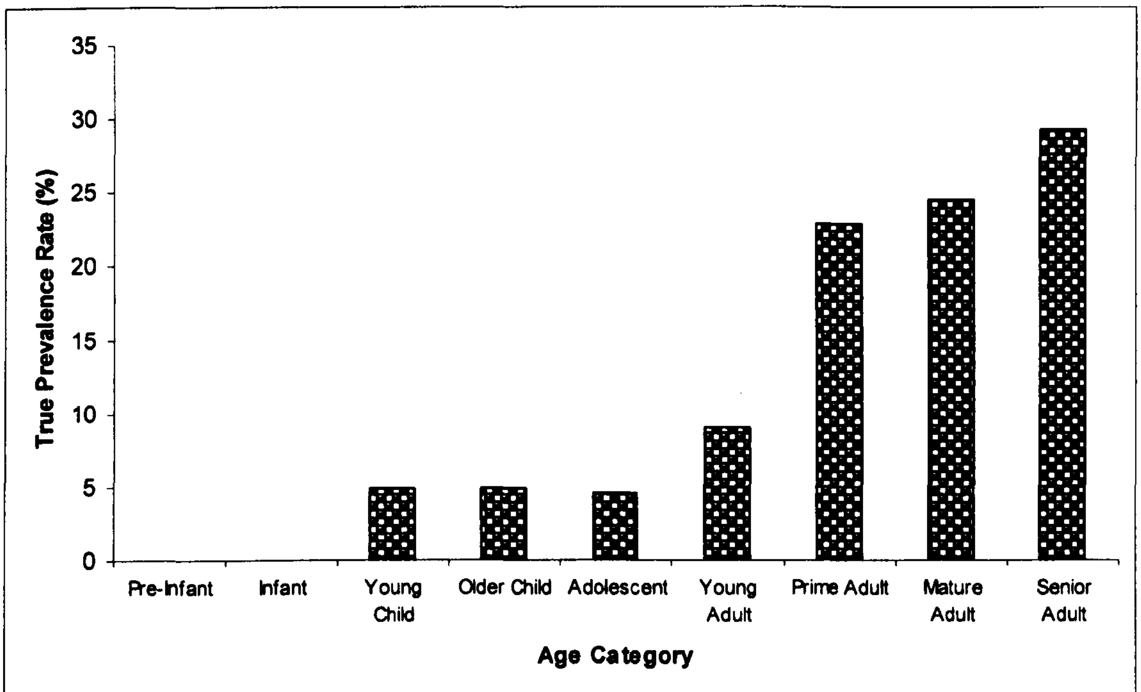


Figure 5.20 *True prevalence rates in percentages for dental calculus for each age category within the Black Gate assemblage (n = 290)*

Dental calculus within the permanent dentition was most prevalent amongst the senior adults (29.3%; 85/290). There was a statistically significant increase in the true prevalence of calculus with advancing age from the pre-infant to the senior adult age category (χ^2 = 43.840; P = 0.000). The increase observed in the adults only was insufficient to be statistically significant.

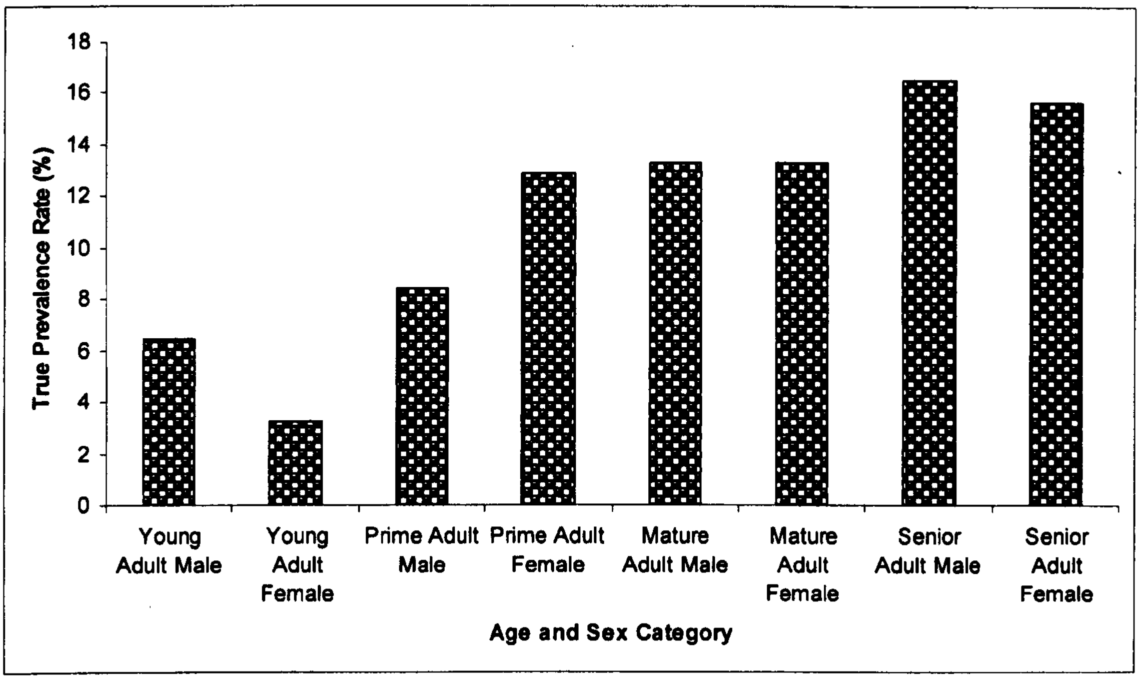


Figure 5.21 *True prevalence rates in percentages for dental calculus for each adult age and sex category within the Black Gate assemblage (n = 249)*

There was no statistically significant difference in the prevalence of calculus between the males and females overall (Figure 5.21). There was, however, a significantly higher prevalence of prime adult females than males exhibiting calculus (χ^2 = 54.347; P = 0.000).

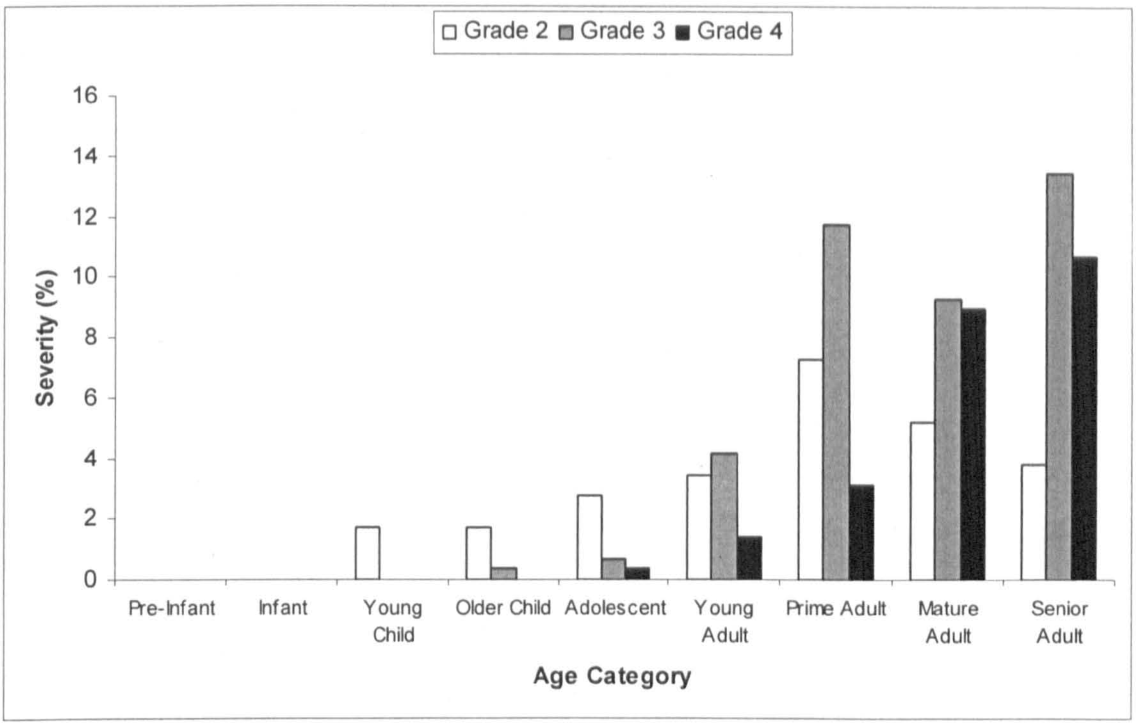


Figure 5.22 *True prevalence rates and severity in percentages for dental calculus for each age category within the Black Gate assemblage (n = 290) (Grade 2 = slight calculus build-up, Grade 3 = medium calculus build-up, Grade 4 = considerable calculus build-up)*

Figure 5.22 shows the frequency of individuals exhibiting slight (Grade 2), moderate (Grade 3) and severe (Grade 4) calculus deposits in each age category. The majority (39.7%; 115/290) of individuals exhibited Grade 3 dental calculus, with approximately equal percentages of individuals exhibiting Grade 2 (26.2%; 76/290) and Grade 4 (24.5%; 71/290) accumulations. Senior adults displayed the highest true prevalences for moderate and severe calculus deposits. There was no significant difference in the number of adults and immatures exhibiting moderate and severe calculus deposits. The severity of calculus deposits showed a statistically significant increase with age for both the total population (χ^2 = 11.009; P = 0.051) and adult population alone (χ^2 = 12.671; P = 0.005).

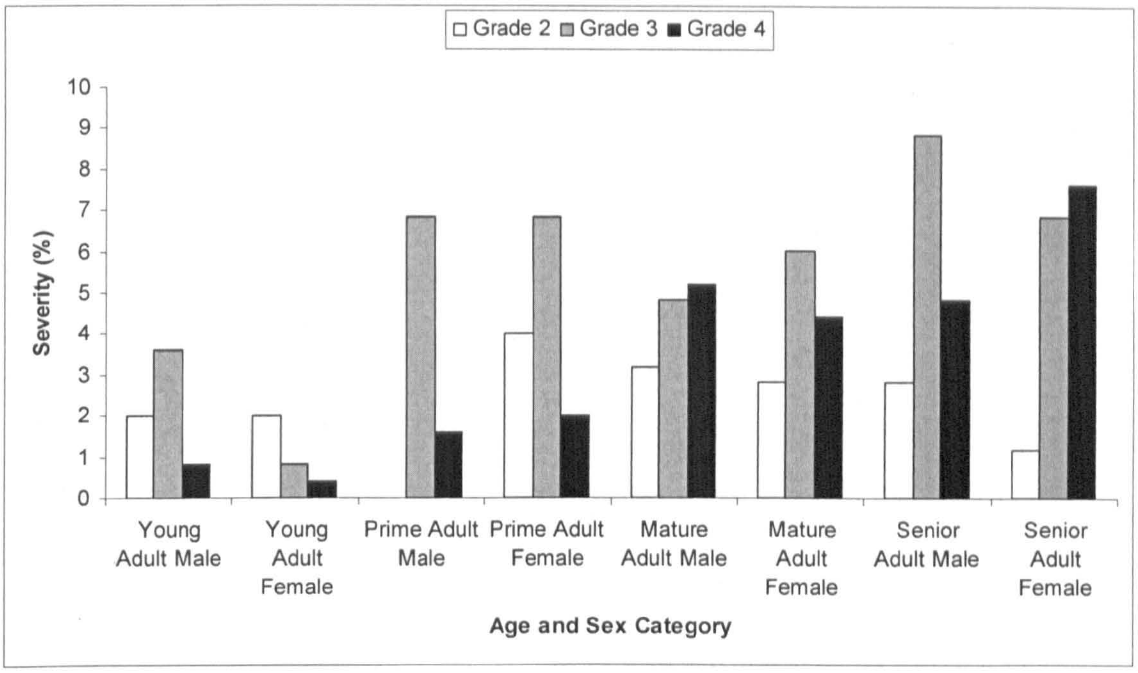


Figure 5.23 True prevalence rates and severity in percentages for dental calculus for each adult age and sex category within the Black Gate assemblage (n = 249) *(Grade 2 = slight calculus build-up, Grade 3 = medium calculus build-up, Grade 4 = considerable calculus build-up)*

There was no statistically significant difference in the frequency of males and females exhibiting Grade 3 or Grade 4 calculus accumulations (Figure 5.23). There were no statistically significant differences in the severity of calculus expressed in males and females for each age category.

5.5.2 Dental Caries

Within the total assemblage, 305 individuals possessed one or more teeth suitable for analysis of dental caries (Figure 5.24). Of these, 50 were immatures and 255 were adults. The TPR of caries for the total assemblage was 38.0% (116/305). The TPRs for immatures and adults were 26.0% (13/50) and 40.4% (103/255) respectively. The difference in the TPRs for caries observed in the immature and adult populations was statistically significant (χ^2 = 4.088; P = 0.043), with adults exhibiting a higher prevalence of caries than the immatures.

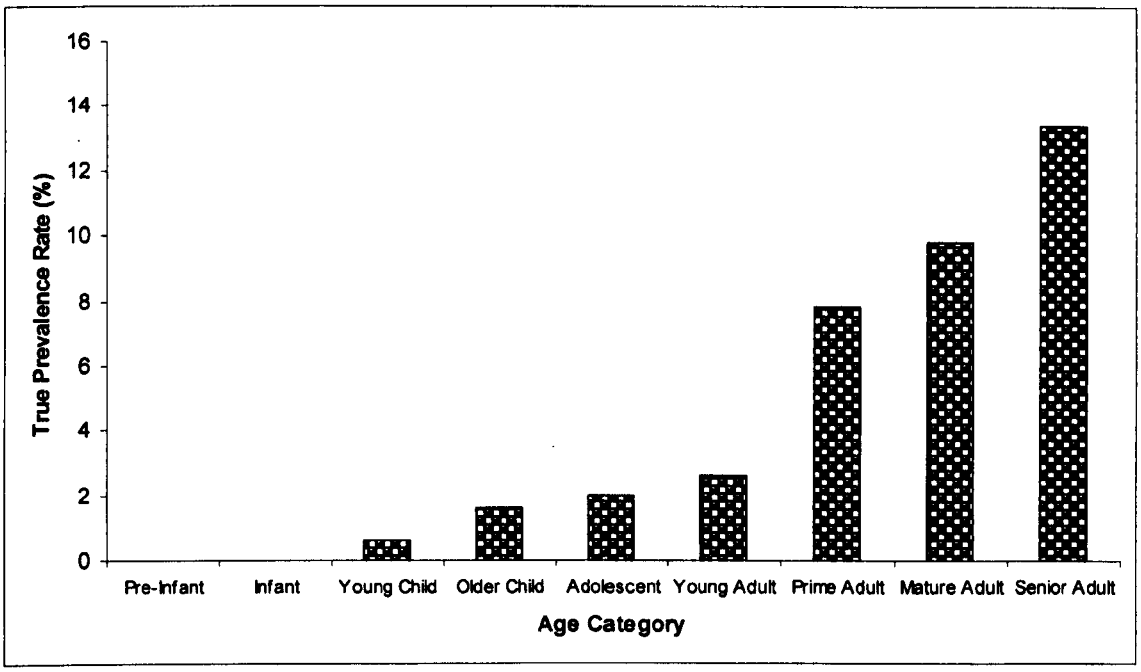


Figure 5.24 *True prevalence rates in percentages for permanent dental caries for each age category within the Black Gate assemblage (n = 305)*

Dental caries in the permanent dentition were most prevalent within the senior adult category (13.4%; 41/305). There was a general increase in the true prevalence of caries with age. However, this relationship was not statistically significant for either the total population or adults only.

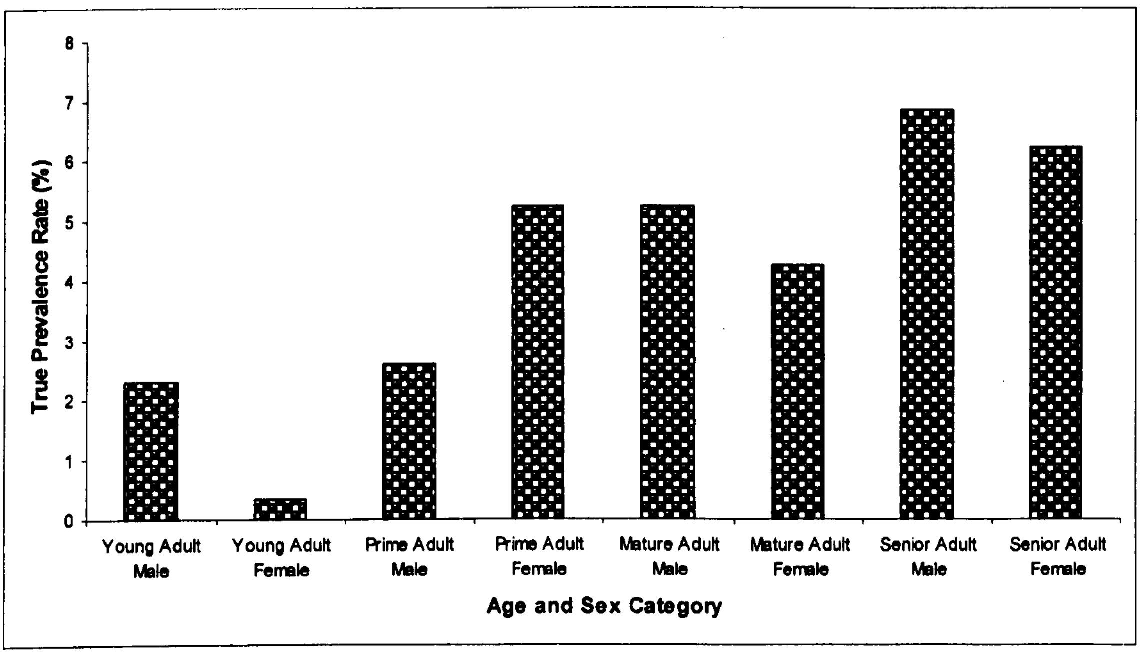


Figure 5.25 *True prevalence rates in percentages for dental caries for each adult age and sex category within the Black Gate assemblage (n = 255)*

There was no statistically significant difference between the prevalence of caries expressed in males and females either for the total population or for each age category (Figure 5.25). However, it must be noted that the higher prevalence of caries observed in prime adult females in comparison with the males was approaching statistical significance (χ^2 = 3.145; P = 0.076).

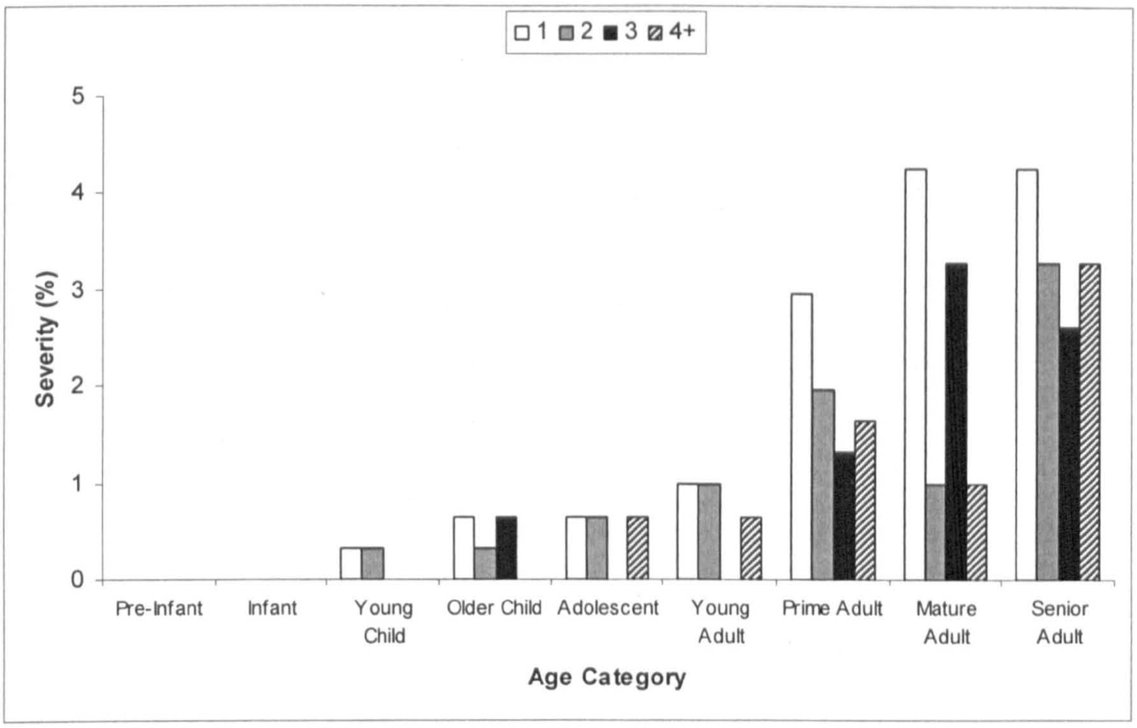


Figure 5.26 *Severity in percentages for permanent dental caries for each age category within the Black Gate assemblage (n = 305)* Dental caries category 0 (individuals with no teeth, and therefore no dental caries) is excluded (Data series 1, 2, 3 and 4+ represent number of teeth affected with carious lesions per individual)

Figure 5.26 shows the severity of caries, quantified by the number of affected teeth, in each age category. The majority (37.4%; 43/115) of individuals exhibiting caries only possessed one carious lesion. A total of 60.0% (69/115) of individuals possessed only one or two carious lesions. This suggests that overall there was a low true prevalence of caries within the Black Gate assemblage, and those who were affected were only mildly so. The severity of cases of caries was greatest in the senior adult age category, with 3.3% (10/305) exhibiting four or more teeth with carious lesions. The percentage of individuals expressing three or more carious lesions showed a general increase with advancing age. However, this increase was not statistically significant.

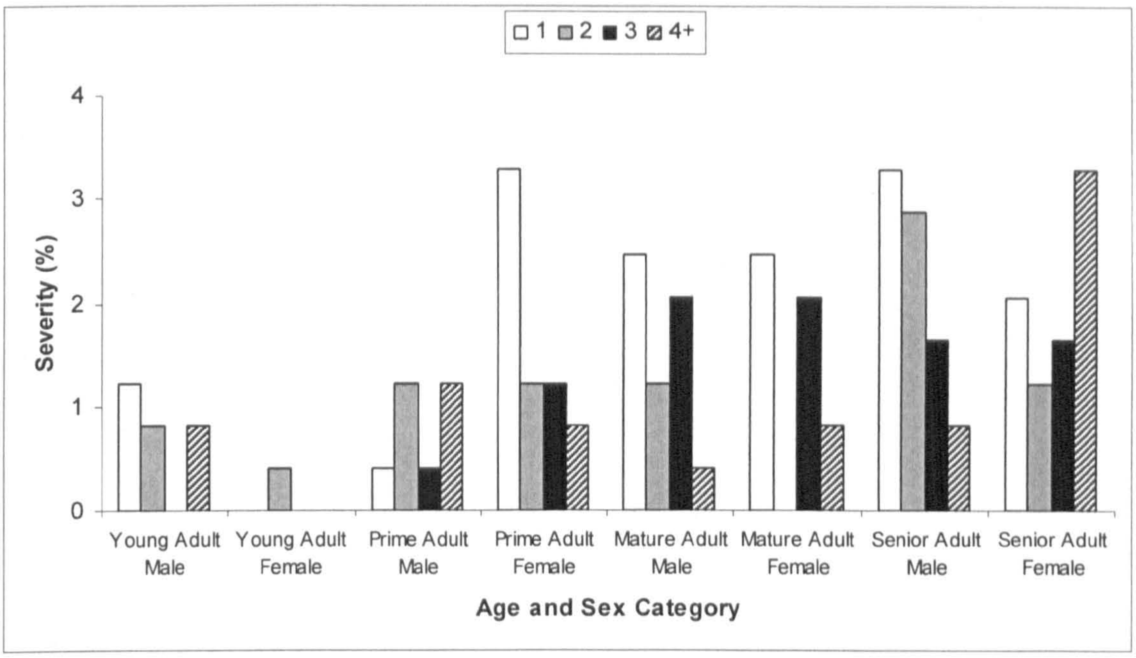


Figure 5.27 *True prevalence rates and severity in percentages for dental caries for each adult age and sex category within the Black Gate assemblage (n = 243)* (Data series 1, 2, 3 and 4+ represent number of teeth affected with carious lesions per individual)

There was no statistically significant difference in the frequency of males and females exhibiting 3 or 4+ teeth containing carious lesions for the total population (Figure 5.27). There was, however, a significantly higher prevalence of females than males exhibiting three or more carious lesions in the senior adult age category (χ^2 = 4.108; P = 0.043).

