Chapter 5: Human remains

SUMMARY

This chapter presents the results of specialist analyses of the human remains which were recovered during the excavations by Oxford Archaeology (OA) at Lankhills. The main body of OA material is represented by the remains of 284 discrete inhumation burials. In addition, 89 deposits of disarticulated human bone were recovered from grave fills, with 11 deposits from other contexts (four pits, two ditches, two deposits of overburden, two pottery concentrations and a 'turf line'). Remains of a total of 29 cremation burials and three deposits of undiagnostic burnt bone were also excavated (see Boston and Marquez-Grant below). Samples from 124 skeletons were submitted for carbon and nitrogen analysis (see Cummings and Hedges below). Analysis of strontium and oxygen isotopes was carried out on samples from 40 skeletons (see Chenery *et al.* below). The results of all the work on human remains are presented in this chapter.

INHUMATIONS AND DISARTICULATED HUMAN BONE *by Sharon Clough and Angela Boyle*

Introduction

The assemblage comprised 284 discrete skeletons, 89 deposits of disarticulated bone from grave fills and a further 11 from other contexts. The period of use of the cemetery spanned the whole of the 4th century AD (see chronological discussion in Chapter 7).

The first phase of archaeological investigation of the cemetery was carried out from 1967 to 1972 and revealed 451 graves (Clarke 1979). The skeletons from Clarke's excavations were assessed largely in order to determine age and sex (Harman 1979, 123, 342) with limited analysis of additional data relating to decapitation (Watt 1979) and subsequently as part of an ongoing programme of analysis and reporting of material from the Winchester Excavation Committee excavations (Stuckert forthcoming). More recently, the material from Clarke's excavation was re-examined as part of a doctoral thesis (Gowland 2002). This work focussed on age as an aspect of social identity and therefore did not include full analysis of all aspects of the assemblage. Assessment of pathology was undertaken, however (Gowland 2004), and elements of this work are touched upon in this chapter. Detailed analysis of OA Lankhills material comprised the establishment of demographic parameters (age, sex and stature), analysis of skeletal and dental pathology, recording of metric and non-metric variation and congenital anomalies. Wherever possible the present group will be compared with that from Clarke's excavations. Henceforward, the material from the first phase of work will be referred to as 'Clarke's Lankhills'; the assemblage excavated by Oxford Archaeology will be referred to as 'OA Lankhills'. Where specific reference is made (in the text or figures) to Gowland's results, the term 'Gowland's Lankhills' is used. Provisional data on 52 individuals recovered in the Wessex Archaeology work of 2007-8 (Wessex Archaeology 2009) are also referred to.

Methodology

All skeletal material was examined in accordance with national guidelines (Hillson 1996a; Brickley and McKinley 2004; Mays *et al*. 2004). During the initial assessment of the assemblage (Clough and Loe 2006) the condition of each skeleton was classified as poor (most bone surfaces considerably eroded), fair (most bone surfaces moderately eroded), good (most bone surfaces slightly eroded) or excellent (most bone surfaces not eroded). At this stage considerable variation in the condition of skeletons was observed, both within individual skeletal elements and across the group, therefore the condition of each skeleton was further scored at the detailed recording stage with reference to different anatomical areas (skull, arms, hands, legs and feet) after McKinley (2004b, 16) and according to the criteria defined in Table 5.1 (ibid.; score 9 was added by the authors).

The degree to which each skeleton was fragmented (or complete) was assessed visually and recorded as 'excellent' (virtually no fragmentation); 'good' (slight fragmentation); 'fair' (moderate fragmentation), 'poor' (most bones are fragmented) or 'destroyed' (considerable fragmentation).

The biological sex of all adult skeletons was based on examination of standard characteristics of the skull and pelvis (Ferembach *et al*. 1980; Schwartz 1995), with greater emphasis on features of the latter as they are known to be more reliable (Cox and Mays 2000). Measurements of the femoral and humeral heads were employed as secondary indicators (Giles 1970). Adult skeletons were recorded as male, female, probable male (?male), probable female (?female), or indeterminate depending on the degree of sexual dimorphism of features. No attempt was made to sex subadults defined as individuals below 18 years of age (though see Discussion below) for whom there are no accepted methods (Cox 2000), with the exception of adolescent skeletons whose innominate bones had fused and where preservation was adequate.

Table 5.1: Scoring criteria for skeletal condition

Score	*Scoring criteria*
0	Surface morphology clearly visible with fresh appearance to bone and no modification
1	Slight and patchy surface erosion
2	More extensive erosion of surface
3	Most of the bone surface affected by some degree of erosion, 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 the whole surface
5	Heavy erosion across whole surface, completely masking normal surface morphology with some modification of profile.
5+	As for Grade 5 with extensive penetrating erosion resulting in modification of profile (includes near-destroyed bone)
9	In the grave catalogue this is used to indicate a complete absence of the anatomical area concerned

Subadults were aged by examination of stage of the formation and eruption of teeth (Moorees *et al.* 1963), epiphyseal fusion (Schwartz 1995; Scheuer and Black 2000) and diaphyseal length (Maresh 1970; Scheuer *et al*. 1980; Hoppa 1992; Black and Scheuer 1996). Adults were aged by examination of late fusing epiphyses (Scheuer and Black 2000), dental attrition (Miles 1963; Brothwell 1981), the pubic symphysis (Brooks and Suchey 1990) and the auricular surface (Lovejoy *et al*. 1985; Buckberry and Chamberlain 2002). Cranial suture closure (Meindl and Lovejoy 1985) was only used as a secondary indicator of age because it is widely considered to be unreliable (for example, see Key *et al.* 1994; Cox 2000; Lynnerup and Jacobsen 2003). Where suture closure was the only indicator present individuals were classified as adult only. Observations of rib end morphology (Iscan and Loth 1986) were employed with caution because they have large margins of error (Loth 1995). Few sternal rib ends survived, and where they did were employed only as a secondary indicator, never as a sole criterion.

Final determination of age used the multiple indicators method, based on the indications provided by all the methods used, balancing these against the accepted reliability of the method concerned. The resulting 'average' figure also involved the judgement of the specialists examining the material. Ageing using dental attrition indicators was considered particularly problematic, and the implications of this are considered below (see Demographic composition below). Skeletons were assigned to one of the age categories in Table 5.2.

Table 5.2: Age categories applied to the assemblage

Age range	*Age category*
36 weeks – 1 month	Neonate
1.1 month–3 years	Infant
4–7 years	Young child
8-12 years	Older child
13–17 years	Adolescent
18–25 years	Young adult
26-35 years	Prime adult
36-45 years	Mature adult
45+ years	Older adult
60+ years	Much older adult
< 18 years (not further defined)	Subadult
> 18 years (not further defined)	Adult

Where possible, adult stature was estimated by taking the maximum length of any available complete long bone and applying to it the appropriate regression formula devised by Trotter (1970). Measurements of the femur were employed in preference, followed by those for the tibia, humerus, radius and ulna (in that order). Stature could not be calculated for adults of unknown sex. All possible males and possible females were, however, included in the measured sample.

Measurements of other long bones and skulls were taken (where appropriate) and used in the calculation of indices to explore variation in the physical attributes of the population, while the presence or absence of frequently recorded non-metrical traits was scored (Berry and Berry 1967; Schwartz 1995; Hillson 1996a).

Skeletal pathology and/or bony abnormality is described and differential diagnoses explored with reference to standard texts (Ortner and Putschar 1981; Resnick 1995; Aufderheide and Rodriguez-Martin 1998). In a small number of cases radiology was also employed. The extent and range of pathology was explored by calculating crude prevalence rates - the number of individuals with a condition out of the total number of individuals observed - (CPR) and true prevalence rates - the number of elements or teeth with a particular condition out of the number of elements or teeth observed - (TPR). These rates were compared with those recorded for contemporary assemblages (where appropriate), depending on the availability of data. In particular, comparisons were made with the assemblages from Poundbury, Dorset (Molleson 1993); Cirencester (Wells 1982) and Butt Road, Colchester (Pinter-Bellows 1993), summary details of which appear below (Table 5.3). The corpus of data synthesised for 52 Romano-British assemblages (5,716 individuals) dating between

AD 43-410 by Roberts and Cox (2003, 107-163) was also employed in comparisons, though it should be noted that this synthesis also includes the key individual sites mentioned above.

Disarticulated human bone is discussed in this chapter. An inventory of all material was made and this can be found in the site archive. For each context, the minimum number of individuals was estimated based on repeated elements and taking into account age and sex. Methods employed to estimate age and sex and record pathology were as described for the articulated remains.