5.5.3 Dental Abscesses

Within the total assemblage, 305 individuals possessed one or more tooth sockets suitable for analysis (Figure 5.28). Of these, 52 were immatures and 253 were adults. The TPR of abscesses for the total assemblage was 9.5% (29/305). The TPRs for the immature and adult assemblages were 3.8% (2/52) and 11.5% (29/253) respectively. There was a statistically significant higher prevalence of abscesses in the adult population compared to the immatures (χ^2 = 10.771; P = 0.001).

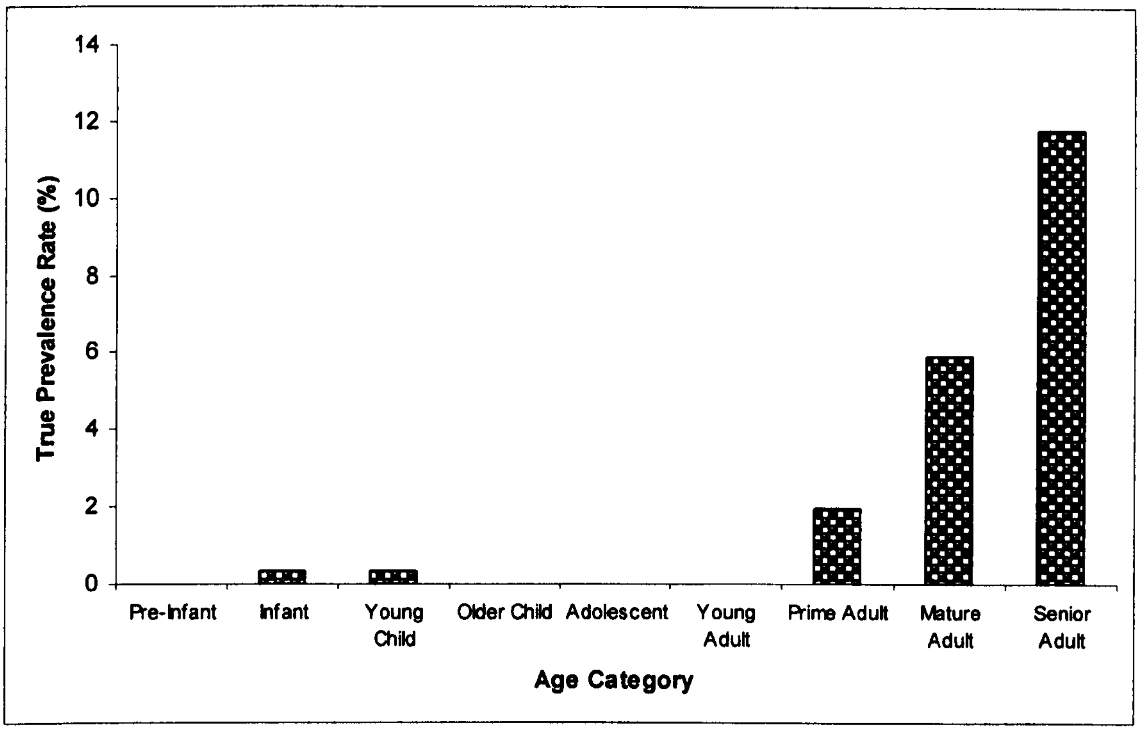


Figure 5.28 *True prevalence rates in percentages for dental abscesses for each age category within the Black Gate assemblage (n = 305 individuals with surviving sockets)*

Dental abscesses were most prevalent in the senior adult age category (12.3%; 37/305). There was a statistically significant increase in the true prevalence of abscesses with increasing age for both the total population (χ^2 = 53.968; P = 0.000) and adults only (χ^2 = 33.204; P = 0.005).

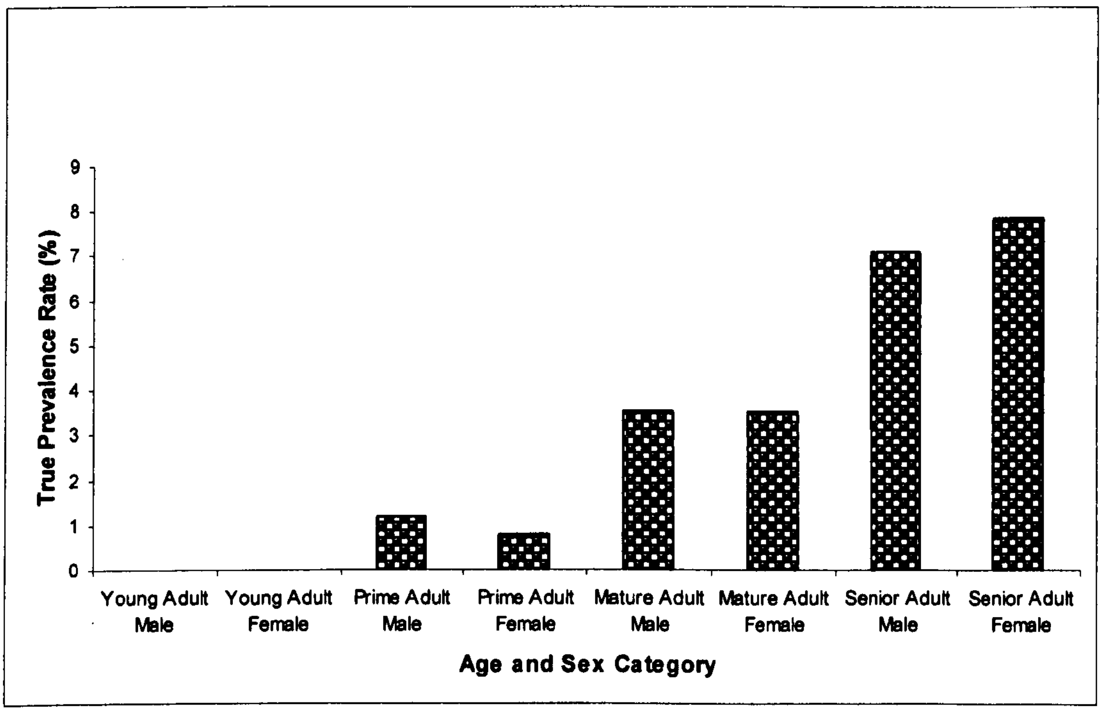


Figure 5.29 *True prevalence rates in percentages for dental abscesses for each adult age and sex category within the Black Gate assemblage (n = 255 individuals with surviving sockets)*

Amongst the adult population, there was no significant difference in the prevalence of abscesses expressed by males and females for either the total population or each adult age category (Figure 5.29).

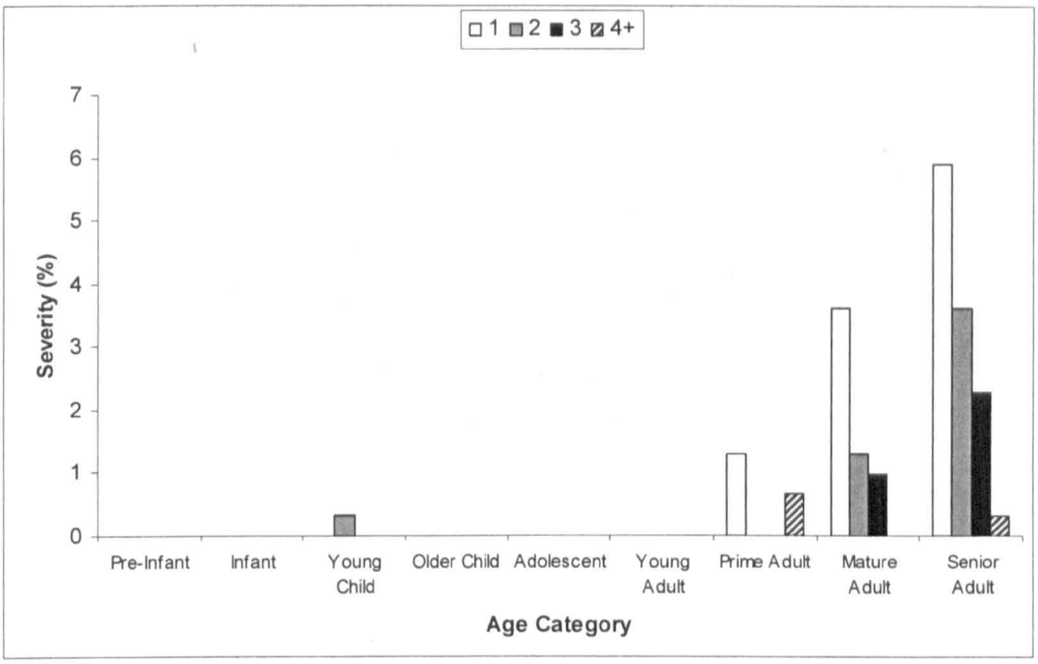


Figure 5.30 True prevalence rates and severity in percentages for dental abscesses for each age category within the Black Gate assemblage (n = 305 individuals with surviving sockets) (Data series 1, 2, 3 and 4+ represent number of teeth affected with abscess lesions per individual)

The severity of cases of dental abscesses was greatest in the senior adult age category, with 2.6% (8/305) possessing three or more abscesses (Figure 5.30). The majority of individuals exhibiting abscesses (53.2%; 33/62) presented a single abscess only. Only 4.8% (3/62) had four or more abscesses. This suggests that the Black Gate population was not severely afflicted with abscesses. Analysis of the percentage of individuals expressing three or more abscesses revealed a general increase with age. However, this increase was not statistically significant for either the total population or adults only.

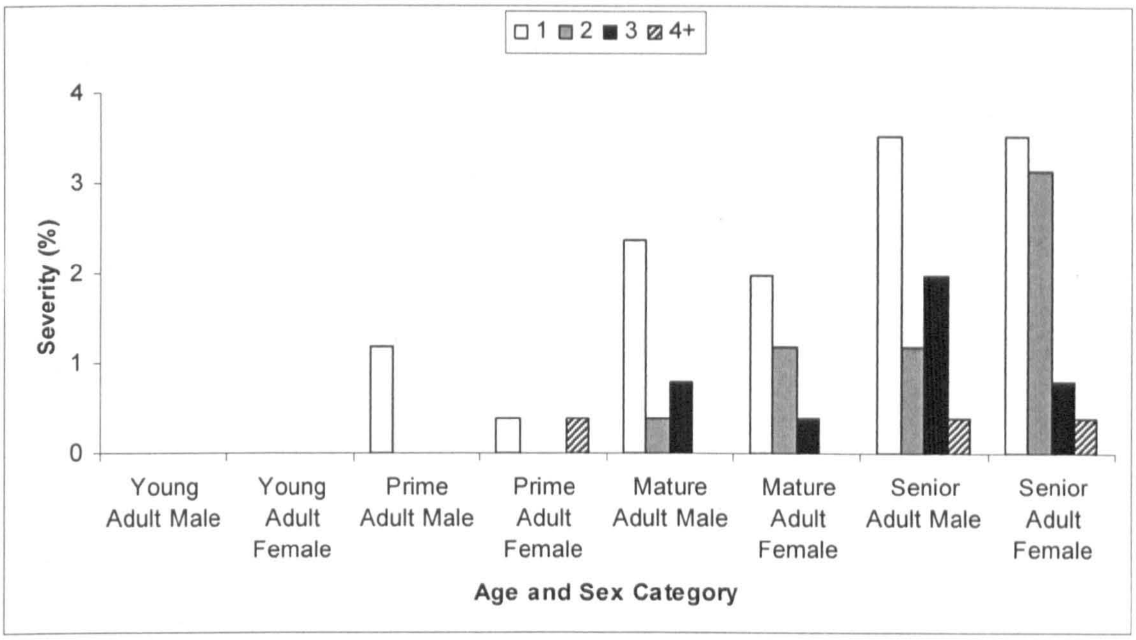


Figure 5.31 True prevalence rates and severity in percentages for dental abscesses for each adult age and sex category within the Black Gate assemblage (n = 255 individuals with surviving sockets) (Data series 1, 2, 3 and 4+ represent number of teeth affected with abscess lesions per individual)

There were no significant differences between the severity of abscesses in males and females for either the total adult population or each age category (Figure 5.31). Due to the low number of abscesses observed within the Black Gate dentitions, any interpretations of the data that can be made will be purely speculative and cannot be proven statistically by the current author.

5.5.4 Ante-Mortem Tooth Loss

Within the total assemblage 305 individuals possessed one or more tooth sockets suitable for the identification of AMTL (Figure 5.32). Of these, 51 were immatures and 254 were adults. The TPR for the total assemblage was 26.2% (80/305). The TPRs for immatures and adults were 2.0% (1/51) and 31.1% (79/254) respectively. The prevalence of AMTL observed in the adults was significantly higher than that seen within the immatures (χ^2 = 10.833; P = 0.001).

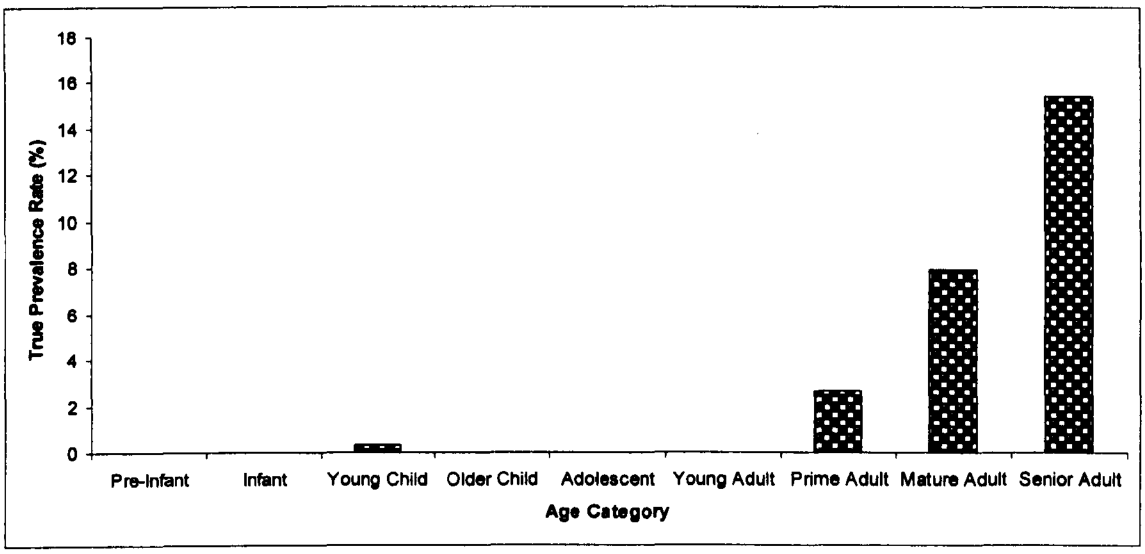


Figure 5.32 *True prevalence rates in percentages for ante-mortem tooth loss (AMTL) for each age category within the Black Gate assemblage (n = 305 individuals with surviving sockets)*

AMTL was most prevalent amongst the senior adults (15.4%; 47/305). There was a statistically significant increase in the true prevalence of AMTL with increasing age amongst both the total population (χ^2 = 43.648; P = 0.000) and the adult population alone (χ^2 = 22.663; P = 0.000).

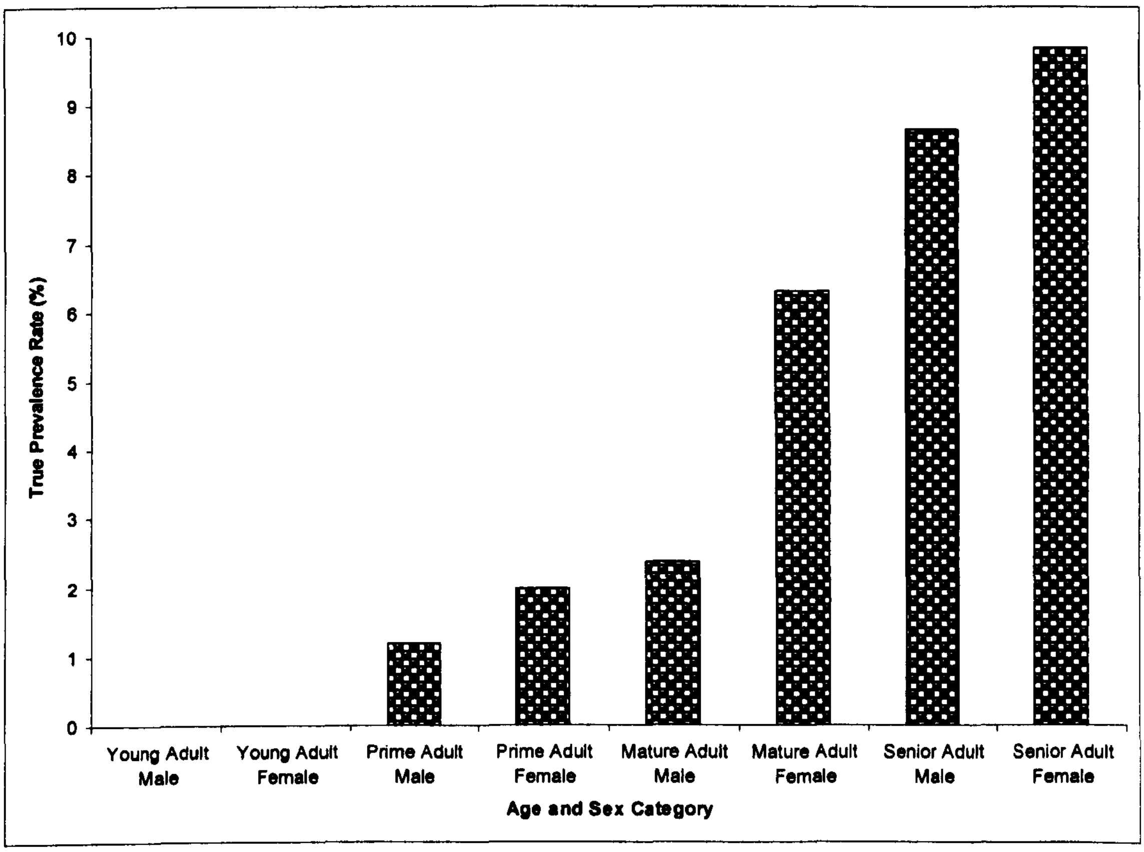


Figure 5.33 *True prevalence rates in percentages for ante-mortem tooth loss (AMTL) for each adult age and sex category within the Black Gate assemblage (n = 254 individuals with surviving sockets)*

Females showed a statistically significant higher prevalence of AMTL compared to males for the total population (male = 25.0% [31/124], female = 37.5% [45/120]) (χ^2 = 33.204; P = 0.005) (Figure 5.33). There was a statistically significant higher prevalence of AMTL observed in mature adult females than mature adult males (χ^2 = 6.256; P = 0.012).

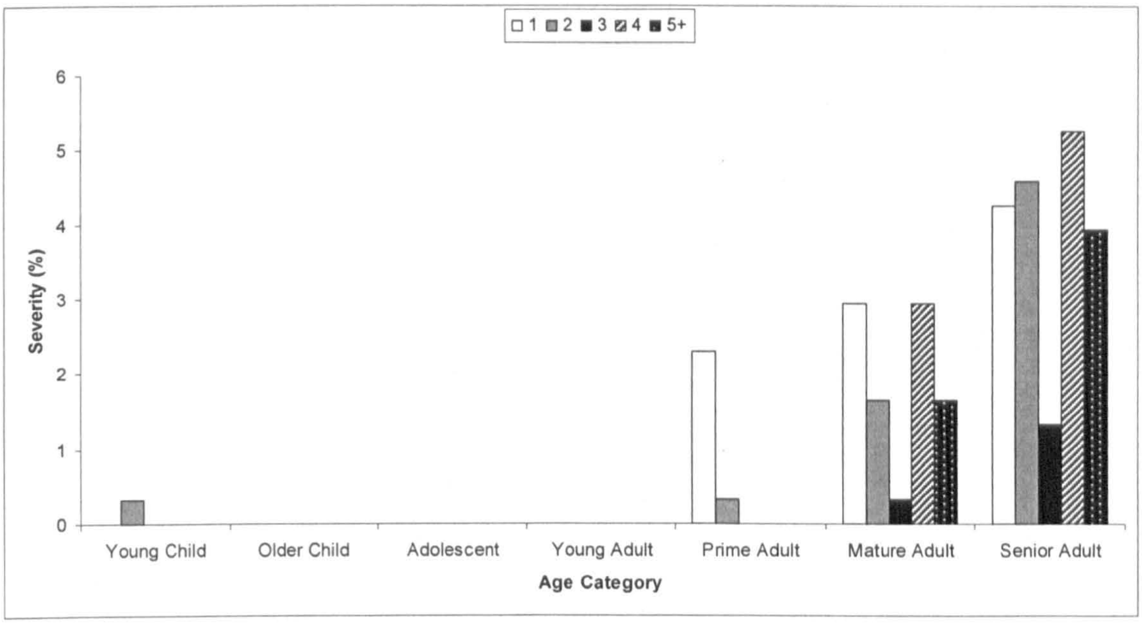


Figure 5.34 *True prevalence rates and severity in percentages for ante-mortem tooth loss (AMTL) for each age category within the Black Gate assemblage (n = 305 individuals with surviving sockets) (Data series 1, 2, 3, 4 and 5+ represent number of teeth lost ante-mortem per individual)*

Overall, the Black Gate population expressed limited AMTL (Figure 5.34). The majority of affected individuals (36.2%; 29/80) were missing a single tooth and only 21.2% (17/80) were missing five or more teeth. Of those individuals missing five or more teeth, 70.6% (12/17) were senior adults. The loss of five or more teeth was only observed in the mature and senior adult age categories, indicating AMTL severity to be correlated with advancing age. Due to the small number of skeletons affected, it was not possible to perform statistical analysis of the correlation between increasing age and the ante-mortem loss of five or more teeth. There was, however, a statistically significant increase in the number of individuals exhibiting a loss of three or more teeth ante-mortem for both the total (χ^2 = 9.374; P = 0.025) and adult (χ^2 = 8.420; P = 0.015) population.

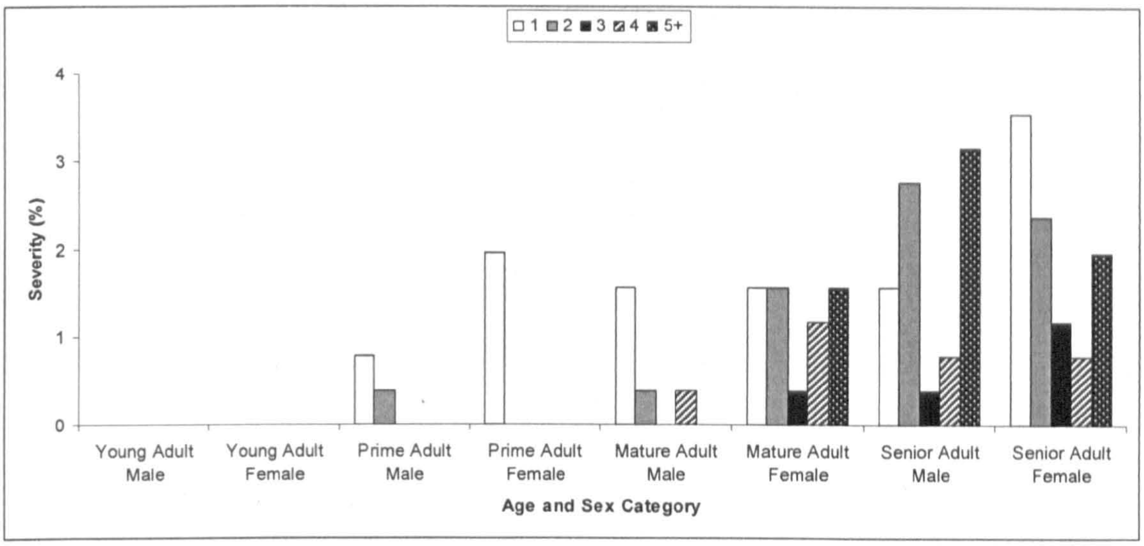


Figure 5.35 *True prevalence rates and severity in percentages for ante-mortem tooth loss (AMTL) for each adult age and sex category within the Black Gate assemblage (n = 254 individuals with surviving sockets) (Data series 1, 2, 3, 4 and 5+ represent number of teeth lost ante-mortem per individual)*

There was no statistically significant difference in the severity of AMTL expressed by males and females for either the total population or each adult age category independently (Figure 5.35).

5.6 Indicators of Environmental Stress: Skeletal Biomechanical Stress

The summary statistics for true prevalence rates and severity of the biomechanical stress indicators observed in the Black Gate cemetery are provided in Appendix B, Tables B.85 to B.132.

5.6.1 Degenerative Joint Disease

Within the Black Gate assemblage 405 adults possessed at least one articular joint surface suitable for the observation of degenerative changes. Of these, 393 had at least one appendicular – shoulder, elbow, hip, knee, wrist/hand or ankle/foot – joint available for analysis. A total of 315 adult individuals had at least one observable vertebral articular surface and 312 possessed both spinal and appendicular joints upon which degenerative disease could be recorded. Appendicular degenerative joint disease (ADJD) was observed in 252 individuals and 244 individuals exhibited spinal degenerative joint disease (SDJD). A combination of both appendicular and spinal joint disease was recorded in 189 adults and 306 exhibited either condition. The general prevalence of degenerative joint disease (DJD), then the frequency of cases of ADJD then SDJD will now be discussed.

5.6.1.1 Degenerative Joint Disease

The TPR of DJD for the total adult assemblage was 75.5% (306/405) (Figure 5.36). Of the adults exhibiting degenerative changes of the skeleton, 19.9% (61/306) exhibited ADJD only and 15.4% (47/306) exhibited SDJD only.

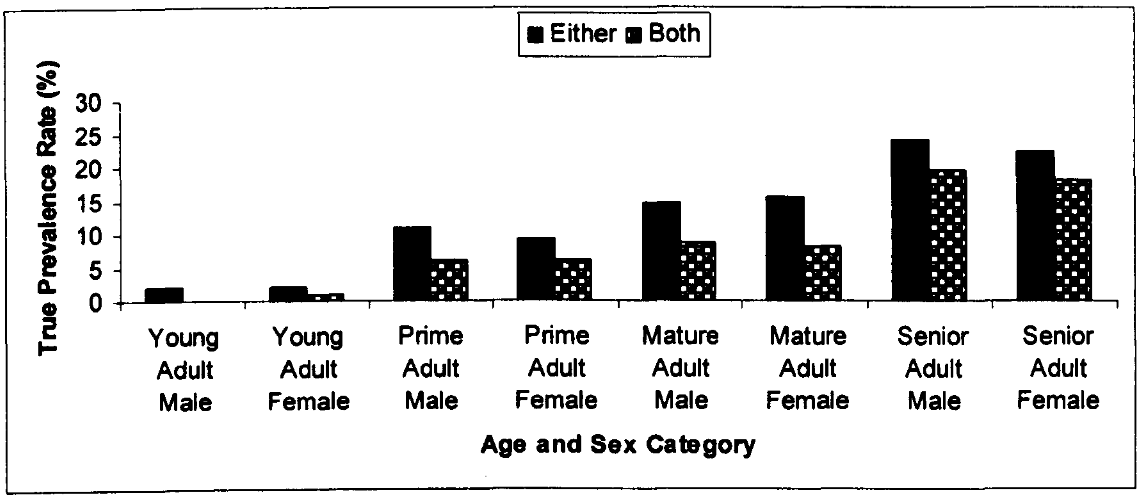


Figure 5.36 *True prevalence rates in percentages for degenerative joint disease for each age and sex category within the Black Gate adult assemblage (n = 306 individuals exhibiting either spinal or appendicular degenerative joint disease)*

The majority of individuals exhibiting DJD were within the senior adult age category (20.9%; 64/306). The percentage of individuals exhibiting either SDJD or ADJD increased significantly with advancing age (χ^2 = 23.199; P = 0.000). There was no statistically significant difference in the true prevalence of DJD between males and females overall. There was a significantly higher prevalence of DJD amongst males than females in the mature adult age category (χ^2 = 5.384; P = 0.020).

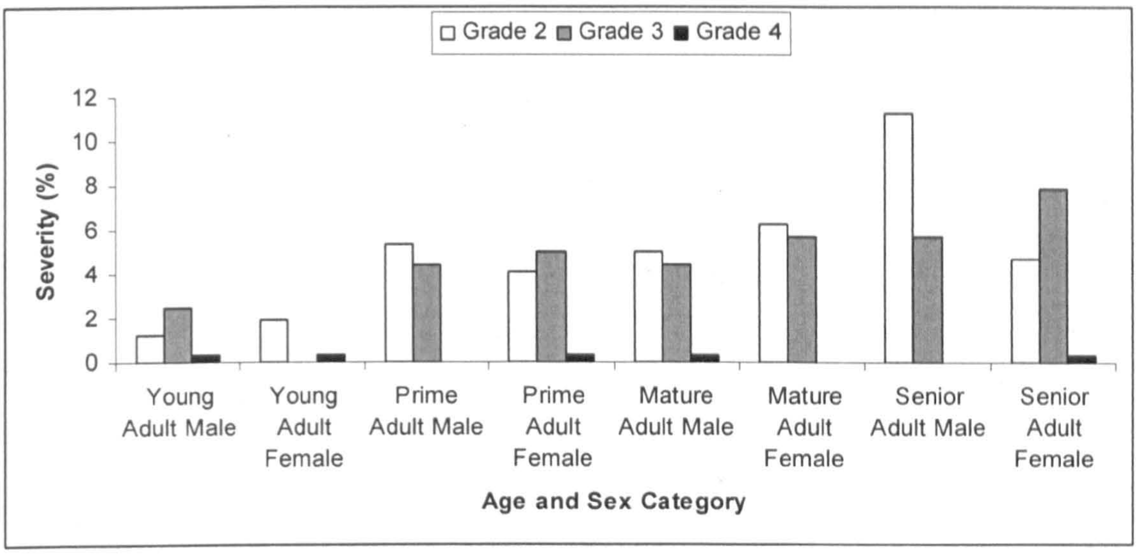


Figure 5.37 *True prevalence rates and severity in percentages for degenerative joint disease for each age category within the Black Gate assemblage (n = 319) (Grade 2 = slight, Grade 3 = moderate, Grade 4 = severe degenerative changes)*

There was a significant difference in the severity of DJD between the adult age categories (χ^2 = 20.713; P = 0.002), with an increase in the frequency of cases exhibiting moderate (Grade 3) and severe (Grade 4) degeneration with advancing age (Figure 5.37). However, it must be noted that severe cases of DJD were observed in all age categories, suggesting the severity was not just an accumulation of the stresses imposed upon the skeleton during life, and that additional factors, such as occupational stresses, may have been at play. There was no statistically significant difference between the severity of DJD observed in the total assemblage of males and females. However, there was a statistically higher frequency of Grade 3 lesions observed in young adult males compared to females (χ^2 = 7.253; P = 0.027) and degeneration was significantly more severe in senior adult females than senior adult males (χ^2 = 9.180; P = 0.010).

5.6.1.2 Appendicular Degenerative Joint Disease

The TPRs for ADJD for each adult age category are shown in Figures 5.38 and 5.39. The TPR for ADJD amongst the adult assemblage was 64.1% (252/393). There was a statistically significant increase in the prevalence of ADJD with advancing age amongst the Black Gate adults (χ^2 = 56.795; P = 0.000).

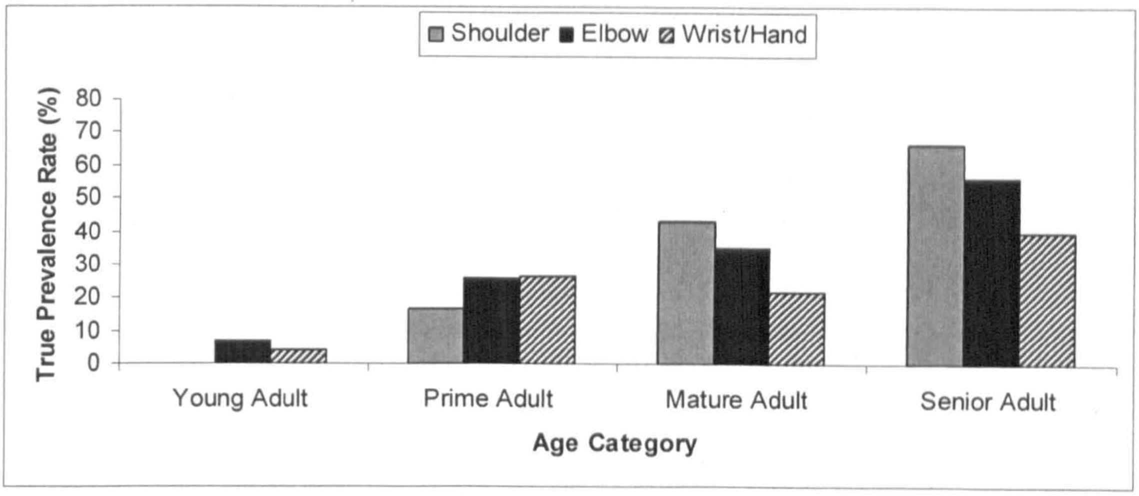


Figure 5.38 *True prevalence rates in percentages for degenerative joint disease of the upper limb for each age category within the Black Gate assemblage (n = 332 individuals with at least one appendicular joint surface available for analysis)*

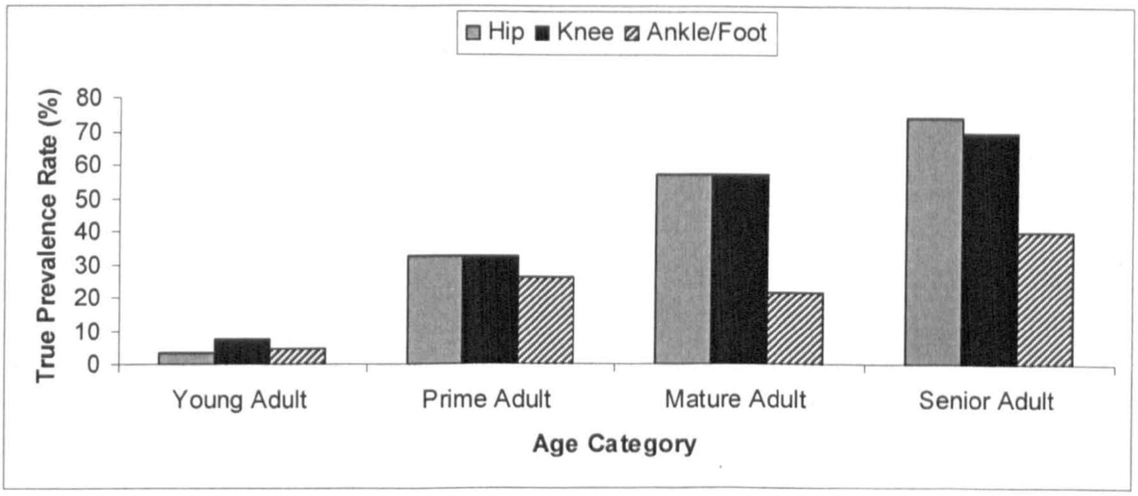


Figure 5.39 *True prevalence rates in percentages for degenerative joint disease of the lower limb for each age category within the Black Gate assemblage (n = 332 individuals with at least one appendicular joint surface available for analysis)*

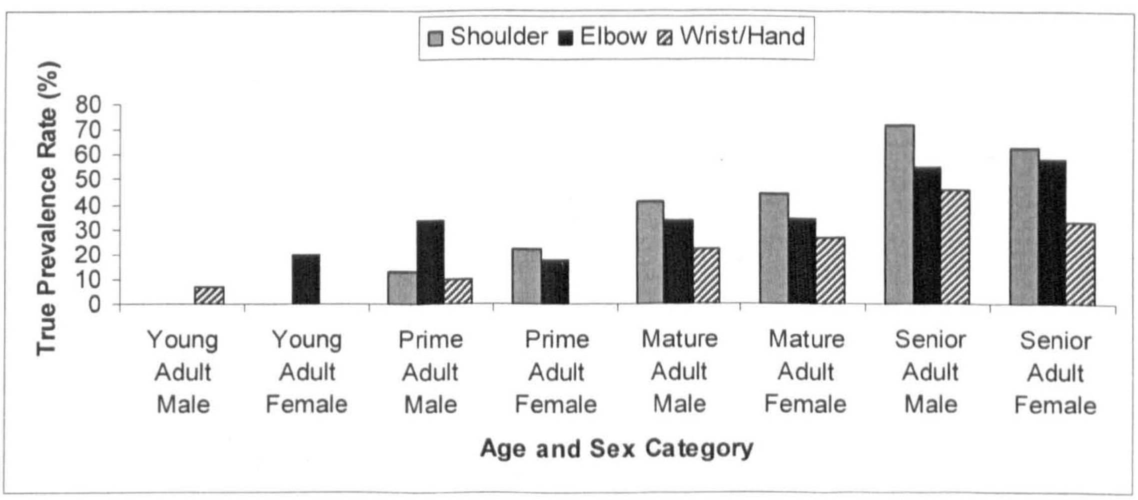


Figure 5.40 *True prevalence rates in percentages for appendicular DJD of the upper limb for each adult age and sex category within the Black Gate assemblage (n = 332 adults with recordable joint surfaces)*

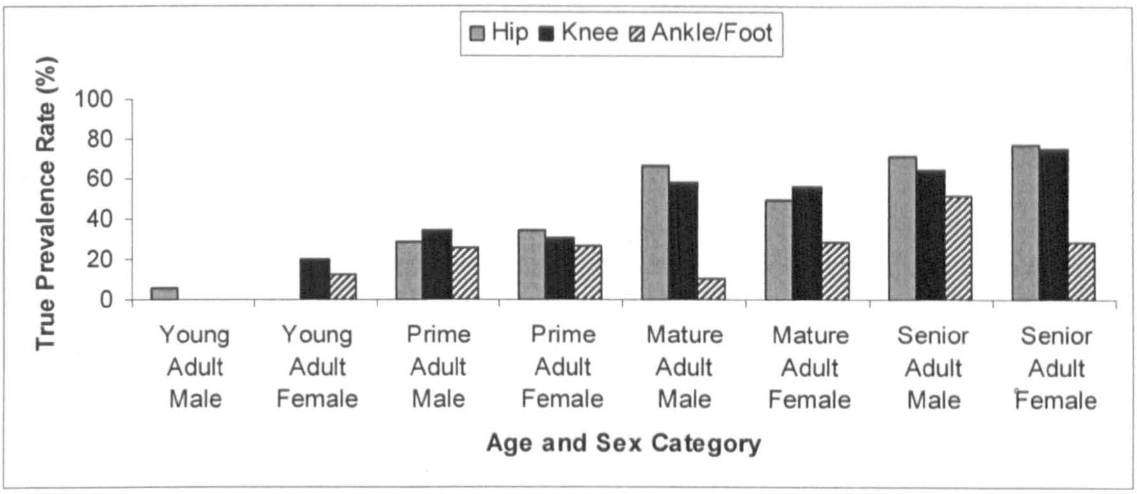


Figure 5.41 *True prevalence rates in percentages for appendicular DJD of the lower limb for each adult age and sex category within the Black Gate assemblage (n = 332 adults with recordable joint surfaces)*

The TPRs of ADJD for males and females within the adult component of the Black Gate assemblage are shown in Figures 5.40 and 5.41. There were no statistical differences in the prevalence of ADJD between males and females for either the total adult population or each adult age category.

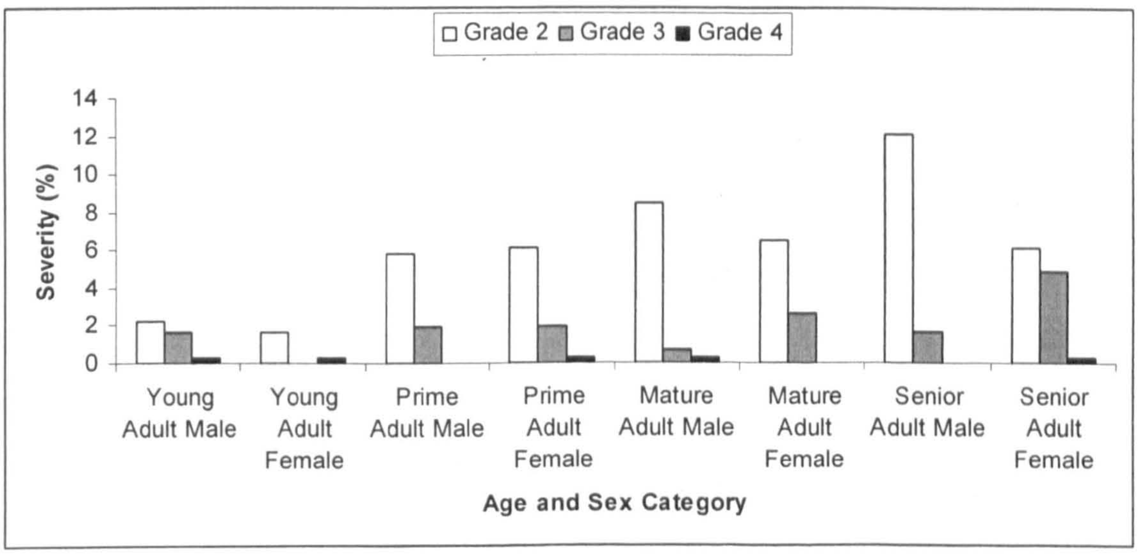


Figure 5.42 *Percentages for severity of appendicular degenerative joint disease for each age category within the Black Gate assemblage (n = 308) (Grade 2 = Slight, Grade 3 = Moderate, Grade 4 = Severe degenerative changes)*

There was no statistically significant difference in the severity of ADJD between the adult age categories (Figure 5.42). There was an increase in the frequency of Grade 3 lesions with advancing age, but the increase was too small to be statistically significant. There was a statistically significant difference in the severity of lesions observed between males and females (χ^2 = 6.106; P = 0.047), with the frequency of Grade 3 lesions being significantly higher amongst senior adult females (χ^2 = 11.242; P = 0.004).

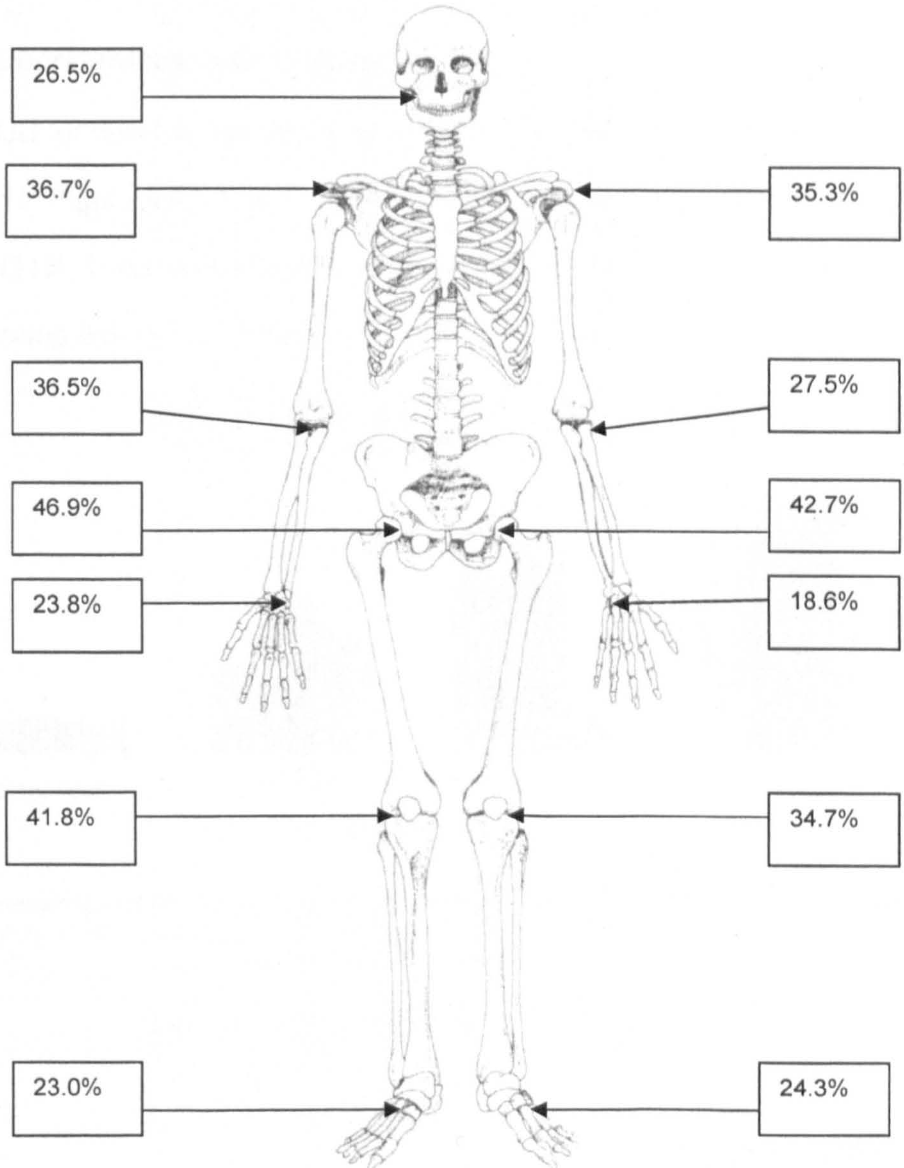


Figure 5.43 *Left and right side distribution percentages for appendicular degenerative joint disease*

Figure 5.43 shows a right sided bias for ADJD in the shoulder, elbow, wrist, hip and knee joints. In contrast, the prevalence of degenerative disease in the ankle joints showed a left side bias. The difference in prevalence observable between the left and right side shoulder and ankle joints was very small, indicating the stresses imposed upon these joints in life were similar or that these joints were not as directly involved in activities requiring a side preference than the other joints which show a distinct right sided dominance. Overall, the difference between the prevalence of DJD on the left and right sides of the body was not statistically significant.