Condition and completeness

Data on condition and completeness are presented below. While the full range of variation was represented, more than half of the skeletons were upwards of 75% complete (161/284, 56.7%) and over half (161/284; 56.7%) were judged to be in excellent condition (Figs 5.1-5.2). No skeletons were classified as poor overall.

The majority of skeletons had bones that were only moderately or slightly fragmented, therefore a total of 171 adults and 23 subadults (68%) were

Table 5.3: Contemporary cemetery sites used for comparison

Site name	*Date range*	*Number of skeletons*	*Location*	*Reference*
Poundbury	Mostly 3rd-4th century	1074*	Dorchester (Dorset)	Molleson 1993
Cirencester North	3rd-5th century	45	Cirencester	Wells 1982
Cirencester South		362		
Butt Road, Colchester	1st-4th century, though most from 3rd-4th century	575	Colchester	Pinter-Bellows 1993

* The total number of individuals referred to by Roberts and Cox (2003) is 1131, which include early Roman burials.

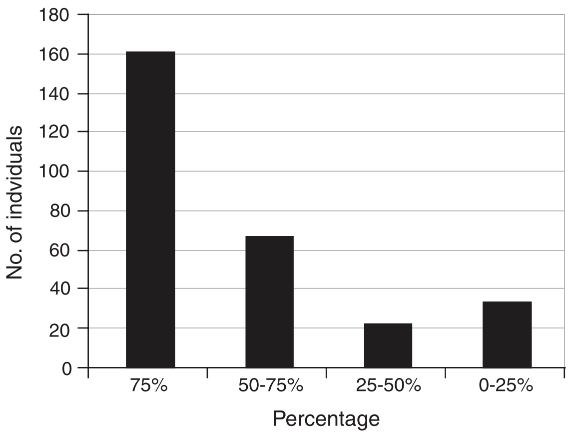

Fig. 5.1 Completeness of skeletons at OA Lankhills (n=284)

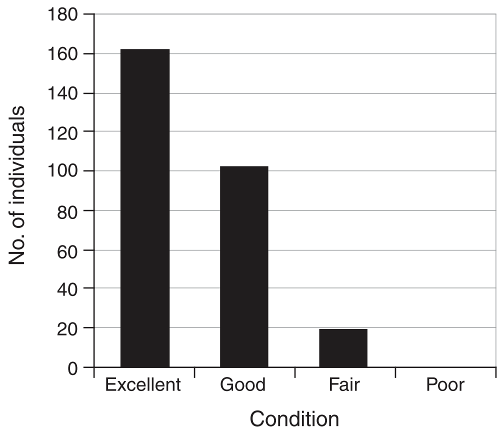

Fig. 5.2 Condition of skeletons at OA Lankhills (n=284)

Table 5.4 Bone condition by skeletal region at OA Lankhills (n=284)

Grade	*Skull*	*Arms*	*Hands*	*Torso*	*Legs*	*Feet*	*Total*
0	19 (6.7%)	20 (7%)	25 (8.8%)	20 (7%)	17 (6%)	19 (6.7%)	120/1704 (7%)
1	77 (27.1%)	47 (16.5%)	55 (19.4%)	63 (22.2%)	61 (21.5%)	92 (32.4%)	395/1704 (23.2%)
2	66 (23.2%)	58 (20%)	31 (10.9%)	32 (11.3%)	67 (23.6%)	45 (15.8%)	299/1704 (17.6%)
3	36 (12.7%)	38 (13.4%)	17 (6%)	23 (8.1%)	49 (17.3%)	14 (4.9%)	177/1704 (10.4%)
4	13 (4.6%)	20 (7%)	9 (3.2%)	12 (4.2%)	17 (6%)	17 (6%)	88/1704 (5.2%)
5	11 (3.9%)	17 (6%)	8 (2.8%)	5 (1.8%)	14 (4.9%)	8 (2.8%)	63/1704 (3.7%)
5+	24 (8.5%)	19 (6.7%)	9 (3.2%)	21 (7.4%)	11 (3.9%)	6 (2.1%)	90/1704 (5.3%)
9 = not present	38 (13.4%)	65 (22.9%)	130 (45.8%)	108 (38%)	48 (16.9%)	83 (29.2%)	472/1704 (27.7%)
Total number	284	284	284	284	284	284	1704/1704

Note: 0 = good; 5+ = very poor

subject to some level of metrical analysis. The assessment of bone condition in relation to body part is shown below (Table 5.4; Fig. 5.3) and this gives a more detailed and specific indication of variation in condition.