5.6.1.3 Spinal Degenerative Joint Disease

The TPRs of SDJD for cervical, thoracic and lumbar vertebrae amongst the Black Gate adults are shown in Figure 5.44. The TPR for SDJD amongst the adult assemblage was 74.1% (244/315). There was a statistically significant increase in the prevalence of SDJD with advancing age (χ^2 = 67.843; P = 0.000).

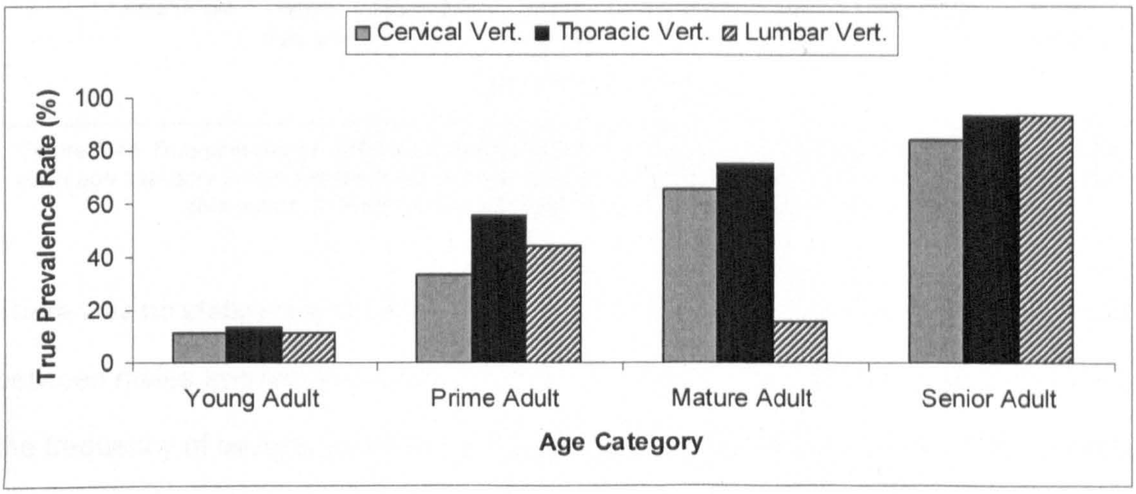


Figure 5.44 *True prevalence rates in percentages for spinal degenerative joint disease for each vertebra type and age category within the Black Gate assemblage (n = 332 individuals with at least one vertebral joint surface available for analysis)*

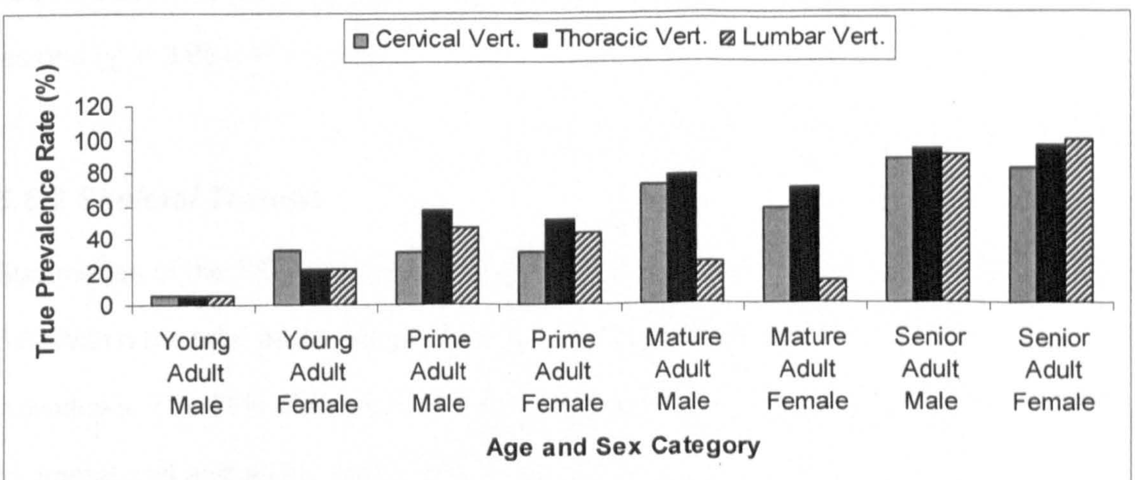


Figure 5.45 *True prevalence rates in percentages for spinal DJD for each adult age and sex category within the Black Gate assemblage (n = 281 adults with recordable joint surfaces)*

There was no statistically significant difference in the prevalence of SDJD observable between the sexes for the total adult population (Figure 5.45). There was a statistically higher prevalence of SDJD in mature adult males, compared to mature adult females

(χ^2 = 7.199; P = 0.007), resulting from a higher prevalence of lumbar SDJD amongst the mature adult males relative to the females (χ^2 = 4.132; P = 0.042).

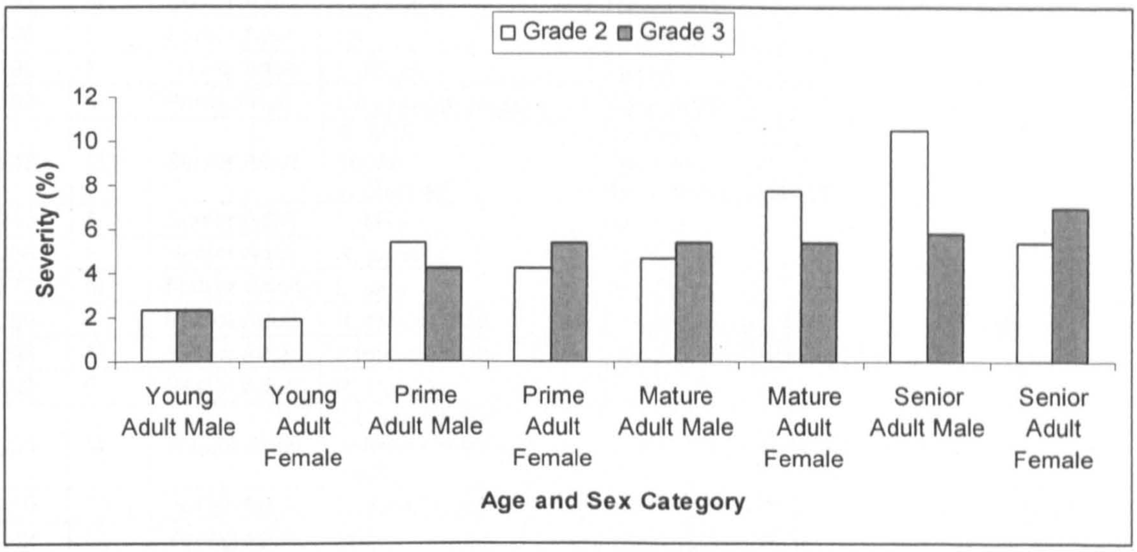


Figure 5.46 *True prevalence rates and severity in percentages for spinal degenerative joint disease for each age category within the Black Gate assemblage (n = 258) (Grade 2 = slight, Grade 3 = moderate) (No cases of Grade 4 –severe degenerative changes – were recorded)*

There was no statistically significant difference in SDJD between the age categories or between males and females overall (Figure 5.46). There was, however, an increase in the frequency of severity with advancing age, but the difference was too small to reach significance. There was a statistically higher frequency of Grade 3 lesions in young adult males compared to young adult females, which only exhibited slight (Grade 2) lesions (χ^2 = 3.864; P = 0.049).

5.6.2 Skeletal Trauma

Summaries of the TPRs of adult and immature trauma are provided in Tables 5.5 and 5.6. Within the total assemblage, forty-six traumatic lesions were observed on forty individuals. The TPR of trauma for the total assemblage was 6.2% (40/643). The TPRs for immatures and adults were 3.0% (6/202) and 7.7% (34/441). There was a significantly higher frequency of traumatic lesions amongst the adults compared to the immatures (χ^2 = 5.334; P = 0.021).

Sk.	Sex	Age	Trauma Location	Trauma Description
153	M	Young Adult	R. rib midshaft	Transverse, callous on cranial/superior surface, well-healed
178	F	Senior Adult	L. humerus	Stress/avulsion
181	M	Senior Adult	L. clavicle	Transverse
186	F	Senior Adult	L5	Compression
190	F	Young Adult	L. fibula	Stress
198	M	Prime Adult	C6 spinous process	Transverse
242	M	Senior Adult	R. MT5; frontal; L. clavicle?	Avulsion; Depression; Well-healed greenstick?
243	F	Senior Adult	L. MT2	Avulsion
256	F	Senior Adult	R. parietal	Depression
277	M	Mature Adult	L. ulna	Avulsion
289	F	Senior Adult	R. femur- neck	Transverse- ununited- pseudoarthrosis
298	M	Senior Adult	2 true right ribs	Transverse- severe callous formation+exostoses
302	F	Senior Adult	R. clavicle	Simple
305	M	Mature Adult	2 L. rib shafts between head and neck	Transverse- healed partially misaligned, callous
315	F?	Senior Adult	L. clavicle, midline	Transverse/ simple, misaligned, well healed
342	M	Young Adult	L5	Compression
375	F	Prime Adult	L. tibia, midshaft	Transverse, callous, well-healed slight malformation on medial side
415	M	Senior Adult	R. clavicle	Stress/transverse
434	M	Mature Adult	L. clavicle lateral third	Open/compound healed misaligned. Inferior
444	U	Adult	L. rib neck angle	Transverse; severe osteophytosis + inflammatory response on articulating surfaces
447	M	Senior Adult	L. humerus - mesial distal	Oblique, slightly misaligned, healed
467	F	Mature Adult	L. ulna- midshaft	Transverse- ununited-healed
493	M?	Young Adult	L. clavicle midshaft; Axis L. side spinous process	Transverse, well healed misaligned; stress fracture, healed
526	U	Adult	L5 spinous process midline	Ununited but with bone remodelling- is this spondylolysis?
538	M	Senior Adult	R. hallux- infection- medio-prox surface	Well healed misaligned, osteophytosis + porosity
550	M	Mature Adult	R. tibia	Oblique
556	F?	Mature Adult	R. radius; ribs	Colles, Ununited
579	F	Mature Adult	L. metatarsal V	Avulsion
588	M?	Senior Adult	R. clavicle	Transverse; displaced anterio-inferior
589	F	Mature Adult	L. clavicle	Simple
610	F	Prime Adult	R. radius- midshaft	Oblique
620	F	Senior Adult	R. scapula-acromion	Comminuted- shortened spine, callous
655	U	Adult	R. calcaneus- post. ant. facet	Compression
191i	M	Young Adult	R.clavicle - distal	Simple/ well healed green stick fracture? Difficult to tell identified by malformation + callous, shortened shaft

Table 5.5 *Summary of traumatic lesions observed within the adult Black Gate assemblage*

Sk.	Age	Trauma Location	Trauma Description
570	Adolescent	R. radius midshaft	Bowing fracture
39	Young Child	R. true rib	Healed greenstick
508	Neonate	R. clavicle - distal	Healed greenstick fracture?, slightly misaligned, callous formation, sharp posterior angle?
581	Adolescent	R. second rib - medial	Incomplete, well aligned
140	Infant	unidentifiable, unsided rib shaft fragment	Simple, misaligned, healed, callous
523	Older Child	R. ulna R. radius	Bowing + callous on lateral diaphysis M-L bowing;

Table 5.6 *Summary of traumatic lesions observed within the immature Black Gate assemblage*

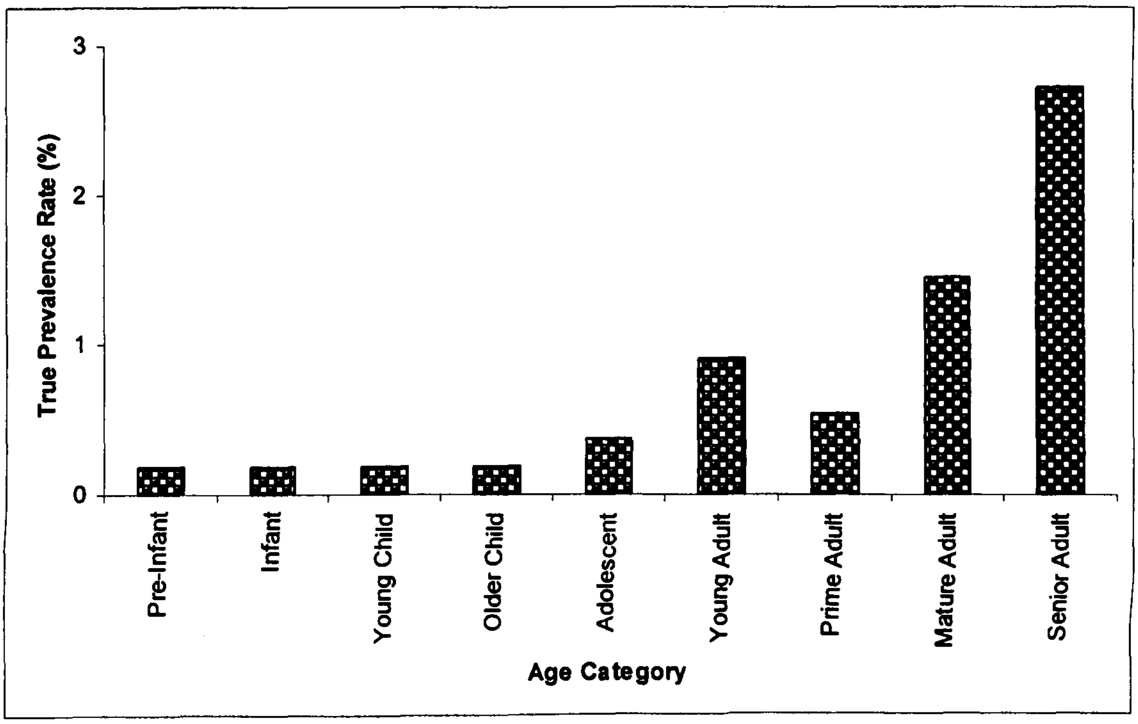


Figure 5.47 *True prevalence rates in percentages for trauma for each age category within the Black Gate assemblage (n = 553 recordable individuals of known age)*

The majority of individuals exhibiting evidence for skeletal trauma were within the senior adult age category (2.3%; 15/643) (Figure 5.47). There was a statistically significant increase in the prevalence of trauma with advancing age for the total population (χ^2 = 16.040; P = 0.042), but not for the adult population alone.

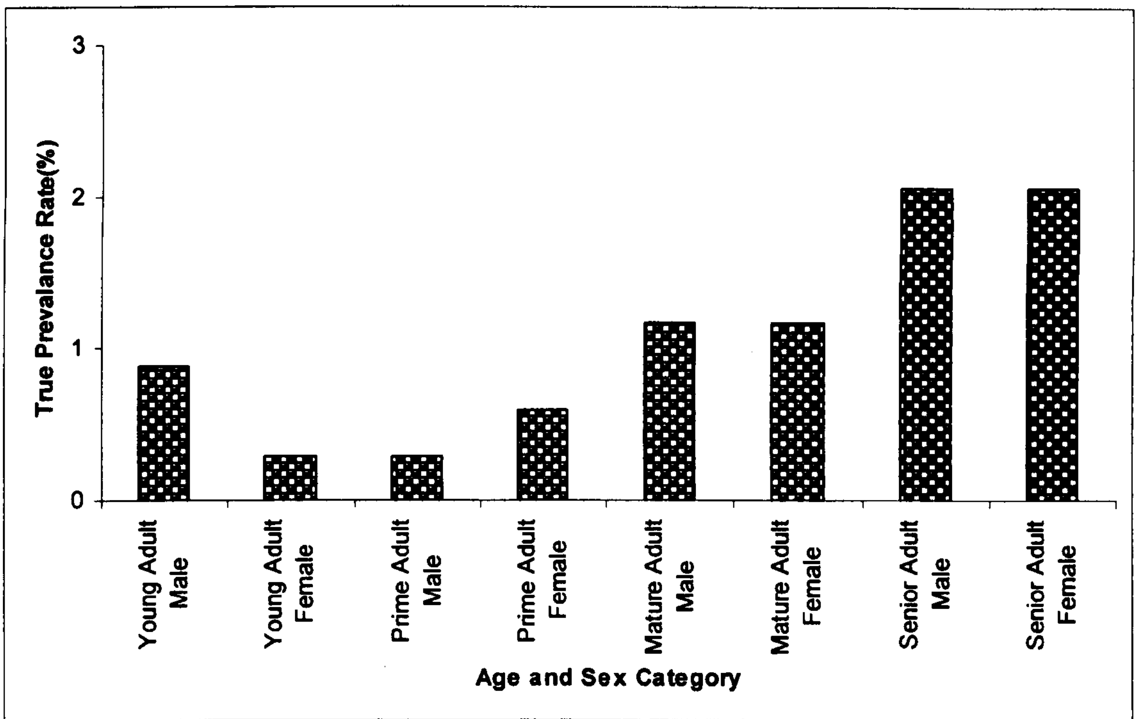


Figure 5.48 *True prevalence rates in percentages for trauma for each adult age and sex category within the Black Gate assemblage (n = 340 adults of known age and sex)*

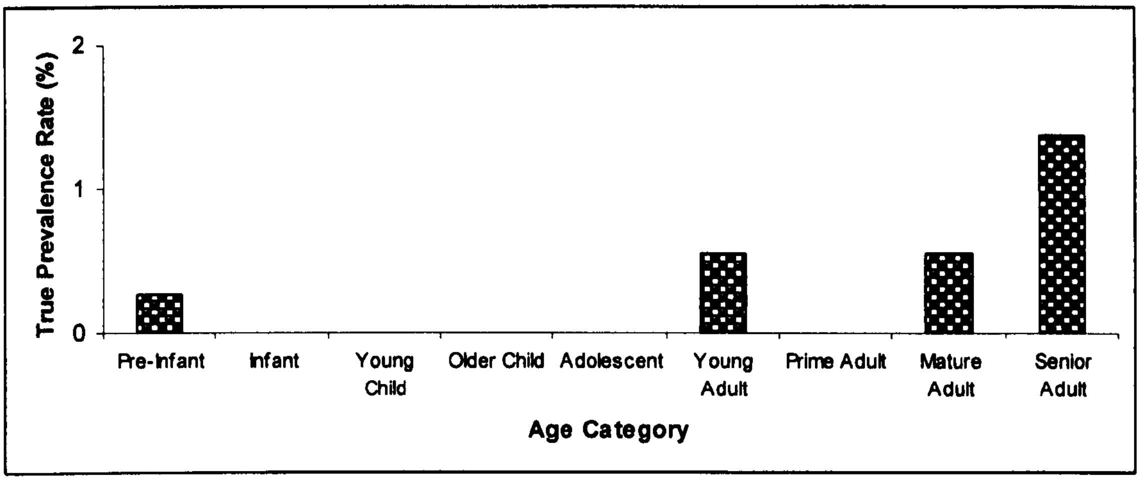
There was no statistically significant difference in the prevalence of skeletal trauma observed in the adult males and females overall or within each adult age category (Figure 5.48). The difference between the sexes was very small, less than one percent, for each age category.

5.6.2.1 Description of Specific Trauma

Within this section, trauma to specific areas of the skeleton – clavicle, ribs, upper limb, lower limb and the presence of spondylolysis – are considered.

5.6.2.1.1 Clavicle

Within the Black Gate assemblage, 327 individuals of known age possessed at least one clavicle available for analysis. Of these, 125 were immatures and 247 were adults. The TPR of clavicular trauma for the total assemblage was 2.7% (10/372). The TPRs for immatures and adults were 0.8% (1/125) and 3.6% (9/247) respectively. There was no statistically significant difference in the prevalence of clavicular trauma between the immatures and adults.



5.49 *True prevalence rates in percentages for clavicular trauma for each age category within the Black Gate assemblage (n = 366 recordable individuals of known age)*

The highest TPR of clavicular trauma for the total recordable assemblage was amongst the senior adult age category (1.4%; 5/366) (Figure 5.49). There was no statistically significant difference for the true prevalence of clavicular trauma between the age categories for either the total or the adult populations.

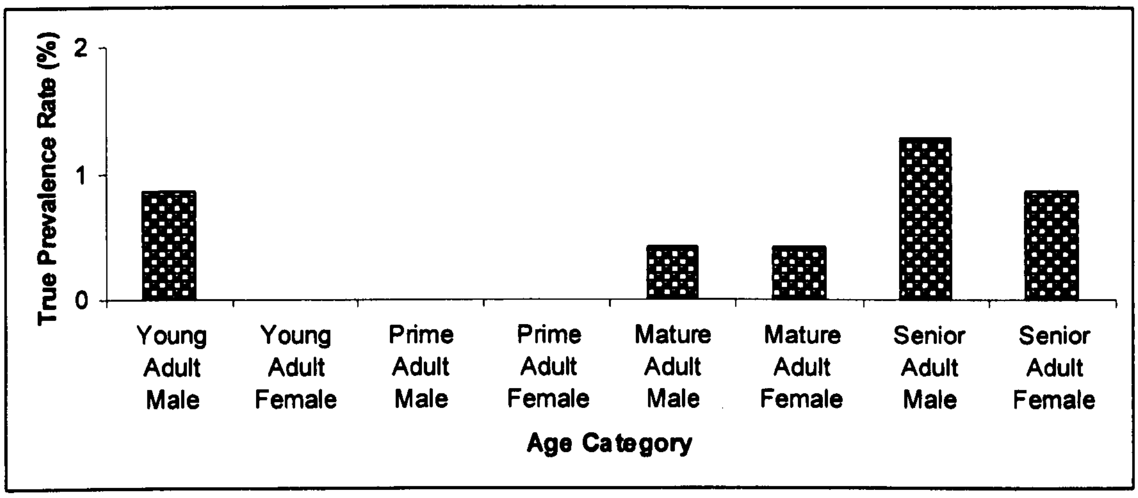
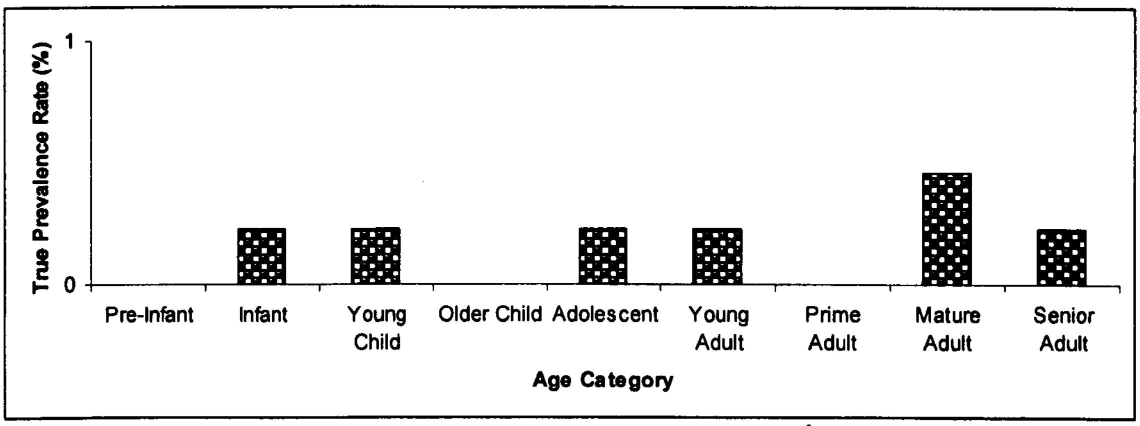


Figure 5.50 *True prevalence rates in percentages for clavicular trauma for each adult age and sex category within the Black Gate assemblage (n = 340 adults of known age and sex)*

There was no statistically significant difference in the prevalence of clavicular trauma between males and females (Figure 5.50). There was no statistically significant difference between the sexes in any of the age categories

5.6.2.1.2 Ribs

Within the Black Gate assemblage, 234 individuals of known age had at least one rib available for analysis. Of these, 158 were immatures and 296 were adults. The TPR of rib trauma for the total assemblage was 1.8% (8/454). The TPRs for immatures and adults were 1.9% (3/158) and 1.7% (5/296) respectively. There was no statistically significant difference in the prevalence of rib trauma between the immatures and adults.



5.51 *True prevalence rates in percentages for rib trauma for each age category within the Black Gate assemblage (n = 234 recordable individuals of known age)*

The highest TPR of rib trauma for the total recordable assemblage was amongst the mature adults (0.9%; 2/234) (Figure 5.51). There was no statistically significant difference for the true prevalence of rib trauma between the age categories for either the total population or the adult population.

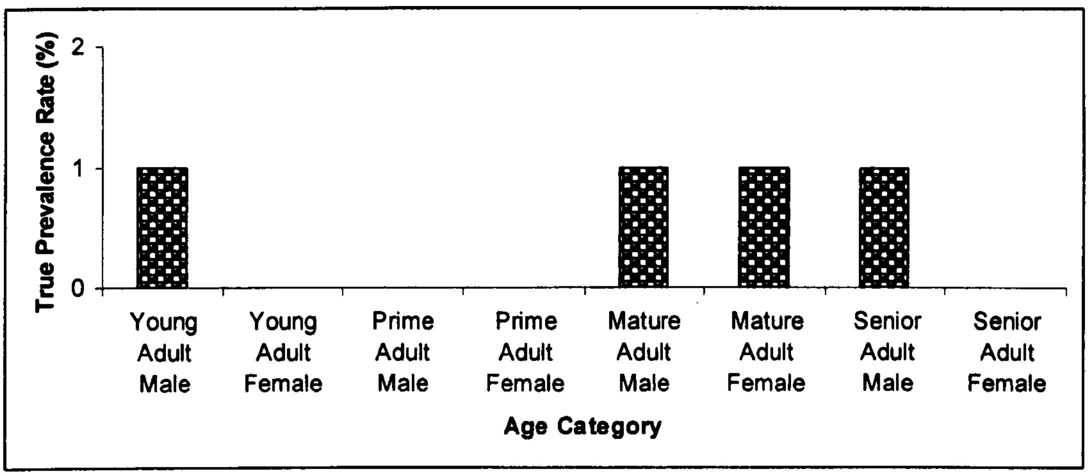


Figure 5.52 *True prevalence rates in percentages for rib trauma for each adult age and sex category within the Black Gate assemblage (n = 270 adults of known age and sex)*

There was no statistically significant difference in the prevalence of rib trauma between males and females (Figure 5.52). There was no statistically significant difference between the sexes in any of the age categories.

5.6.2.1.3 Upper Limb

Within the Black Gate assemblage, 472 individuals possessed at least one upper limb bone (humerus, radius or ulna) available for analysis. Of these, 153 were immatures and 319 were adults. The TPR of upper limb trauma for the total assemblage was 1.9% (9/472). The TPRs for immatures and adults were 1.3% (2/153) and 2.2% (7/319) respectively. There was no statistically significant difference between the prevalence of trauma expressed in the immatures and adults.

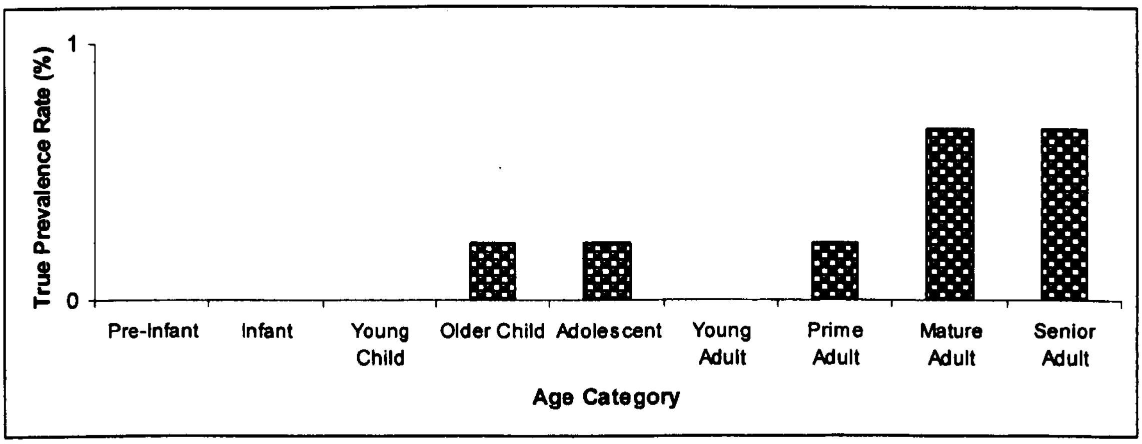


Figure 5.53 *True prevalence rates in percentages for upper limb trauma for each age category within the Black Gate assemblage (n = 472 recordable individuals of known age)*

The highest TPR of upper limb trauma for the total recordable assemblage was amongst the mature adult age category (3.8%; 3/80) (Figure 5.53). There was no statistically significant difference for the true prevalence of upper limb trauma between the age categories for either the total or the adult populations.

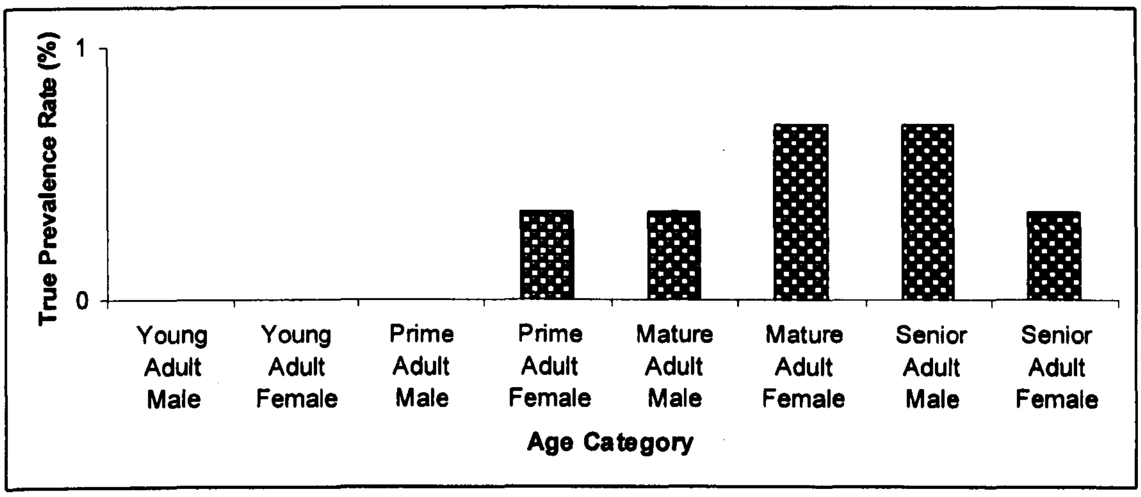


Figure 5.54 *True prevalence rates in percentages for upper limb trauma for each adult age and sex category within the Black Gate assemblage (n = 288 adults of known age and sex)*

There was no statistically significant difference in the prevalence of upper limb trauma between males and females (Figure 5.54). There was no statistically significant difference between the sexes in any of the age categories

5.6.2.1.4 Lower Limb

Within the Black Gate assemblage, 444 individuals possessed at least one lower limb bone (femur, tibia or fibula) available for analysis. Of these, 134 were immatures and 310 were adults. The TPR of lower limb trauma for the total assemblage was 0.9% (4/444). No lower limb traumas were recorded for the immature assemblage. The TPR for adults was 1.3% (4/310). There was no statistically significant difference between the prevalence of lower limb trauma expressed in the immatures and adults.

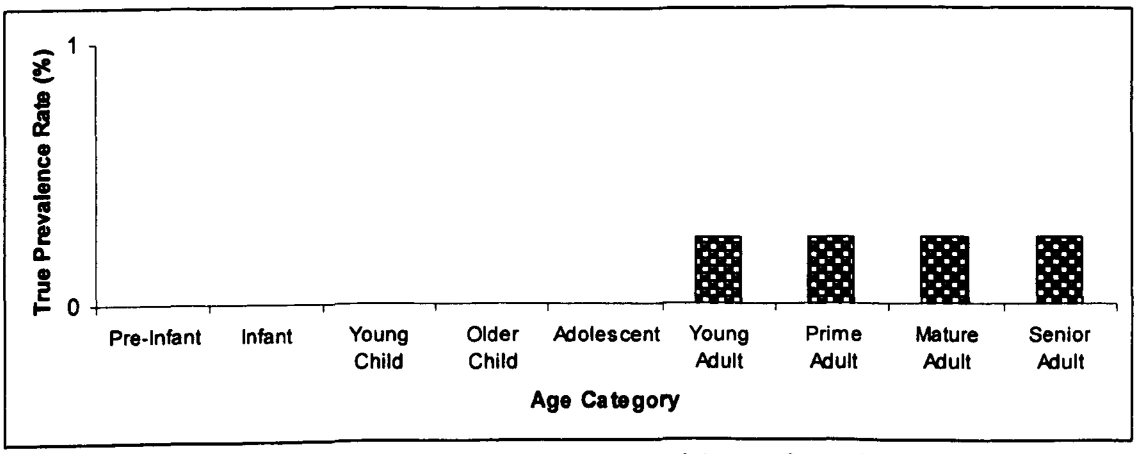


Figure 5.55 *True prevalence rates in percentages for lower limb trauma for each age category within the Black Gate assemblage (n = 389 recordable individuals of known age)*

Only one individual expressed lower limb trauma in each of the adult age categories (Figure 5.55). The highest TPR of lower limb trauma for the total recordable assemblage was amongst the young adult age category (3.7%; 1/27), but this was purely because there were fewer observable adults in this age category relative to any of the others, not a higher number of cases of lower limb trauma. There was no statistically significant difference for the true prevalence of lower limb trauma between the adult age categories.

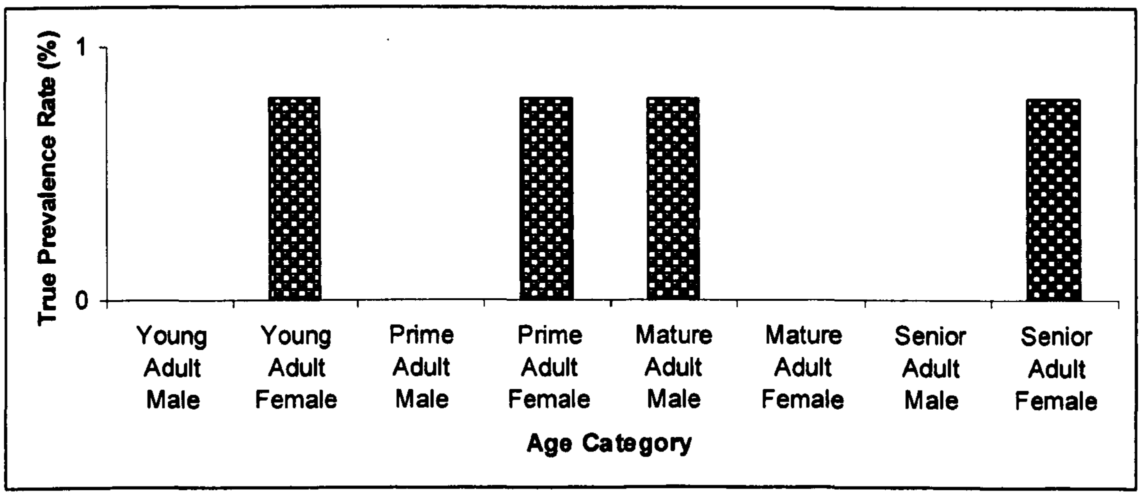


Figure 5.56 *True prevalence rates in percentages for lower limb trauma for each adult age and sex category within the Black Gate assemblage (n = 252 adults of known age and sex)*

There was no statistically significant difference in the prevalence of lower limb trauma between males and females (Figure 5.56). There was no statistically significant difference between the sexes in any of the age categories. However, the number of cases of lower limb trauma was insufficient to make accurate inferences about the relationship between age, sex and traumatic injuries to the lower limb.

5.6.2.1.5 Spondylolysis

Within the Black Gate adult assemblage, 436 individuals possessed at least one lumbar vertebra available for analysis. The TPR of spondylolysis for adults was 1.1% (5/436). No immatures exhibited spondylolysis.

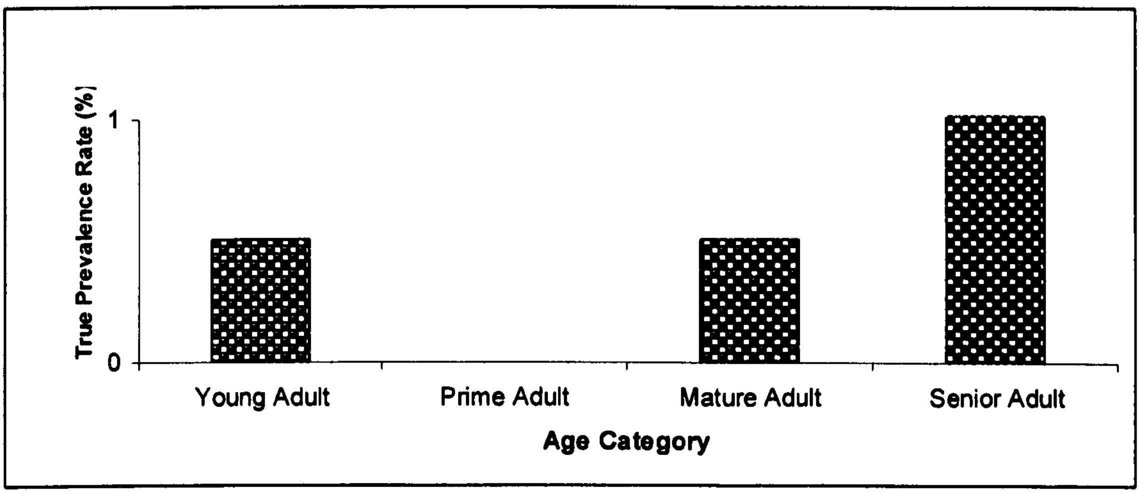


Figure 5.57 *True prevalence rates in percentages for spondylolysis for each age category within the Black Gate assemblage (n = 196 recordable individuals of known age)*

The highest TPR of spondylolysis was amongst the senior adult age category (2.2%; 2/92) (Figure 5.57). There was no statistically significant difference for the true prevalence of spondylolysis between the adult age categories.

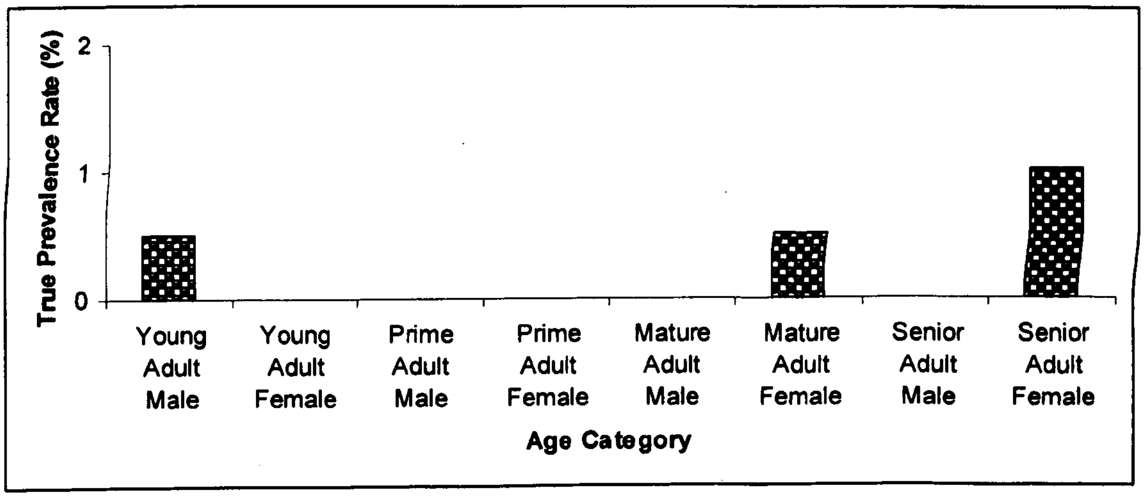


Figure 5.58 *True prevalence rates in percentages for spondylolysis for each adult age and sex category within the Black Gate assemblage (n = 193 adults of known age and sex)*

There was no statistically significant difference in the prevalence of spondylolysis between males and females (Figure 5.58). There was no statistically significant difference between the sexes in any of the age categories. However, the number of cases of spondylolysis was inadequate for accurate inferences about the relationship between age, sex and lower limb trauma to be made.

5.7 Discussion of Black Gate Mortality and Morbidity

The following section provides a detailed synthesis and interpretation of the results presented in the preceding sections.

5.7.1 Mortality: Demography and Assemblage Composition

The Black Gate mortality profile displayed an increase from birth peaking in the young childhood age category, followed by a reduction in older childhood, adolescence and young adulthood and then increasing throughout adulthood to a peak in senior adults. The presence of deaths in all age categories, with a peak in the youngest and oldest members of the population is characteristic of an attritional mortality profile, which represents the normal life course of individuals in most populations, whereby the young and old are the most at risk of death (Chamberlain 2006: 123, 162). A previous study by Gowland and Chamberlain (2005) on attritional and catastrophic mortality profiles also found that the Black Gate demographic data provided an exact match for an attritional mortality profile (Figure 5.59). The Black Gate mortality profile is typical of the later Anglo-Saxon period, being also found at York Minster, Swinegate, Jarrow, Llandough, Wharram Percy and Addingham.

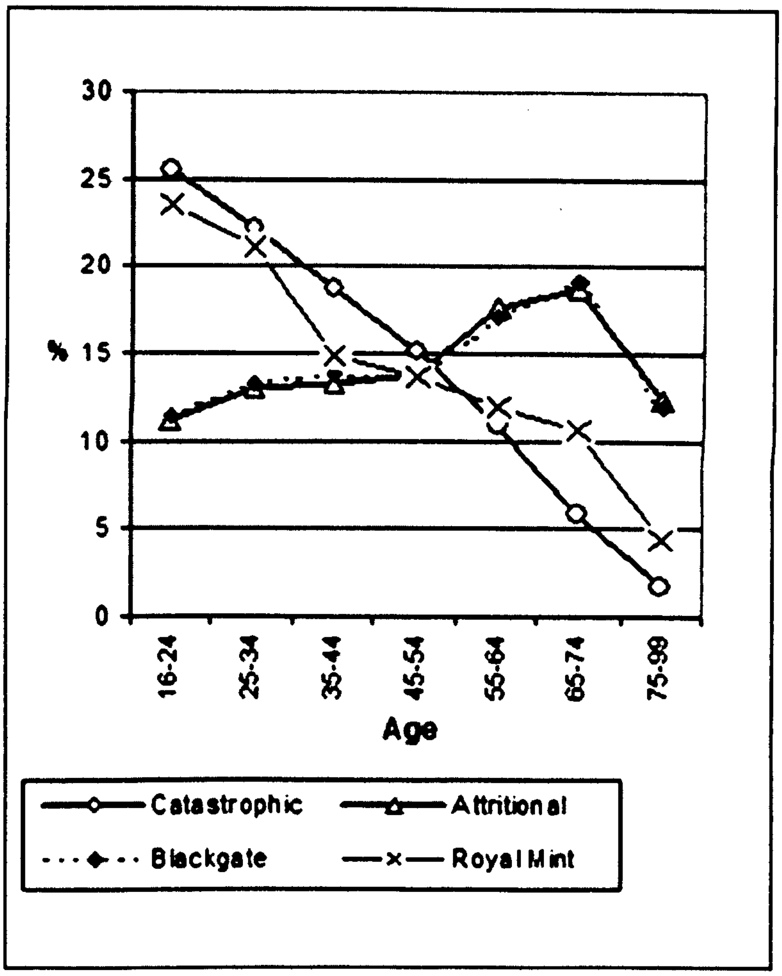


Figure 5.59 Age at death profile of the Black Gate cemetery in comparison to an attritional mortality profile aged by auricular surface and with attritional priors (Gowland and Chamberlain 2005: 153, Figure 4)

In developing modern populations, children under the age of 5 are highly susceptible to under-nutrition and an increased pathogen load. Consequently, young children experience high death rates, with figures quoted between 40 and 50% of all the deaths recorded for any given population (Goodman and Armelagos 1984: 225; Kamp 2001: 9). It is reasonable to assume that children in archaeological populations would have experienced similar environmental stresses due to the same lack of access to modern medical care and sanitation systems (Goodman and Armelagos 1984: 225; Mays 2007: 89) and, therefore, exhibit similar mortality profiles. Indeed, Chamberlain (2006: 182) estimated that attritional deaths of immatures aged less than 15 years of age would have constituted between 33 and 50% of deaths in past populations, a similar figure to the 30% proposed by White (1988: 30) and Waldron (1994: 23). Immature mortality within the Black Gate assemblage was consistent with these studies as infants and young children (aged from birth to 5 years), constituted 22.2% and all the immatures (aged less than 15 years) made up 29.2% of the total number of deaths.