Analysis by skeletal region shows that almost half of the skeletons were without hands (130/284; 45.8%) while more than a third were without torsos (108/284; 38%), yet comparable numbers for both skeletal regions fell into the better preserved categories: 111 or 39.1% of hands and 115 or 40.5% of torsos fell within grades 0-2. Similarly, just under a third of skeletons were missing feet (115/284; 29.2%) while 156 or 54.9% of feet fell within grades 0-2.

Intercutting of graves was limited at Lankhills and therefore only accounts for a small proportion of the missing elements. There is a clear variation in preservation of skeletal elements across the site with no clearly identifiable factors involved. Some effort seems to have been made to avoid disturbing existing burial remains, with the result that the majority of the graves were dug into previously undisturbed ground.

The bone condition data were also examined in relation to the age and sex of individuals within the assemblage. The results are presented below for males (Table 5.5; Fig. 5.4), females (Table 5.6; Fig. 5.5) and subadults (Table 5.7; Fig. 5.6).

In general, the data for males and females reflect the patterns seen in the assemblage overall. Hands are the most poorly preserved region with a third of male hands (31/94; 33%) and just under a third of female hands (28/94; 29.8%) completely absent.

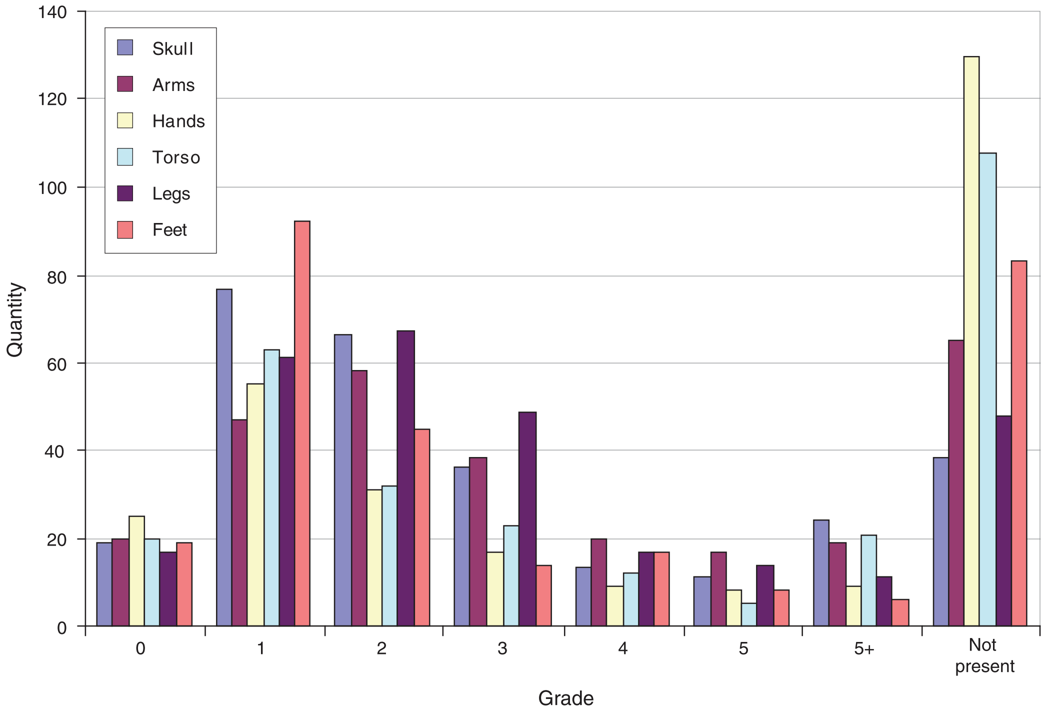

Fig. 5.3 Bone condition by skeletal region at OA Lankhills (n=284)

Table 5.5: Bone condition by skeletal region, adult males only (n=94)