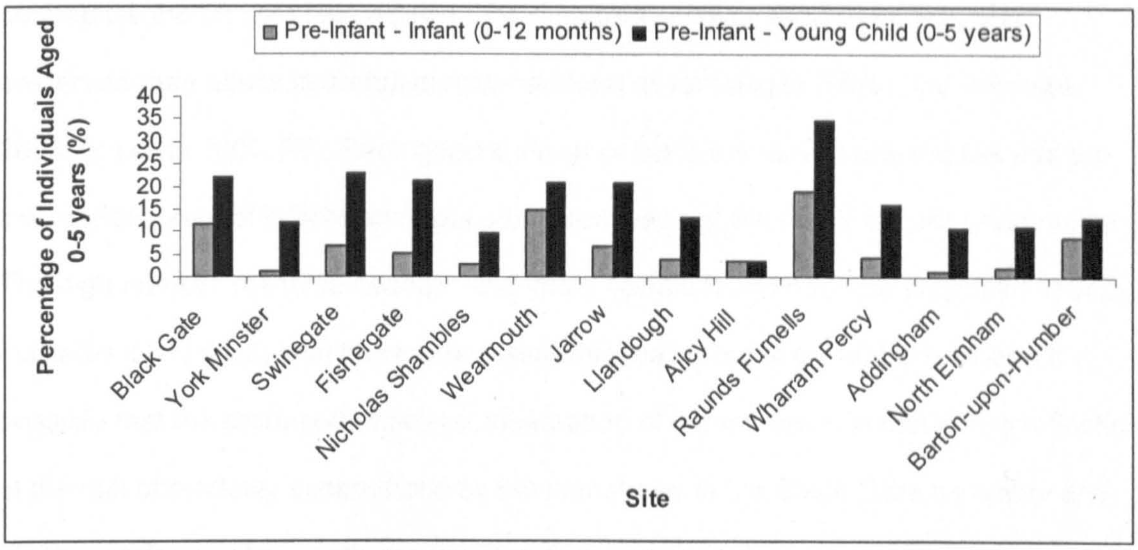


Figure 5.60 *The 'under-representation' of immatures aged 0-12 months and 0-5 years within Black Gate and the comparative sites*

When the percentage of individuals aged under 5 years of age was compared with other early medieval cemeteries it was apparent that there was a great diversity in the presence of children, from the very small 3.7% of children recovered from Ailcy Hill to the 34.7% recovered from Raunds Furnells (Figure 5.60). If Ailcy Hill, which is an exceptional monastic assemblage, was excluded, the mean percentage of deaths of children aged between birth and 5 years of age was still only 16.7% with a range from 9.8% (St Nicholas Shambles) to 34.7% (Raunds Furnells). Even when all immature individuals aged less than 18 years were combined for each of the burial assemblages within this study, none of the figures reached the 50% mark. The closest was Raunds Furnells with a percentage of 47.1%. These figures suggest that a dearth of infants and immatures was a common feature of early medieval cemeteries of all types. Similar low numbers of immature interments were also seen in sites such as the late medieval cemetery of Nova Raca in Croatia (Slaus 2008), indicating the under-representation of immatures to be a characteristic of archaeological skeletal assemblages in general. The under-representation of infants (aged 0-1 year) and young children (1-5 years) has been typically accorded to a combination of poor preservation, selective burial practices and excavation methods (Buckberry 2000; Bello and Andrews 2006: 10-11;

Hamerow 2006). However, the high proportion of Black Gate immature skeletons recorded as in 'good' or 'excellent' condition, in comparison to the adult population, contradicts the oft held assumption that immature remains tend to be less well preserved than adults in archaeological skeletal assemblages (Bello and Andrews 2006: 5; Lewis 2007: 20). Such good survival of the Black Gate bone implies that the low mortality rate of infants and young children was not the result of poor preservation. The high number of foetal, neonate and infant burials found near the proposed church indicates it is unlikely that there was a separate 'baby' burial ground elsewhere. It is possible that the proposed under-representation of immatures is in fact a true reflection of the risk of mortality experienced by the immatures in the Black Gate cemetery and other cemeteries of the early medieval period.

The almost equal representation of male and female adults, with no significant difference between them in any of the age categories, further suggests the Black Gate cemetery to be representative of a 'normal' population. An exclusion, or bias, of any age or sex group may have indicated a specialist use for the cemetery. For example, the hypothesis that the cemetery served a monastic community (Monkchester) may have been supported by a preponderance of male burials, as seen in Phase 2 at Ailcy Hill, Ripon (Hall and Whyman 1996: 83-4,120), and at the later Gilbertine priory at St Andrew's, Fishergate, York (Knüsel *et al.* 1997). The absence of a male bias could be used to infer that the Black Gate assemblage does not represent a monastic community. However, the assemblage composition of monastic cemeteries containing lay burials such as Wearmouth, Jarrow and Llandough contained all demographic groups, making them indistinguishable from other later Anglo-Saxon cemetery types. Consequently, the demographic profile alone could not be used to prove or disprove the monastic origins of the Black Gate cemetery population. The site may have originally served a monastic or manorial population, resulting in predominantly male burials, then later became a secular settlement resulting in a more equal representation of females, negating the dominance of earlier male burials. If it was possible to assign the sex of 'possible' males and females and adult individuals of unknown sex , there may have been a shift towards a male dominated assemblage. However, the low percentage of individuals of unknown sex compared to the large number of identified individuals makes it unlikely that the proportions of males and females within the assemblage would shift dramatically. Also, there was little segregation by sex within the cemetery. Thus, it is unlikely that the unsexed skeletons, which came from throughout the burial area, would turn out to all be males or females if their sex was determinable.

Many archaeological populations show a higher rate of female to male mortality coupled with high rates of neonate mortality, suggesting the deaths of the young adult females and neonates to be related to complications in pregnancy and childbirth (Slaus 2008: 194). In the Black Gate cemetery, female deaths were less frequent in young adult females relative to males. There were higher relative mortality rates in females in the prime (26-35 years) and mature (36-45 years) age categories, but the differences observed were nominal and not statistically significant. Furthermore, neonate births constituted 4.0% of deaths, which was a similar risk to that seen in young children (0-5 years). The increased risk of female death compared to males in females aged 25-45 years and high incidence of neonate deaths may represent the long term accumulative effects of the compromised health and stress associated with repeated periods of pregnancy and lactation (Slaus 2008: 194) as well as the immediate dangers of childbirth.

The monks of St Andrew's, Fishergate showed a more extended lifespan relative to all other status group (Sullivan 2004: 340). If the Black Gate males were accorded a greater social status due to their wealth or if they were monks, or secular elites, it is expected that they would have lived to a great age and therefore be most prevalent in the senior adult age category. Males (15.2%) were indeed more prevalent than females (14.5%) in the senior adult age category, but the difference was nominal, and may be due to methodological bias. Female skeletons aged over 45 years of age develop more masculine cranial features, such as more pronounced supra-orbital ridges due to reduced oestrogen levels and increased levels of testosterone (Walker 1995: 40). Consequently, senior adult females may have been sexed as male. Indeed, the greatest number of skeletons identified as probable males were in the senior adult age category (8/21; 38.1%), indicating the sexing of senior adults was problematic. In consideration of the evidence presented here, there was no indication that the Black Gate males experienced a greater longevity of life relative to the females. This observation suggests that both sexes were accorded equivocal social status and experienced similar lifestyles.

5.7.2 Indicators of Environmental Stress: Growth and Development

Immature Growth

The growth profile of the Black Gate immature assemblage was statistically indistinct from those created by Lewis (2002 a, b) for the rural sites of Wharram Percy and Raunds Furnells and the urban St Helen-on-the-Walls and Christ Church, Spitalfields. The growth profile was also comparable to those documented by Mays *et al.* (2008: 86) for the 19th-century urban cemetery of St Martin's churchyard, Birmingham and the 10th-19th-century rural cemetery of Wharram Percy and five further European sites of varying context dating from the Romano-British period to the 19th century (Mays 1999: 293-6). It is possible that the similarities in these growth profiles of urban and rural settlements from the Romano-British to post-medieval periods represented similar environmental stressors, or physiological responses to stress within those populations and that stress and chronic malnutrition had a limited impact on immature growth in the past. Ribot and Roberts (1996) came to such a conclusion when their investigation into the relationship between stress indicators (including dental enamel hypoplasia, cribra orbitalia, porotic hyperostosis and periosteal new bone formation) and diaphyseal length at age at death failed to find any correlation between physiological stress and longitudinal growth of long bone diaphyses. Alternatively, as argued by Mays *et al.* (2008: 91; 2009), it is possible that longitudinal diaphyseal growth is too insensitive a physiological indicator of environmental stressors upon the skeleton to show any correlation with settlement type or socio-economic status. The inaccuracy of skeletal ageing methods undermines the reliability of diaphyseal-length-at-age as an indicator of physiological response to environmental stress. In this instance, the one-year age categories used to create the growth profile were in fact arbitrary age groups produced from charts of dental calcification and formation. The stages of dental development correlate with estimated age bands, which can range between several months or years. Thus, an individual with an age range of 2.25 to 3.75 years provided by completion of the crown on the first pre-molar (Coc) (Moorrees *et al.* 1963) would have a mean age of 3 years, but could easily be either 2.25 or 3.75 years of age. Furthermore, the dental charts are specific to one population; therefore, they do not account for differences in growth and development between populations, increasing the scope for error.

Adult Stature

Adult stature for the Black Gate assemblage was within the range observed for the early medieval period (Roberts and Cox 2003: 195). The consistently comparable adult stature between the sites complimented the similar immature diaphyseal lengths between Black Gate and the medieval sites recorded by Lewis (2002 a, b). The similarity in adult growth between sites may indicate that all the sites underwent similar levels of environmental and nutritional stress. Alternatively, immatures who expressed growth retarding periods of environmental or nutritional stress may have later acquired sufficient levels of the necessary dietary requirements during adolescence to enable 'catch-up growth', resulting in the ultimate attainment of their expected stature in adulthood (Larsen 1995: 190-1).

The Black Gate males were significantly taller than the females. Stature is to a certain extent genetically predisposed and is often ascribed to differences in the levels of hormones, particularly testosterone and oestrogen, within males and females (Mays 1998; Sinclair 1989; Bogin 1999b). However, environmental factors also determine an individual's final attained height. The sexual dimorphism in stature observed at Black Gate may have resulted from different levels of physiological stress experienced by males and females during periods of growth, such as differences in living conditions, sanitary provision and standards of hygiene, nutritional quality and quantity during infancy, energy expenditure and overall health (Cardoso and Gomes 2009: 712). Several scholars have hypothesised that nutritional surplus was invested in the males to enable their optimal growth, and this is thought to be a characteristic of rural communities (Jenkins 1993: 121 citing Stini 1969; Loe and Robson-Brown 2005: 46). However, females were shorter than males in all of the sites included within this thesis, regardless of whether they were urban or rural. This indiscriminate sexual dimorphism undermines the argument that the reduced female stature signifies a rural community and that urban and rural communities were identical in their outlook and treatment of males and females. Differential access to food has been linked specifically to reduced female life expectancy throughout the Anglo-Saxon period (Härke 1997: 135). However, there was no divergence in the life expectancy of males and females within the Black Gate population. Both males and females had a mean average age at death of 39 years (males = 39.3 years; females = 39.8 years), suggesting that there was no differential access to food, or that if there was, the differences may have influenced health but not to such an extent as to reduce life expectancy. The average stature observed amongst the Black Gate females was greater than observed at any other of the comparative sites. There are a myriad of reasons for this, as for stature differences between the sexes within the assemblage, but without further radio-carbon dating, stable carbon and nitrogen isotope or DNA analysis, the cause remains unknown. Chapter 8 will address the potential of chemical analysis within the Black Gate assemblage. Differences in stature between sexes and populations may also derive from inaccuracies and variability in the methods used to determine stature from long bone lengths. For example, Cardoso and Gomes (2009: 712) state that in their research the regression formulae produced by Trotter and Gleser (1952) consistently produced a stature estimate 4-5 cm above that provided by Pearson's method (1899).

5.7.3 Health and Diet Indicators

Figure 5.61 summarises the true prevalence rates of all the health indicators included within this study for immatures, adults, males and females. It shows the age group experiencing the highest TPR, and documents if there was an increase in prevalence with age.

Health Indicator	Immatures vs. Adults	Highest TPR	Increase with Age	Males vs. Females
Cribra Orbitalia	Immature > Adult	Young Children	Adolescent-Senior Adult	Male > Female
Porotic Hyperostosis	Immature > Adult	Young Children	No increase with age	Male > Female
DEH	Immature ≥ Adult	Senior Adults	Young Child-Senior Adult	Male > Female
TPNB	Immature < Adult	Senior Adults	Older Child-Senior Adult	Male > Female
Maxillary Sinusitis	Immature < Adult	Mature Adults	No increase with age	Male < Female
Dental Calculus	Immature < Adult	Senior Adults	Pre-infant-Senior Adult	Male > Female
Dental Caries	Immature < Adult	Senior Adults	Young Child-Senior Adult	Male < Female
Dental Abscesses	Immature < Adult	Senior Adults	Infant-Senior Adult	Male < Female
AMTL	Immature < Adult	Senior Adults	Young Child-Senior Adult	Male < Female
DJD	Immature < Adult	Senior Adult	Young Adult-Senior Adult	Male > Female
ADJD	Immature < Adult	Senior Adult	Young Adult-Senior Adult	Male < Female
SDJD	Immature < Adult	Senior Adults	Young Adult-Senior Adult	Male > Female
Trauma	Immature < Adult	Senior Adults	Pre-Infant-Senior Adult	Male > Female

Figure 5.61 *True prevalence rates of skeletal stress indicators for the Black Gate population (n= 643 skeletons)*

The statistically significant higher prevalence of both cribra orbitalia and porotic hyperostosis in the Black Gate immature population in comparison to the adults, suggests an association between porotic lesions of the skull and childhood stress. Cribra orbitalia and porotic hyperostosis differed further from the other health indicators in the fact that they peaked in the young child age category, strengthening the interpretation that such lesions were a skeletal manifestation of childhood stress. The comparable prevalence of dental enamel hypoplasia between the immatures and adults indicates the causes of perturbations of growth, which resulted in the enamel defect, were non-fatal, and that those who were affected were just as likely to survive or die as those unaffected. This observation, in association with the high prevalence of cribra orbitalia amongst the immatures, supports the notion that the Black Gate immatures were experiencing prolonged periods of mild systemic stress. All other health indicators were more prevalent in the adults than the immatures. The greater true prevalence of all the dental and degenerative joint disease indicators was statistically significant, whereas the difference between immatures and adults expressing TPNB or maxillary sinusitis were not. Almost all the other health indicators revealed a peak in the senior adult age category, which appeared to be linked to a progressive accumulation of lesions with age from childhood through to senior adulthood. The increases in prevalence with advancing age were statistically significant for dental calculus, abscesses, AMTL, ADJD, SDJD and trauma. The exception was maxillary sinusitis, which presented a peak in the mature adults and exhibited no steady increase in frequency with age, i.e. it showed irregular fluctuations between age categories. The lack of progressive age increase in the frequency of cases of maxillary sinusitis suggests that the formation of these lesions was influenced by different factors than the natural decline in the body's immunological defences as it ages. Maxillary sinusitis was probably linked to extrinsic behavioural and/or environmental factors.

Males exhibited higher prevalences of cribra orbitalia, porotic hyperostosis, DEH, TPNB, calculus, DJD, SDJD and trauma than females. Of these stress markers, only the differences in porotic hyperostosis and TPNB were statistically significant. Females exhibited greater prevalences of maxillary sinusitis, dental caries, abscesses, AMTL and ADJD than males. However, only the presence of AMTL was significantly greater in the females. The dissimilarities in frequencies of these health indicators between the sexes suggest biological, behavioural or cultural differences. The higher prevalence of cribra orbitalia, porotic hyperostosis and DEH suggests that males experienced greater stresses than females during childhood, or that male children showed a preferential rate of survival than females from episodes of systemic stress. The greater expression of TPNB amongst males could be caused by several factors. Males may have been more susceptible to injuries to the shin during work or leisure activities. Alternatively, males may have had a greater susceptibility to intrinsic blood-borne infections than females, or even just had a lowered immunological response to infection, which meant they suffered from infections for a sufficient duration for bony responses to manifest. Indeed research has shown that females exhibit a more effective immune response to infectious disease compared to men due to the selective pressure of the risks of pregnancy and childbirth (Ortner 1998; Klein *et al.* 2012). Consequently, females would recover from infections quicker than males, before skeletal responses to the infection could manifest. The higher prevalence of maxillary sinusitis in females may represent behavioural differences. For example, they may have been exposed to irritants from hearths during cooking or craft activities, or simply been more susceptible to infections of the sinus. The higher prevalence of calculus in males and carious lesions, abscesses and AMTL in females may indicate dietary differentiation between them, with males consuming more protein based foods and females more carbohydrate rich foods. The higher prevalence of dental health indicators in females may also represent a greater biological susceptibility or the impact of the physiological stresses of pregnancy, childbirth and child rearing. The higher presence of DJD in males relative to females may represent occupational or lifestyle differences imposing different stresses upon the skeleton. The greater difference between the sexes in ADJD than SDJD implies the appendicular joints are more susceptible to degeneration from physical activities, whereas the degeneration of the spine is more of an age-related phenomenon, more closely linked to the morphological characteristics of the spine, although mechanical loading may have exaggerated such degeneration. The higher prevalence of adult trauma suggests that what we are seeing is the accumulative effects of traumatic episode throughout life – i.e. the longer an individual lives the more likely they are to have experienced a traumatic episode – and the increasing frailty of the skeleton with advancing age can further amplify the chances of skeletal trauma as an individual ages. The similarity in the frequency, types and location of trauma seen in male and female skeletons implies both sexes were equally susceptible to trauma and that traumatic events in the Black Gate population predominantly resulted from accidental injury and were not specifically linked to occupation, and definitely not linked to violence. Indeed, the limited evidence of violence within the assemblage corresponds with the evidence for care and nurture in the inclusion of disabled individuals within the cemetery, who must have been accorded a sufficient level of care to have survived their disability (in particular, skeleton BG442). Adult male BG442 aged 20-29 years suffered several skeletal abnormalities, which suggest a neuromuscular impairment condition, such as cerebral palsy. The limited mobility associated with this condition means somebody must have cared for him to enable his life to extend to almost 30 years. The relationship between age, sex and health indicators in the Black Gate assemblage is more complex than is suggested in this brief summary. The following discussion explores the nature of stress and health indicators within the assemblage in more detail.

5.7.3.1 Non-Specific Stress Indicators

Cribra Orbitalia and Porotic Hyperostosis

Cribra orbitalia affected over 50% of immatures, implying a chronic condition that affected many immatures, but was not as fatal or detrimental to health in the adults, of whom only 22.2% were affected. Because porotic lesions can heal and remodel such that they are no longer visible in adult life, it is possible that the adult individuals may have survived cribra orbitalia forming events as children, but no skeletal evidence of such survives. It is probable that one of the main contributing factors towards the high numbers of young children expressing cribra orbitalia and porotic hyperostosis is that they were undergoing weaning. Prior to weaning, infants would have been buffered from iron-deficiency from the iron-resources within breast milk (Grauer 1993: 207; Ortner 2003). In contrast, the process of weaning deprives the infant of the immunological and nutritional benefits of maternal milk and increases their exposure to poor quality replacement foods and diarrhoea causing bacterial and parasitic infections (weanling's dilemma) (Lewis 2007: 100; Mays 2007: 102). Such diarrhoea could cause malnourishment, possibly resulting in an iron or vitamin B12 deficiency. The consequence of malnourishment resulting from prolonged periods of diarrhoea is often death, which would account for the peak in mortality observed amongst young children in the Black Gate assemblage. Iron deficiency in the past has also been linked to cereal-based diets, which not only yield a low iron content, but also contain phytic acid which inhibits its uptake during digestion (Holland and O'Brian 1997: 184). In light of this observation, the foods utilised during weaning may have had a high cereal content, which lacked and inhibited the production and absorption of iron and that the cranial porotic lesions result from this inhibition, not parasitic infections. It is possible that they were experiencing both mal- or under-nutrition and parasitism. The argument that nutritional stress coincides with weaning in the Black Gate population is supported by stable isotope analysis undertaken by Pam MacPherson (MacPherson 2005; MacPherson *et al.* 2007). A decrease in oxygen and nitrogen values in the mandibular first permanent molars suggests that the Black Gate immatures acquired their nutritional requirements from maternal milk for at least the first six to nine months of their life, and were weaned around the first year (MacPherson *et al.* 2007: 42).

The presence of cribra orbitalia and porotic hyperostosis in the Black Gate adults may result from the high consumption of cereals such as wheat, rye and barley as bread and ale in the North East (Hammond 1998; Kermode 2000; Dyer 2002; Müldner and Richards 2007a). The effects of these cereal products upon the body's ability to metabolise nutrients such as iron may have been lessened by a presence of animal proteins and iron in the diet from dairy products and meat. The consensus amongst historians and archaeologists is that agriculture was the basis of economic life in later Anglo-Saxon England (Dyer 2002: 13). It has been recognised from documentary resources, such as place names and charters, and extensive zooarchaeological and archaeobotanical data, that cereals, especially wheat, were the most important staple crops during both the Roman and Medieval periods (Dyer 2002: 24; Müldner and Richards 2007a). Based on tenant numbers in the Domesday Book and the backward projection of information on grain output recorded in the *Nonarum inquisitiones*[2] of 1340-1 it has been calculated that there were 5.75-6.0 million acres of arable land in England in 1086. On this basis, it would be expected that the net output of grain in England was between 3.4 and 3.9 quarters, 50-56% of which was extracted for human consumption (Campbell 2000: 386-99). The main use of grain crops such as wheat, rye and barley documented in early medieval sources was in the production of bread and ale (Stone 2006: 12). The importance of bread as a daily staple, and consequently evidence for the consumption of cereal produce, is provided by the baker in the *Colloquies* of Aelfric, the Abbot of Eynsham (*c.* 1000), who writes that 'without my skill every table seems empty and without bread all food is turned to loathing. I gladden the heart of men; I strengthen folk, and because of this, the little children will not shun me' (*buton cræfte minon ælc beod æmtig byþ gesewen 7 buton hlafe ælc mete to wlættan byþ gehwyrfed. Ic heortan mannes gastrangie, ic mægen were 7 furþon litlincgas nellaþ forbigean me*) (Hagen 1992: 11). It must certainly be taken into consideration that each craftsman within Aelfric's *Colloquy,* which was a fictional dialogue written as an aide to learning Latin, exaggerates the importance of their own craft (Fleming 2010: 286). However, the importance of bread as an essential component of the medieval diet is further evidenced by its use as payment by tenants to landlords or masters to their servants and its high level of consumption. For example, it is documented that by the 11th century the monastery of Bury St Edmunds was to receive 1,000 loaves

[2] A survey of the agricultural production of 1341 AD in response to a parliamentary grant of one-ninth of corn, wool and lambs produced in the realm to Edward III to assist him in his wars (Baker 1966: 518).

annually on September 4th (Hagen 1992: 12). The processing of cereal products for consumption during the later Anglo-Saxon period is evidenced archaeologically by the presence, and increase in number, of water-mills from the 7th century onwards. Radiocarbon dating of a water-mill at Tamworth (Staffordshire), possibly part of the palace complex of Offa (757-796), the king of Mercia, was radio-carbon dated to the 8th century while dendrochronological data indicate a late 7th-century date for the water-mill at Old Windsor (Berkshire) (Hagen 1992: 5). By the time of the Domesday survey some 6,000 water-mills were established in England, and many villages had more than one mill; for example, Hatfield (Hertfordshire) had four (Hagen 1992: 5; Dyer 2002: 26), although some villages shared mills with neighbouring villages.

The cold, wet weather in the Newcastle area would have been most favourable for the cultivation of oats, although some barley and wheat cultivation would have occurred (Hammond 1998: 2; Kermode 2000: 659). Archaeobotanical evidence for cereal grains, mostly oats, has been recovered from the York sites of Coppergate and Pavement (Hall *et al.* 1983: 207-8). Oats also formed the principal grain recovered from a corn drier excavated at Addingham, comprising roughly 80% of the grain assemblage, with the remainder consisting of rye, wheat and a very small quantity of barley (Bastow 1996: 180). Both barley and oats can be used to produce bread, ale and pottage, a thick soup also including leeks, onions and any other vegetables available, which was a principal component in the peasant diet (Dyer 2006: 29; Stone 2006: 11, 13). However, the presence of cereal pollen and grains does not necessarily prove human consumption as oats were often used as fodder, most commonly for horses (Moffett 1994: 63; Hammond 1998: 2). The archaeological evidence for the actual ingestion of cereals in Northumbria comes in the form of faecal matter recovered from excavations at Coppergate, York, which was rich in cereal bran, probably wheat or rye (Kenward and Hall 1995: 753).

The presence of cribra orbitalia in the adults indicates that the cause of the manifestation of orbital lesions was frequently survived by those impacted by such stresses (Grauer 1993: 208). The increase in prevalence of cribra orbitalia with age from adolescents through to senior adults, although not statistically significant, may indicate that individuals who survived childhood stress episodes manifesting in cribra orbitalia were stronger individuals and survived to an older age than those individuals without porotic lesions. This would support the osteological paradox model of Wood *et al.* (1992). Alternatively, older individuals may become victims of a decreased immunological response capacity and therefore succumb to pathogens that cause cranial porotic lesions. Further research into the healed or active state of porotic lesions would be necessary to determine which scenario was the most likely cause of the increased frequency of cribra orbitalia with advancing adult age. Healed lesions would suggest older individuals had survived early cribra orbitalia formation. Active lesions observed in senior adult males would support the hypothesis that they were succumbing to assaults upon their immune system, such as increased pathogen load, in later life. The recording of healed or active cases of cribra orbitalia are often excluded from morbidity studies due to problems in distinguishing one from the other macroscopically (Bennike *et al.* 2005: 738). There was no convincing evidence for increased severity of cribra orbitalia or porotic hyperostosis with advancing age, which one would expect if the advancing prevalence of cribra was due to the declining immunological response system associated with the ageing process, and not an accumulation of lesions throughout life.

There were no cases of rickets within the Black Gate immatures, indicating a sufficient supply of Vitamin D from either the diet or exposure to sunlight. The only two individuals exhibiting symptoms pathognomic of scurvy were aged between 1 and 2 years of age. These two scorbutic infants would have been too young to chew solid foods (Brickley and Ives 2006: 165) and, therefore, could not have benefited from Vitamin C rich foods available to older individuals. The lack of other dietary deficiencies and the restriction of scurvy to infants support the hypothesis that the high presence of cribra orbitalia in young children reflects a deficiency in the diet specific to these individuals. This deficiency may be associated with weaning, or even a parasitic assault on the system resulting from their increased mobility through the development of crawling, and consequent higher risk of exposure to pathogens. The comparatively low presence of cribra orbitalia in the older child to senior adult age categories implies that the diet was sufficiently varied to alleviate vitamin deficiencies but the high cereal content was detrimental to the levels of iron in the system. Seasonal consumables such as vegetables, fruits and nuts were cultivated and consumed in the later Anglo-Saxon period (Pearson 1997; MacPherson *et al.* 2007; Müldner and Richards 2007a) and this is evidenced by the recovery of remnants of wild fruits such as apples, sloes and plums from the Anglo-Scandinavian deposits at Coppergate, York (Stroud 1993: 257). Further evidence for a Vitamin C rich diet is provided by the inclusion of antiscorbutic fruit and vegetables in place names dating back to the medieval period. Examples of such place names are Peasenhall (Suffolk) (peas), Colworth (Bedfordshire) (cabbage), and Appledore (Kent) (apples) (Lester 1976: 28-9). Melikian and Waldron have stated that scurvy was likely to have shown considerable seasonal variation in the past, being most prevalent in the seasons when fresh fruit and vegetables were least available, and that scurvy was common during the winter months in Northern Europe during the medieval period (Waldron 1989; Melikian and Waldron 2003: 211). The winter months may have put a strain on food sources, but the impact upon health would have been reduced by the farming practices of the later Anglo-Saxon period, which were designed to enable a sufficient supply of food throughout a year of unpredictable weather, and to prevent starvation during periods of poor food growth.

The lack of a significant difference in the prevalence of cribra orbitalia between males and females is consistent with the findings of Stuart-Macadam (1998: 189). All the adults of known sex expressing porotic hyperostosis with the Black Gate assemblage were male (only prime, mature and senior adult male skeletons exhibited porosity of the parietals). This could indicate that the males within this assemblage had experienced a period of nutritional stress and survived, which the females either did not experience, or failed to survive long enough for porotic hyperostosis to form. It is possible that the porotic hyperostosis afflicting the males represents periods of fasting by monks. Indeed, twice as many males as females exhibited porotic hyperostosis within the monastic cemetery at Llandough (Loe 2003: 224). Stuart-Macadam (1998) also records that porotic hyperostosis is slightly more common in males but relates it to a male biological predisposition to these porotic lesions. The differences in prevalence patterns observed for cribra orbitalia and porotic hyperostosis between males and females may indicate a difference in aetiology for the two conditions.

Aside from the work of Stuart-Macadam, cribra orbitalia is typically associated with females, particularly young adults aged 18 to 25 years, in the literature addressing health in the past (Sullivan 2005; Loe 2003; 218). The higher frequency of cases in this age band and amongst females in general is often ascribed to the blood loss associated with menstruation and childbirth (Holland and O'Brian 1997: 188; Sullivan 2005: 261-2). The absence of a peak in cases of cribra orbitalia in the young adult females and lack of significant difference in the true prevalence of cribra orbitalia relative to the other age categories in the Black Gate assemblage implies that the loss of blood associated with reproductive functions is not the primary cause of cribra orbitalia in this population. The low prevalence in both young males and females implies an exogenous cause for cribra orbitalia within this population, to which individuals within this age category, who would typically be considered those of optimum health, were not succumbing. If cribra orbitalia in other populations is a direct reflection of the biological demands of reproduction, the lack of impact of reproduction on the levels of iron in the Black Gate young females may indicate either dietary practices designed to limit such nutritional deficiency, or different practices relating to childbirth, which reduced the levels of stress upon the body. Unfortunately, there is no documentary evidence detailing the typical ages for pregnancy and reproductive cycles of later Anglo-Saxon women.

Dental Enamel Hypoplasia

The prevalence of DEH was higher in the immatures relative to the adults, but the difference was too small to be statistically significant. Over 50% of both the immatures and adults exhibited DEH. This high prevalence suggests a widespread chronic physiological disturbance amongst the immature population, rather than intermittent periods of poor health experienced by individuals.

The higher prevalence of DEH in the immatures relative to adults is common in archaeological assemblages (Duray 1996; Slaus 2008). DEH is generally regarded as an indicator of early childhood stress (Duray 1996: 275), and the decreased life expectancy of individuals with enamel defects has been linked to biological damage to the immune system during prenatal or post-natal development, which reduces an individual's resistance to disease (Goodman and Armelagos 1989; Duray 1996: 275; Slaus 2008: 206). Furthermore, whether an individual expresses hypoplasias in response to dietary or physiological stress or not is partially determined by their susceptibility, determined by their immune system, a paradox known as the hidden heterogeneity of risks (Wood *et al.* 1992: 344-5; Palubeckaite *et al.* 2002: 190). However, in this instance comparisons were being made within the Black Gate cemetery and, therefore, it was assumed that the underlying susceptibility to the expression of DEH during periods of stress was similar throughout the contributing population as they would have, theoretically, not derived from vastly different population groups.

DEH in the maxillary and mandibular incisors formed in the second quartile between 1.4-2.9 years. In both the maxillary and mandibular canines, the majority of hypoplastic defects were in the third quartile providing age ranges of 3.0-4.0 and 3.1-4.5 years. The timing of these defects correlates with the observation that young children were the most susceptible to nutritional deficiencies and exposure to parasites and pathogens due to weaning practices. However, the high prevalence of defects observed in these age bands may be a consequence of recording bias. The majority of hypoplastic defects observed in the dentitions recorded for the post-medieval London cemeteries of Christ Church, Spitalfields and St Brides (King *et al.* 2005: 547) and the medieval cemetery at Wharram Percy were recorded for the 'middle third' of the canine. The central positioning of these hypoplasias on the tooth crown provide an age range of 2-4 yeas for the London sites and 2.5 to 4.0 years at Wharram Percy (King *et al.* 2005: 550; Mays 2007: 139), consistent with the Black Gate age ranges. Goodman and Armelagos (1985: 487) state that the 'middle third' of tooth crowns tend to display greater numbers of hypoplastic defects than the cervical and apical areas. They ascribe the high concentration of defects in the middle of the tooth crown to developmental and morphological characteristics of the tooth crown, rather than simply a greater susceptibility to physiological stress. Goodman and Armelagos (1985) identify that there is a reduction in the number of secretory ameloblasts in the cervical half of the crown, which would reduce the formation of enamel matrix to compensate for periods of disruption in amelogenesis, and subsequently make such perturbations in development more pronounced on the enamel surface. There is also an increase in the rate of crown development in the middle and cervical third of the tooth crown, which would render the more rapidly forming ameloblasts more susceptible to disruption during periods of physiological stress. Thirdly, the prisms within the enamel are longer and oriented more perpendicular to the enamel surface in the area immediately cervical to the midline of the tooth crown. Goodman and Armelagos (1985: 488) argue that the increased length and angle of the prisms increses their vulnerability to damage, increasing enamel disturbance in that area. Essentially, the enamel on the middle surface of the tooth crown more readily forms clearly discernible lines of DEH, which are easier to spot and more often recorded.

The greater prevalence of males to females expressing enamel hypoplastic defects was also observed at the Addingham cemetery, within which 57.7% of the 97 affected teeth belonged to males (Boylston and Roberts 1996: 177). This higher frequency of males exhibiting dental enamel hypoplasias has been suggested to result from growing males having a greater biological sensitivity to stress than females (Ortner and Theobald 1993; Palubeckaite *et al.* 2002:190).

5.7.3.2 Non-Specific Infection Indicators

Tibial Periosteal New Bone Formation

It is probable that the lesions associated with TPNB result from minor localised trauma to the tibia or a localised irritation caused by intrinsic factors such as varicose veins and abscesses or localised infections related to the wearing of stockings. The increase in age but lack of difference between immatures and adults within the Black Gate cemetery indicates that anybody could be susceptible to the factors causing TPNB, and that this condition does not necessarily represent some form of physiological stress, more an indicator of mild irritation. However, at Black Gate the majority of cases of TPNB were isolated on the anterior surface of the tibia, which indicates that the periosteal reactions result from direct trauma to the tibia, or indirect trauma from forces associated with heavy walking and running (Merbs 1989: 168-9; Robb *et al.* 2001: 219; Weston 2008: 50), more so than systemic infections.

There was a statistically significant greater prevalence of TPNB in adult males, with the higher frequency observed in senior adult males to females being statistically significant. A similar male bias was seen at Llandough, which was ascribed to conditions such as varicose veins (Loe and Robson-Brown 2005). It is also possible that the higher prevalence of TPNB observed in males relative to females represents a cultural behaviour, such as clothing fashions. For example, Anglo-Saxon monks wore stockings, which may have resulted in localised soft tissue infection and subsequent irritation of the tibia (Owen-Crocker 2010: 328). Alternatively, the aforementioned localisation of periosteal reactions to the tibial may also have resulted from increased risk of trauma to the shin in male occupations and activities (examples of which are provided in the discussion of trauma within the Black Gate assemblage).

Maxillary Sinusitis

It is possible that the peak in maxillary sinusitis observed in mature adults represents occupational or behavioural activities whereby mature adult females and males were involved in more agricultural, industrial or craft activities or spending more time inside domestic dwellings inhaling irritants from the hearths. The true prevalence rates of maxillary sinusitis were independent of age at death and are more likely to be a reflection of the surrounding environment and lifestyle. The comparable prevalence of maxillary sinusitis seen in adults and immatures and males and females may indicate that all members of the community were equally exposed to an extrinsic factor that caused maxillary sinusitis. It is quite probable that the responsible factor was the inclement weather of later Anglo-Saxon Northumbria. Pollen analysis and dendrochronology have shown that the climate in Britain and Ireland in the early medieval period was temperate but variable (Charles-Edwards 2003: 64) and it would be expected that the exposed north-east of England would have been particularly susceptible to harsh weather. The quantity of woodland present in the Anglo-Saxon period would have been greater than that observed in the Roman period which saw an extensive consumption of wood as fuel to heat domestic baths and hypocausts, and for the production of bricks, pottery iron and glass (Rackham 1994: 8). The decline in population seen in the earlier Anglo-Saxon period would have enabled some woodland areas cultivated during the Roman period to regenerate (Dyer 2002: 13). The subsequent increase in woodland had a direct impact upon the climate, reducing temperatures particularly in the north-west of England and south-east Scotland (Rackham 1994: 8; Roberts 1998: 201; Dark 2000: 134). In Northumbria the underlying geology and the topography would have been the same as today and the weather would have been equally as wet and cold. Evidence for the wet and cold conditions is provided by archaeobotanical and dendrochronological data. For example, the carbonised chaff on rye and oat grains recovered from Addingham had blistered, burst or sprouted prior to carbonization, indicating that these crops had been harvested when wet and had not been winnowed (i.e. the grain had not been separated from the chaff). Narrow growth rings visible on charcoal fragments recovered from Addingham indicate retarded growth restricted by bad weather (Bastow 1996: 180).

A further probable contributing factor to the presence of sinusitis in the Black Gate population is pollutants and irritants from hearths routinely discovered in the domestic buildings Anglo-Saxon people inhabited. Large timber-built rectangular buildings, often referred to as halls, appear in the British archaeological record in the 7th century (Hamerow 2002: 97). Examples of large halls dating to the later Anglo-Saxon period have been found at Cheddar (Somerset) (23.75m x 6.1m), North Elmham Park (Norfolk) (18.3m x 6.1m) and Sulgrave (Northamptonshire) (24.4m x width not known) (Addyman 1972: 286-8, 296-7). Comparisons with sites from northern Germany and the Netherlands, and evidence from law codes and other documents suggest that the halls represent a central dwelling and that cooking, food preparation and storage may have occurred in separate buildings in England by the 10th century, therefore the hearths in the main dwellings were mainly used for providing heat. The use of hearths in industry and domestic activities, such as cooking and heating, would have created high concentrations of smoke, carbon dioxide and other associated pollutants. This increase in pollution, in association with the proposed poor ventilation of these buildings, would have resulted in irritation of the eyes, sinuses and respiratory tract, causing conditions such as sinusitis, bronchitis and possibly lung cancer (Boocock *et al.* 1995). Calvin Wells partly ascribes the higher prevalence of maxillary sinusitis in the early medieval period to an increase in respiratory irritants from agricultural processing of cereals, as well as metalworking and textile production (Wells 1977; Boocock *et al.* 1995). In later Anglo-Saxon towns of the 9th to 12th centuries, such as Chester, Ipswich, London and York, the increasing pressure on inhabitation space resulted in people commonly living in the cellars or basements beneath the street-level buildings (Richards 2000: 79; Tipper 2004: 7, 14). Indeed, excavations of over 50 timber buildings in London, dating from the 9th to 12th centuries revealed that 40% of the structures were sunken buildings (Richards 2000: 79), highlighting the high density of people living below ground level. Overcrowding in these cramped, underground dwellings would have resulted in increased transmission of air- and water- borne diseases. Manchester (2001: 172) identified that respiratory transmission of disease such as tuberculosis would have been more prevalent with the higher density of people associated with increased urbanisation of the later Anglo-Saxon period. A high transmission rate of respiratory infections is evidenced by the higher incidence of maxillary sinusitis in an urban (St Helen-on-the-Walls = 55%) than a rural (Wharram Percy = 39%) early medieval population (Lewis *et. al.* 1995: 497).

It is possible that mature adult females and males were those members of the population most commonly exposed to irritants. It may be that mature adult males were the skilled craftsmen who were most exposed to the by-products of such activities as glass making, or farmers exposed to irritants during the processing of the cereals. Mature adult females may have been the principal cooks and have spent more time indoors near hearths, preparing food, weaving and spinning, caring for small children and cleaning (Bennett 1987; Mays 1998: 119), and so were exposed to the irritants from the hearths, more often than young females, as part of their daily routine. The frequencies of maxillary sinusitis may also be influenced by other cultural practices, such as where individuals within a household sat of an evening. Adult males, as the heads of households, may have been accorded a privileged position closest to the fire of a cold evening. While these scenarios are conjectural, nonetheless there is ample indication from the written record that households and communities were constructed along gendered lines, and so, therefore, these hypotheses are plausible.

5.7.3.3 Dental Health Indicators

Dental health is intrinsically linked to systemic and general health (DeWitte and Bekvalac 2010). The extent to which teeth are affected by stress is determined by biological factors, such as different enamel susceptibility, and lifestyle factors such as the differential consumption of foods and occupational use of the teeth. The increases in dental pathology with advancing age amongst the Black Gate skeletons may reflect the accumulative degenerative effect of exposure of enamel over time and indicate that the older individuals have survived through periods of chronic underlying systemic and dental infection, which increase the likelihood of dental palaeopathology. Alternatively, it may reflect the reduced immunological response capability of the body with advancing age.

Dental Calculus

The low prevalence of dental calculus in the young and older child categories may be due to fewer permanent teeth associated with their stage of development and the lower length of exposure of the teeth to plaque-forming factors. The similar percentages observed between the young child, older child, and adolescent age categories may represent a similar diet or comparable standards of oral hygiene amongst these age groups. The increase in calculus with advancing age, although not statistically significant, may result from the body's decreasing immunological response ability enabling more plaque-forming bacteria to form. Alternatively, the increase in calculus with advancing age may simply represent the accumulative build-up of calculus throughout life i.e. teeth have had longer to accumulate calculus deposits. The high true prevalence rate for dental calculus within the Black Gate cemetery population as a whole and the high percentage of individuals expressing moderate calculus deposits indicates that the entire population consumed a protein rich diet or had limited oral hygiene. The low levels of dental caries, abscesses and AMTL, in contrast to the ubiquitous presence of dental calculus, coupled with the fact that the majority of cases were slight to moderate, indicates that the presence of dental calculus is related to diet and not poor oral hygiene. The oral environment of the Black Gate population appears not to have been particularly suited to bacterial growth and infections and consequently there were low levels of caries, abscesses and AMTL, which are all interconnected to bacterial growth in the mouth. There was no statistically significant difference in the prevalence of calculus between the males and females overall, indicating that they both consumed a similar protein based diet. There is sufficient evidence to suggest that the later Anglo-Saxon diet, although largely cereal based, did contain a protein component from both the meat and secondary produce of animals and fish. Animal remains from archaeological assemblages dating from the 6th to the 11th century suggest that domesticated sheep, goats, cattle, pigs, domestic fowl and geese were the main animals kept, with sheep and pigs increasing in importance over the period (Dark 2000: 13; Dobney *et al.* 2007: 87-90). Domestic animals not only provided meat, but also secondary products such as milk, eggs, wool, and leather, and many played important roles within the economy and inhabited environment (Charles-Edwards 2003: 65). Due to the rugged terrain and cold damp climate, the inhabitants of Northumbria would have cultivated arable land as far as possible, but would have been dependent on pastures, sheep, cattle, fishing and hunting sea-birds (Dyer 2002: 16-17). Pigs were a vital food resource during winter months and were typically slaughtered during their second or third winter (i.e. at an age of 16-24 months) after sows had produced two to three litters (Dobney *et al.* 2007: 89). Domestic fowl, as with sheep and cattle, were not primarily kept for their meat, but for their eggs (Müldner and Richards 2007a: 683). Over 85% of chicken long bones recovered from Flixborough were from adult birds and numerous fragments of eggshell were also recovered, supporting the hypothesis that eggs were the most valuable assets obtained from domestic fowl (Dobney *et al.* 2007: 89-90). Consequently, eggs would have provided a protein component to the diet. Fish would have further supplemented the predominantly cereal-based diet of later Anglo-Saxon populations. During the later Anglo-Saxon period there is a shift in the patterns of consumption and trade of fish in England. In the 7th to 10th centuries diets were dominated by freshwater species, such as burbot, and migratory species, particularly herrings and eels. River, estuarine or inshore fishing were particularly important for acquiring fish for consumption (Serjeantson and Woolgar 2006: 103). Prior to *c.* 1000 most professional fishing may have been done for elite patrons rather than public sale and the trade of sea water fish was restricted to the modest transport of cod to inland sites such as York, which is apparent from the 7th century (Barrett *et al.* 2004: 627). However, by the 11th century people began to consume more marine fish, including preserved cod and shell fish such as molluscs, especially oysters (Barrett *et al.* 2004: 619, 621). The main transition in fishing practices was a large-scale increase in regional and long distance fish trading which occurs around 1000 and has been termed the 'fish event horizon' (Barrett *et al.* 2004: 623). Analysis of the stable isotopes of carbon, nitrogen and sulphur in collagen from deciduous and permanent molars of 41 individuals (20 adults and 21 immatures) from Black Gate determined that they consumed a predominantly terrestrial diet, favouring the consumption of sheep and pig protein over that derived from cows (MacPherson 2005: 74-5, 162-3). There was no discernible marine isotope signature for the Black Gate population indicating that marine fish was not a favoured source of food, or perhaps that the individuals sampled lived before the 11th century, from which time we might expect to find a less pronounced marine isotope signature among, at least some, of the individuals (MacPherson 2005: 162-3). As there were no samples of freshwater fish bones available for analysis from Black Gate, it is not possible to speculate whether or not freshwater fish was widely consumed.

There was a significantly greater prevalence of prime adult females than males exhibiting calculus. Such an age specific difference is more likely to be a result of differences in the pH balance of the oral environment than dietary differences. Differences in the oral environment can be caused by hormonal change associated with pregnancy (Lukacs and Largaespade 2006: 547). The accumulative nature of dental calculus would mean that the brief period of higher calculus formation seen in prime adult females would soon be disguised by the deposition, or lack of deposits, in mature and senior females (35-45 years plus) over the next ten years of their lives.