Grade	*Skull*	*Arms*	*Hands*	*Torso*	*Legs*	*Feet*	*Total*
0	10 (10.7%)	9 (9.6%)	12 (12.8%)	8 (8.5%)	8 (8.5%)	7 (7.5%)	54/564 (9.6%)
1	27 (28.7%)	15 (16%)	20 (21.3%)	24 (25.5%)	24 (25.5%)	37 (39.4%)	147/564 (26.1%)
2	29 (30.9%)	28 (29.8%)	17 (18.1%)	15 (16%)	29 (30.9%)	19 (20.2%)	137/564 (24.3%)
3	12 (12.8%)	14 (14.9%)	4 (4.3%)	8 (8.5%)	17 (18.1%)	6 (6.4%)	61/564 (10.8%)
4	3 (3.2%)	9 (9.6%)	5 (5.3%)	5 (5.3%)	6 (6.4%)	7 (7.5%)	35/564 (6.2%)
5	4 (4.3%)	7 (7.5%)	2 (2.1%)	2 (2.1%)	4 (4.3%)	4 (4.3%)	23/564 (4.1%)
5+	5 (5.3%)	6 (6.4%)	3 (3.2%)	7 (7.5%)	2 (2.1%)	1 (1.1%)	24/564 (4.3%)
9 = not present	4 (4.3%)	6 (6.4%)	31 (33%)	25 (26.6%)	4 (4.3%)	13 (13.8%)	83/564 (14.6%)
Total number	94	94	94	94	94	94	564/564 (100%)

Notes: 0 = good; 5+ = very poor; probable males are included in totals

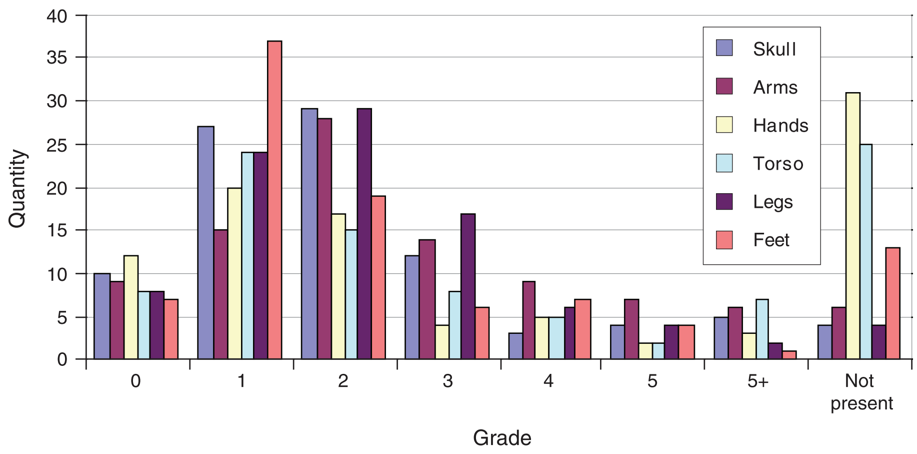

Fig. 5.4 Bone condition by skeletal region for males only (n=94)

Table 5.6: Bone condition by skeletal region, females only (n=94)

Grade	*Skull*	*Arms*	*Hands*	*Torso*	*Legs*	*Feet*	*Total*
0	6 (6.4%)	7 (7.5%)	8 (8.5%)	6 (6.4%)	6 (6.4%)	10 (10.6%)	43/564 (7.6%)
1	28 (29.8%)	18 (19.1%)	24 (25.5%)	23 (24.5%)	24 (25.6%)	40 (42.6%)	157/564 (27.8%)
2	26 (27.7%)	19 (20.2%)	9 (9.6%)	9 (9.6%)	24 (25.6%)	18 (19.1%)	105/564 (18.6%)
3	13 (13.8%)	19 (20.2%)	12 (12.8%)	14 (14.9%)	19 (20.2%)	3 (3.2%)	80/564 (14.2%)
4	8 (8.5%)	10 (10.6%)	3 (3.2%)	5 (5.3%)	7 (7.5%)	7 (7.5%)	40/564 (7.1%)
5	5 (5.3%)	8 (8.5%)	4 (4.3%)	2 (2.1%)	3 (3.2%)	2 (2.1%)	24/564 (4.3%)
5+	3 (3.2%)	5 (5.3%)	6 (6.4%)	9 (9.6%)	2 (2.1%)	0	25/564 (4.4%)
9 = not present	5 (5.3%)	8 (8.5%)	28 (29.8%)	26 (27.7%)	9 (9.6%)	14 (14.9%)	90/564 (16%)
Total number	94	94	94	94	94	94	564/564 (100%)

Notes: 0 = good; 5+ = very poor; probable females are included in totals

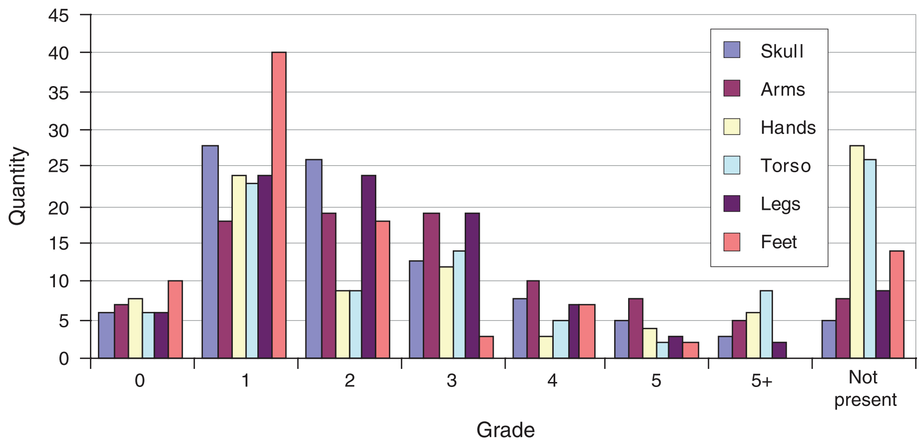

Fig. 5.5 Bone condition by skeletal region, females only (n=94)

This is followed by torsos with just over a quarter absent for both females (26/94; 27.7%) and males (25/94; 26.6%). Feet are absent in 13 male graves (13.8%) and 14 female graves (14.9%).

Overall, males are slightly better preserved, with 60% of skeletal elements assigned to grades 0-2 compared with 54% of females and 36.2% of subadults. This is mostly accounted for by variation in the preservation of the legs: four males were without legs (4.3%) which is less than half the figure for females (9; 9.6%). Across the skeleton the figures for absence of skeletal parts were slightly better for males (83; 14.6%) than those for females (90; 16%). In marked contrast the figure for subadults was

48.4% with hands and feet the most commonly missing skeletal elements (64.1%).

This pattern is broadly reflected by Clarke's Lankhills. He carried out a detailed analysis of preservation by skeleton and variation according to age and sex though *not* by skeletal region (Clarke 1979, 137-138, table 9). He defined six categories of skeletal preservation which appear below (Table 5.8).

These results are broadly comparable with the data for OA Lankhills: preservation for males is better than for females and preservation of subadults is much poorer (see below). Clarke suggested a possible link between poorer preservation and burial within coffins and wearing of clothing or shrouds: '…in graves where personal ornaments worn at burial suggest that the corpse

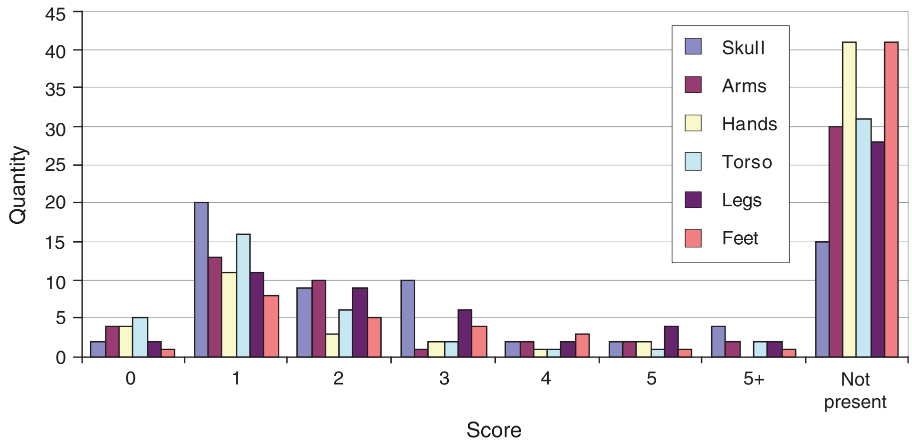

Fig. 5.6 Bone condition by skeletal region, subadults only (n-64)

Table 5.7: Bone condition by skeletal region, subadults only (n=64)