Dental Caries

The true prevalences of dental caries observed for the Black Gate immatures (26%) and adults (40%) are noteably high for the early medieval period. The projected prevalences for this period are typically below 10% (Roberts and Cox 2003: 189). For the comparative sites included within this thesis (see Chapter 7), the highest CPR value is 12.77% (Saint Andrew's. Fishergate) and the highest TPR is 7.69% (Wearmouth). Of the 13 Black Gate immatures exhibiting dental caries, six are adolescents, five are older children and two are young children. The highest frequency of cases of dental caries in the immatures was in the permanent first molar, which was affected in nine individuals. The high prevalence of caries in the permanent first molar is consistent with clinical studies, which have shown this tooth to typically be the site of first expression of dental caries in mixed dentitions of deciduous and permanent teeth (Carvalho *et al.* 1989: 773). The predisposition of the permanent first molar to occlusal caries fissures associated with its typical eruption at 6 years of age accounts for the high prevalence observed in immatures aged 6-17 years. The high prevalence of dental caries in the Black Gate assemblage may result from a greater recovery of permanent first molars than other sites, due to the good levels of preservation.

The low prevalence of dental caries in the young child, older child and adolescent categories, relative to the adult dentitions, may be due to fewer permanent teeth in the early developmental stages and the lower length of exposure of the teeth to enamel destroying factors. The similar percentages expressed in the older child and adolescent age categories may represent similar diets or levels of physiological stress. The true prevalence increase with age observed amongst the Black Gate adults could represent the body's decreasing immunological response ability with age, or the consequence of these individuals having had a better immunological response during their life and therefore surviving periods of dietary stress, which could instigate carious lesion formation. The increase in prevalence of dental caries with age may also represent the accumulative effect of age and wear on the dental enamel over time, increasing the chances of fissures and pits into which food can be deposited and trapped. Alternatively, accumulative attrition may have exposed the softer, underlying dentine, which would be more susceptible to the formation of dental caries than un-corrupted enamel. In this study, analysis of the prevalence and severity of dental caries excluded infants (individuals aged less than 12 months), which lack permanent teeth. However, observations of the deciduous teeth – which were recorded but not included within the interpretation of the data – revealed no carious lesions. The absence of such lesions in infants may be a combination of non-consumption of sugar-based foods prior to weaning and the fact that the carious lesions have not had sufficient time to form. Within the palaeopathological and clinical literature, females typically display a higher prevalence of dental caries than males (Boylston and Roberts 1996: 176; Anderson *et al.* 2006: 488; Mays 2007: 133; Cucina and Tiesler 2003; Lukacs and Largaespade 2006: 540). Within the Black Gate assemblage there is a higher prevalence of females to males exhibiting caries, but the differences is only 1.9%. Only in prime and senior adults are females with caries more prevalent than males. The difference is nominal between senior adult males and females, whereas prime adult females are 21.3% more frequently affected by caries than males. Higher rates of dental caries in females are commonly attributed to behavioural factors such as sexual division of labour and differential consumption of food, such as females snacking on foodstuffs during preparation (Larsen 1995: 189). However, the high prevalence of prime adult females exhibiting caries compared to males lends support to the argument that hormone fluctuations during pregnancy affect saliva flow and therefore the oral environment of the mouth predisposing the teeth of pregnant women to dental caries (Lukacs and Largaespade 2006: 547-8). Research has shown than oestrogen levels are higher in females than males throughout the entire life cycle, but are significantly higher during times of puberty, pregnancy and menstruation (Lukacs and Largaespade 2006: 547). Higher oestrogen levels have been clinical proven to increase proportionally with caries rates (Lukacs and Largaespade 2006: 547), linked to changes in composition and reduction of the flow rate of saliva, which have been linked to adverse changes to oral health predisposing females to caries (Lukacs and Largaespade 2006: 548). During pregnancy, oestrogen levels reach the highest levels they attain during the whole of a female's lifetime. Clinical tests show caries rates increase with pregnancy, and the effects are compounded with each pregnancy (Lukacs and Largaespade 2006: 549).There is no information regarding the age of pregnancy specific to the later Anglo-Saxon period, therefore inferences must be made based on the, admittedly indirect, early Anglo-Saxon evidence, in the form of age-related deposition of grave goods. Patterns in the deposition of grave goods suggest that childbearing commenced from 15 years of age in the early Anglo-Saxon period, with 17 to 25 years being the optimal childbearing age (Boddington 1996: 14; Crawford 1999: 63). For example, a pregnant female aged 15 to 16 years, recovered from the early Anglo-Saxon cemetery at Abingdon (Oxfordshire), was buried with beads, disc brooches, a knife and a possible girdle-hanger, in other words with all due respect, and an assemblage of grave goods appropriate for an adult female. This indicates that pregnancy in 15 to 16 year old females was, at least in this instance, an accepted occurrence (Crawford 1999: 47-8). Consequently, one would expect the greatest frequency of carious lesions to manifest in adolescents and young adults. The discrepancy between proposed childbearing age and prevalence of carious lesions may be explained by a delayed response between the hormone fluctuation and the time it takes the carious lesion to progress to a cavity in the enamel macroscopically visible in the archaeological remains (Liebe-Harkort *et al.* 2010). Earlier stages of the formation of the carious lesion, such as discolouration of the enamel surface, were excluded from this study, which may possibly have resulted in under-estimation of the number of cases of dental caries in younger females. Prime adult females were still of childbearing age, and it is possible that women in these age categories may be more susceptible to fluctuations in hormone levels than young females, and therefore, more readily exhibit reduced saliva flow and increased susceptibility to the formation of carious lesions. However, a range of behavioural, environmental and physiological factors, aside from hormonal fluctuations, influences caries rates. A greater understanding of sex differences in caries prevalence rates can be obtained by studying each of these influences, the relative impact of which will vary by cultural affiliation, environment, and genetic constitution (Lukacs and Largaespade 2006: 551).

The impact of culturally defined accessibility of dietary sugars upon the rates of dental caries observed in adult males and females is likely to have been less substantial than hormonal differences. This is because raw sugar was not introduced into England until 1099, and even then it was principally used in medicine, not food (Eagan 2006: 10). However, it is feasible that honey was influential in the presence of caries within the Black Gate cemetery; there is certainly evidence for the maintenance of bees in later Anglo-Saxon England. For example, a high concentration of dead bees intermixed with straw was recovered from the Anglo-Scandinavian levels of 16-22 Coppergate, York, which has been interpreted as evidence for the location of a beehive. This suggests that bees were kept by the inhabitants of York, at least a proportion of whom enjoyed honey as a sweetener or fermented as mead (Hall and Kenward 2004: 397). Honey was also collected from managed woodlands (Dyer 2002: 25; 2006: 29).

Dental Abscesses

The low prevalence of dental abscesses in the immature and young adult categories may be a result of the lack of permanent teeth due to the stage of development and the lower length of exposure of the teeth to abscess forming factors. The low prevalence of dental abscesses suggests either a reasonable level of oral hygiene or that the Black Gate population either possessed a good immunological response system, which prevented the formation of abscesses. Alternatively, the individuals affected by the underlying infections or disease, which eventually manifest as dental abscesses were not strong enough to survive the episode of underlying stress and consequently died before the abscess had time to manifest into a lesion visible upon the bone. The true prevalence increase observed amongst the Black Gate prime to senior adults could represent palaeopathological influences throughout life such as the body's decreasing immunological response ability with age and also the symbiotic relationship between dental abscesses and calculus and dental caries, which also increase with age in this population. The lack of significant difference in the prevalence of abscesses expressed by males and females for either the total population or each adult age category is probably an artefact of the small number of individuals with dental abscesses.

Ante-Mortem Tooth Loss

The increase in true prevalence of AMTL with age could represent biological influences throughout life such as the body's decreasing immunological response ability with age, and may represent the symbiotic relationship between AMTL, calculus and dental caries, which also increase with age in this population.

The aetiology of many of the dental health indicators are multifactorial, therefore it is dangerous to make interpretations of the dental health indicators based on diet alone. A large contributing factor in the prevalence of all the dental health indicators within the Black Gate assemblage appears to be the deteriorating effects of age upon the teeth. The high prevalence of ante-mortem tooth loss in females, particularly mature adult females, may indicate women were using their teeth in occupational or domestic activities, which created stress upon the teeth, more so than in the men. However, there was no obvious presence of wear facets associated with such activities. It is possible that the higher prevalence in females is a physiological characteristic. For, example, clinical studies have shown that women are more susceptible to periodontal disease during pregnancy due to hormonal changes and this may have had a subsequent impact upon the later loss of teeth (Lukacs and Largaespade 2006: 547-8). Analysis of the proportions of male and female adults expressing dental caries, abscesses and AMTL at St Peter's, Barton-upon-Humber throughout its entire period of use also revealed actual increases in prevalence with age and a positive relationship between the dental pathologies (Waldron 2007: 118-19).

Individuals who experience periods of childhood stress have a reduced capacity to recover from insults later in life (Goodman *et al.* 1988: 181) and are predisposed to periods of illness throughout adulthood. Consequently, it would be expected that individuals experiencing DEH and cribra orbitalia would experience higher levels of physiological stress and a reduced life expectancy than those without. Indeed research undertaken by Goodman and associates (Goodman *et al.* 1988: 181) showed that individuals without DEH lived for an extra 5 years than those exhibiting one linear defect and an extra 9 years than those with two or more defects. In accordance with the observations made by Goodman *et al.* (1988) a higher mean age at death was observed in the Black Gate individuals without cribra orbitalia and DEH, than those with lesions (Table 5.7). This confirms that periods of childhood stress can impose on longevity of life, to a limited extent. The limited difference of 0.3 years in the mean age at death between individuals with and without maxillary sinusitis implies maxillary sinusitis has little detrimental effect on the overall health of an individual. Thus, maxillary sinusitis indicates a skeletal response to respiratory infection or to airborne pollutants, which had little impact on the overall health and consequently longevity of life. The greater mean average life expectancy in individuals with each of the four dental health indicators (calculus, caries, abscesses and AMTL) can be interpreted in three ways. Firstly, the presence of calculus, caries, abscesses and AMTL do not have a detrimental effect on health. Secondly, those exhibiting dental pathologies do so as a result of dietary differences between them and those who do not exhibit calculus, caries, abscesses and AMTL. Either the diet consumed by those with dental pathologies prolonged their life or they were individuals of a better socio-economic status with a greater access to specific foods, such as honey, or their access to dietary resources also reflects access to preferential health care and less stressful lives, and consequently they lived longer. Thirdly, the cumulative expression of dental calculus, caries, abscesses and AMTL with age mans that the higher age at death in individuals with dental health indicators simply reflects that those who lived to a greater age had accumulated dental pathologies, or that their increased immunological response with advancing age means caries, abscesses and AMTL were more likely to form.

Pathology	Average Age at Death (years)	
	Individuals with Pathology	Individuals without Pathology
Cribra orbitalia	38.3	39.8
DEH	37.8	38.4
TPNB	41.4	38.1
Maxillary Sinusitis	38.5	38.8
Calculus	41.6	38.8
Caries	40.6	38.0
Abscess	45.9	36.9
AMTL	46.0	36.0

Table 5.7 *Average age of death observed for individuals with and without specific health and stress indicators within the Black Gate assemblage*

5.7.3.4 Biomechanical Stress Indicators

Degenerative Joint Disease

Amongst the Black Gate adults there was an actual right-sided bias for DJD in the elbow, wrist, hip and knee joints. The prevalence of degenerative disease in the shoulders and ankle/wrist joints was bilaterally similar. It is possible that the higher prevalence of degeneration on the right side may indicate preferential use; in other words, the people of Black Gate may have been predominantly right handed and preferred the right leg for weight bearing activities.

The high prevalence of appendicular and spinal degenerative joint disease in the senior age category indicates that both non-spinal and spinal joints, and weight bearing and dextrous articulations, were affected by age-related degenerative changes and the differences observed were not the direct consequence of occupational specific 'wear and tear' (Mann and Hunt 2005: 18). The body gradually loses its ability to maintain joint cartilage and osteophytes develop in an attempt to strengthen the vertebral bodies against the continual pressure imposed on the spine during an individual's lifetime. Horizontal expansion of the cartilage in response to compression forces it to project beyond the joint margins and results in the subsequent ossification of the synovial lining creating osteophytes (Mann and Hunt 2005: 18-19; van der Merwe *et al.* 2006: 462). The low prevalence of spinal degenerative changes observed in the young adults correlates with the fact that full fusion of the epiphyseal rings of the vertebral bodies does not occur until approximately 20 to 25 years of age (Krogman and Isçan 1986; Schwartz 1995). This non-union increases the adaptability of the vertebral bodies in response to physical stress, and the near absence of spinal degenerative joint disease in individuals aged less than 20 years of age is a typical feature of the human skeleton, both past and present (van der Merwe *et al.* 2006: 459). The prevalences amongst the prime and mature adult categories alternated by a couple of per cent but remained similar throughout. The alternations may be a consequence of the use of arbitrary age categories to compartmentalise the Black Gate assemblage into workable groups for comparative analysis.

There was no statistically significant difference in the true prevalence of DJD, ADJD or SDJD between males and females overall. However, males exhibited greater frequencies of DJD and SDJD. Females exhibited a higher preponderance for ADJD. The differences between the sexes may indicate occupational differences. Sexual division of labour is evidenced in several industries in early medieval England. For example, on large estates men were herdsmen, and were responsible for milking the animals in their care. In contrast, dairy workers were usually female. This is suggested by King Aethelred's (978-1016) fourth law code, which states that 'Women who deal in dairy produce – who sell cheese and butter – pay one penny a fortnight before Christmas and another penny a week before Christmas' (Hagen 1992: 18). This confirms not only that dairying was regarded as women's work, but also that dairy products were sold in towns. Grinding corn in a hand mill, even for a small family, might take a considerable amount of time and it seems generally to have been women's work (Hagen 1992: 4).

The significantly higher prevalence of both DJD and SDJD amongst males than females in the mature adult age category may represent the accumulative effects of demands upon the spine in activities requiring prolonged standing, walking or heavy or repetitive movements of the spine, such as shovelling hay for food for the animals. Senior adult females displayed a greater prevalence of degeneration of the thoracic and lumbar vertebrae than males. It is expected that senior adult females would exhibit a higher frequency of degenerative joint disease of the spine due to their longer life-span and pre-disposition for osteoporosis, which causes pathological fractures and degeneration, more frequently than in men (Stini 1990; Mays *et al.* 2006).

Trauma

Trauma within the Black Gate assemblage was predominantly found in the ribs and upper limb, indicating that the majority of cases resulted from indirect forces, such as accidental falls (Judd and Roberts 1999: 241; Loe and Robson-Brown 2005: 52). The most commonly occurring fractures were to the clavicle and ribs. Fractures of the clavicle predominantly result from a direct trauma to the shoulder, or from the indirect forces involved with a fall onto an outstretched hand (Lovell 1997: 160), indicating them to be accidental in origin. Rib fractures are most commonly the consequence of direct trauma from either a blow or fall against a hard solid object, stress fractures from habitual, often occupational, labour or persistent coughing and vomiting (Lovell 1997: 159; Mays 2007: 148). However, none of the individuals expressing rib fractures displayed any sign of new bone formation on the ventral surfaces of the ribs associated with respiratory infection, which would indicate that coughing had caused the fractures. However, although this questions the likelihood of fractures deriving from persistent coughing, it does not provide definitive evidence negating it as a cause because such rib lesions associated with respiratory infections may heal much sooner or more effectively than fractures to the ribs. Fractures to the humerus, radius and ulna, as seen in the Black Gate population, are also predominantly associated with accidental falls. The Colle's fracture, as seen in mature adult female BG556 alongside rib fractures, is typically a secondary fracture associated with a fall onto the hand (Lovell 1997: 161). It is possible, although not a certainty, that the same incident caused both the radial and rib fractures in this individual. All the immature traumas, save for the possible birth-related clavicle trauma observed on one neonate, were of the ribs and ulna and radius, indicating accidental falls, the same as in adults. The majority of discussions relating to trauma in early medieval populations centre on occupational activities and exclude recreational activities. Adults would have partaken in risky ventures such as horseracing. Children participated in pursuits such as wrestling, ball games and played with hoops, which would have exposed them to falls and tripping hazards (Crawford 1999: 140-4). All the adult fractures observed in the Black Gate assemblage were well healed and predominantly in good alignment and with little shortening or deformity, suggesting medical intervention in the form of splintering or setting the bone (Mays 1998: 176). The statistically significant increase in the prevalence of trauma from the pre-infant to senior adult age categories and the high frequency of fractures observed in senior adults (those ages over 45 years at time of death) is also seen at Raunds Furnells (Judd and Roberts 1999: 241). This evidence indicates that skeletal traumas in the Black Gate population, as in cemeteries generally from the Anglo-Saxon period, accumulated with age and that no specific age group was more susceptible to traumatic injuries (Mays 1998: 176).

There was no difference in the prevalence of trauma between males and females indicating little sexual division of labour or leisure activities. There was a higher number of cases observed in young adult males relative to females but the number of cases overall were so few that any interpretations made are tenuous. Prime adult females showed a noticeably higher frequency of cases of trauma than the males. The frequencies were the same between senior adult males and females. This may be reflect a general balancing out of trauma between the sexes throughout life.

Overall, the frequency of trauma increases with age. All of the trauma observed within the Black Gate population was healed. The increase in healed trauma with age is a prime example of the osteological paradox, with only those who have survived traumatic events reaching older age. The number of cases of each trauma type were too small to be of any statistical significance, but there were a few interesting patterns. Spondylolysis was only observed in mature and senior adult females, suggesting an aetiology of osteoporosis in these individuals. The higher prevalence of pathological fractures of the spine, such as spondylolysis, seen in the senior females was as would be expected due to their longer lifespan and predisposition to osteoporosis, which has shown to cause pathological fractures more commonly that in men (Stini 1990; Brickley 2002; Mays *et al.* 2006). The young adult male case of spondylolysis may genuinely be a consequence of mechanical stress related to repetitive loading upon the lumbar spine. Strenuous activity partaken in an upright standing position, such as lifting goods, ploughing, digging, weeding the fields and reaping (Gies and Gies 1990), has been implicated as the main cause of a high number of cases in pars interarticularis defects at Wharram Percy (Mays 2007: 216)

5.7.3.5 Severity of Health Indicators

There are few palaeopathological studies investigating severity of health indicators. Most studies rely on frequency of cases, however, it has been suggested that studies of severity could enhance the current understanding of conditions such as rickets and infantile scurvy (Ortner *et al.* 2001; Mays *et al.* 2006; Pinhasi and Mays 2008: 242). The applicability of the severity of palaeopathologies as a quantifier of the actual presence or severity of specific diseases in skeletal populations has, however, been called into question. Several authors argue that the skeletal response to a disease is not an accurate representation of the presence or severity of that disease and, therefore, recording the presence or absence of a pathology is a more consistent observational criteria (Wood *et al.* 1992: 350; Jacobi and Danforth 2002). The most commonly contested link between severity of the underlying condition and the subsequent skeletal response is that between anaemia and cribra orbitalia (O'Sullivan *et al.* 1992: 27; Stuart-Macadam 2009) Stuart-Macadam (2009) refers to clinical studies which show that the severity of skeletal lesions in cases of cribra orbitalia do not directly correlate with the severity of anaemic reactions. Severity of conditions, which genuinely reflect episodes of physiological, environmental or nutritional stress, may not be as directly affected by the accumulative effects of age. Whereas a greater number of older individuals would have had more opportunities to experience stress, and therefore manifest it skeletally, severity may reveal the true nature of the body's capability to fight off infections and assaults upon its immune system.

Severity of skeletal health indicators was recorded for cribra orbitalia, dental enamel hypoplasia, all the dental pathologies and degenerative joint disease. There was no significant difference in the number adults and immatures exhibiting severe cribra orbitalia or dental calculus. Severe cases of dental enamel hypoplasia were significantly greater in adults compared to immatures. There was no increase in the severity of cribra orbitalia or dental enamel hypoplasia with advancing age, although the greatest frequency of severe dental enamel hypoplasia was within the senior adult age category. There were non-significant increases in severity with advancing age for caries, abscesses, AMTL, ADJD and SDJD. The severity of calculus deposits and degenerative joint disease displayed a statistically significant increase with age. The greatest frequency of lesions recorded as severe were within the senior adult age category for all of the skeletal health indicators for which this information was available. The only exception was cribra orbitalia for which the greatest number of severe cases was amongst young children. There was no statistically significant difference in the severity of calculus, caries, abscesses, AMTL, DJD, ADJD or SDJD between males and females. There were no statistically significant differences in the severity of calculus, abscesses or AMTL expressed in males and females for each age category. There was a significantly higher severity of caries and ADJD observed in senior adult females than males. There was a statistically higher severity of DJD observed in young adult males compared to females and senior adult females than senior adult males.

There was a statistically higher frequency of severe SDJD in young adult males compared to young adult females, which only exhibited slight lesions.

There was no statistically significant difference in the severity of any palaeopathology observed between the sexes in general. The hormonal changes associated with puberty, may explain why severe cases (Grade 3 and Grade 4) of dental calculus and caries do not occur in Black Gate until older child and adolescent ages. Severe cases of degenerative joint disease were observed in all age categories, suggesting the severity was not just an accumulation of the stresses imposed upon the skeleton during life, and that additional factors, such as occupational stresses, may be at play.

Severity in both calculus and AMTL was quantified by a cumulative factor, that is, the extent of calculus build-up and the number of teeth lost ante-mortem, therefore, it would be expected that the factors that instigated their occurrence remained. Calculus has been specifically linked to protein in the diet, so older members of the community may have been eating a diet more rich in protein than younger members of the contributing population. However, it is also highly likely that the calculus build-up had simply been accumulated during life and represents poor oral hygiene. AMTL may just represent the lessening viability of the alveolar bone, resulting in the loss of more teeth with old age. The severity of the other conditions may represent skeletal responses to acute attacks upon the body. Representations of a specific episode influencing upon the skeleton, for example severe cribra orbitalia, is not necessarily preceded by slight cribra. A severe dental infection tends to result in a large abscess.

5.8. Summary

The Black Gate cemetery assemblage composition and mortality profile, immature growth trajectories and adult stature were all within the norm for the later Anglo-Saxon period. Immatures displayed higher frequencies of cribra orbitalia than adults, but the reverse is observed for all of the other health indicators. There was a comparatively high prevalence of chronic childhood diseases represented by cribra orbitalia and DEH suggesting prolonged periods of chronic physiological stress caused by either nutritional deficiencies or long-lasting mild gastro-intestinal infections. The peak in mortality and frequencies of cribra orbitalia and DEH in young children implies this age group was experiencing the greatest levels of physiological stress, weaning and accidents. The majority of health indicators increase with advancing age indicating them to be a consequence of the decreased immunological response capacity of the body as it declines with age. Alternatively, the increase with advancing age may relate to the 'osteological paradox' (Wood *et al.* 1992) whereby those who survive to an older age are those who have been strong enough to withstand and survive events that lead to a skeletal response long enough for the relevant bony lesions to manifest. Maxillary sinusitis was not, in contrast, age related and was likely a consequence of extrinsic factors such as pollution and domestic or occupational irritants. There were no statistically significant differences in the prevalence or severity of any of the conditions between males and females overall. There were occasional differences in specific age bands, such as the greater prevalence of AMTL in prime adult females, which may represent physiological differences between the sexes and conditions such as the higher severity of spinal degenerative joint disease observed in young adult males than females, which may represent occupational or activity differences. It is possible that some of the stress and health frequencies seen in the Black Gate population between the adults and immatures and the sexes represent differences in activity patterns and resource access perhaps related to differences in social status. The relationships between biological status and social status are explored in Chapter 6.