Grade	*Skull*	*Arms*	*Hands*	*Torso*	*Legs*	*Feet*	*Total*
0	2 (3.1%)	4 (6.3%)	4 (6.3%)	5 (7.8%)	2 (3.1%)	1 (1.6%)	18/384 (4.7%)
1	20 (31.3%)	13 (20.3%)	11 (17.2%)	16 (25%)	11 (17.2%)	8 (12.5%)	79/384 (20.6%)
2	9 (14.1%)	10 (15.6%)	3 (4.7%)	6 (9.4%)	9 (14.1%)	5 (7.8%)	42/384 (10.9%)
3	10 (15.6%)	1 (1.6%)	2 (3.1%)	2 (3.1%)	6 (9.4%)	4 (6.3%)	25/384 (6.5%)
4	2 (3.1%)	2 (3.1%)	1 (1.6%)	1 (1.6%)	2 (3.1%)	3 (4.7%)	11/384 (2.9%)
5	2 (3.1%)	2 (3.1%)	2 (3.1%)	1 (1.6%)	4 (6.3%)	1 (1.6%)	12/384 (3.1%)
5+	4 (6.3%)	2 (3.1%)	0	2 (3.1%)	2 (3.1%)	1 (1.6%)	11/384 (2.9%)
9 = not present	15 (23.4%)	30 (46.9%)	41 (64.1%)	31 (48.4%)	28 (43.8%)	41 (64.1%)	186/384 (48.4%)
Total number	64	64	64	64	64	64	384/384 (100%)

Notes: 0 = good; 5+ = very poor

Table 5.8: Skeletal preservation by age and sex for Clarke's Lankhills (n=408)

State of preservation	*Overall incidence*	*Incidence among men*	*Incidence among women*	*Incidence among all adults*	*Incidence among subadults*
A almost perfect	33 (8%)	17 (15%)	4 (6%)	29 (10%)	4 (4%)
B slight decomposition	96 (24%)	36 (32%)	12 (17%)	71 (24%)	25 (23%)
C smaller bones decayed	84 (21%)	27 (24%)	23 (32%)	71 (24%)	13 (12%)
D only major bones left	101 (25%)	26 (23%)	26 (37%)	87 (29%)	14 (13%)
E only skull and legs left	52 (13%)	6 (5%)	6 (8%)	34 (11%)	18 (17%)
F little or nothing left	42 (10%)	0 (0%)	0 (0%)	8 (3%)	34 (31%)
Total	408 (100%)	112 (100%)	71 (100%)	300 (100%)	108 (100%)

Note: It should be emphasised that the data on age and sex provided by Harman for this table were revised by Gowland, although even allowing for this there is still significant variation between the sexes.

was indeed fully clothed, the skeleton was almost invariably badly preserved. The poor preservation of female skeletons could thus indicate that women were generally buried with heavier clothing or shrouds than men' (Clarke 1979, 138). However, in more recent research on the taphonomy of human remains it has been observed that there is 'significant retardation of decomposition in clothed bodies buried directly in the soil without a coffin. Clothing will partially negate the effects of the general soil environment and delay the process of decay' (quoted in Janaway 1996, 69). Certainly in the OA assemblage there does not appear to be an obvious link between poor preservation and burial in coffins. There was evidence to indicate that virtually all the dead had been buried in coffins. Where evidence for coffins was not recovered the graves were often extremely truncated. There is some evidence for the preservation of textiles in association with objects though in only three graves could the material be identified. In two cases the material was probably linen and in the third it was wool. However, the way in which it was associated with the objects does not necessarily suggest garments which were worn (see Chapter 7).

A further explanation for variable decomposition could be in the observation that vegetable matter (eg straw, pine branches) when placed into the burial environment. introduces additional bacteria and surrounds the body with a layer of air. It may then act as an insulator and generate heat in its breakdown, speeding up decomposition of the body (Janaway 1996, 69). It has been observed that remains of Box (*Buxus sempervirens*) leaves have been found in Roman burials, as they were believed to keep the grave sweet and perhaps served as a symbol of eternal life. No evidence for such coffin packing was present at Lankhills, however, though Box has been recorded, for example, in the cemetery at Roden Downs, Berkshire (Hood and Walton 1948, 47).

Preservation of subadults is much poorer than that of males or females, with nearly half of skeletal elements being completely absent (186/384; 48.4%). Once again, however, the general assemblage-wide trends are broadly reflected within this group. Considerably more than half of hands are absent (41/64; 64.1%) with equal numbers of feet, followed by torso (31/64; 48.4%), legs (28/64; 43.8%), arms (30/64; 46.9%) and skull (15/64; 23.4%). Just over one third of the assemblage is graded 0-2 (139/384; 36.2%). There was no obvious correlation between grave depth and preservation/completeness.

Demographic composition

Quantification of the assemblage

There were 64 subadults and 220 adults in the total of 284 articulated skeletons from OA Lankhills. The adults comprised 64 males, 30 probable males, 68 females, 26 probable females and 32 unsexed individuals. Five adolescents in whom pelvic development was complete exhibited sexually dimorphic characteristics; there were two females (skeletons 20 (Grave 18) and 507 (Grave 545)), two probable females (skeletons 926 (Grave 985) and 1244 (Grave 1360)) and one probable male (skeleton 712 (Grave 745)). The 'probable' adolescents had slightly less complete pelves with slightly more fragmentation.

Sex

The number of males and females, 94 of each, gives an equal ratio of 1:1. In some aspects, sexual dimorphism was quite marked among the adult population. The females were significantly smaller and more gracile than the males. In contrast, however, it was notable that the skulls had more mixed characteristics, particularly in the angle and gonial flaring of the mandible, which was commonly masculine in nature even in individuals sexed as female. In addition, it was observed that the sciatic notch of the pelvis of males was wider than in other populations (this comment is based on a general observation; the width of the sciatic notch was not measured). Where there was significant difference between the indications presented by the skull and pelvis the latter was given more weight.

The majority of the 32 unsexed skeletons were missing the skull and pelvis and preservation was generally poor. It was possible to take measurements on only two of these skeletons. Skeleton 1474 (Grave 1455) had both male and female measurements while the measurements for skeleton 1926 (Grave 1925) were indeterminate.

Skeletons aged less than 18 years of age were examined for sexually dimorphic traits and only included where these were well-defined. Caution was exercised, as it is known that young adult males tend to have less well defined supraorbital ridges and generally less robust features than older males, which can lead to a reduction in the numbers of males identified in the younger adult age categories. In all, five individuals in the adolescent category (13-17 years) were assigned a definite or

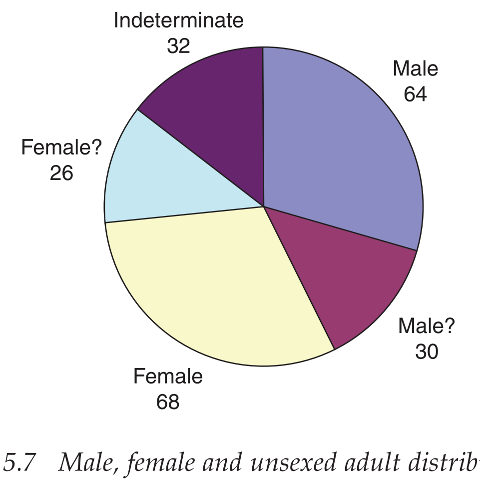

Fig. 5.7 Male, female and unsexed adult distribution at OA Lankhills (n=220)

probable sex and are included in the analysis. Of these, four were female and only one was male (see above).

The original assessment of Clarke's Lankhills identified a preponderance of males over females (112: 71) out of a total of 439 inhumations: 'All these [adult] burials were of people over 17: 111 men, 70 women and one double grave with both a man and a woman' (Harman 1979, 123). Gowland (2001, 154) re-aged and re-sexed all skeletons from Clarke's Lankhills as the original report represented an assessment only and was conducted prior to the development of some of the more recent ageing techniques, for example assessment of the auricular surface (Lovejoy *et al.* 1985) and pubic symphysis (Brooks and Suchey 1990). She identified 112 males and probable males with 119 females and probable females while the remaining 94 adults could not be sexed (Fig. 5.8; Table 5.9). The skeletal material excavated by Clarke was a little more fragmented and less well-preserved than the OA assemblage, with 19.5% of skeletons not assigned to sex (94/481) compared to 11.3% (32/284) in the OA assemblage. A total of 18 out of 481 individuals (3.7%) were unaged and unsexed. Gowland's age and sex determinations are used for all further comparisons in this report. Table 5.9 also summarises the evidence from the Wessex Archaeology excavations of 2007-8.

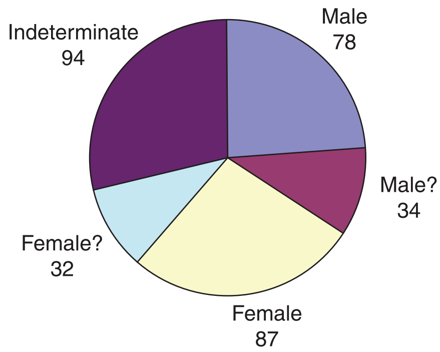

Fig. 5.8 Male, female and unsexed adult distribution at Gowland's Lankhills (n=325)

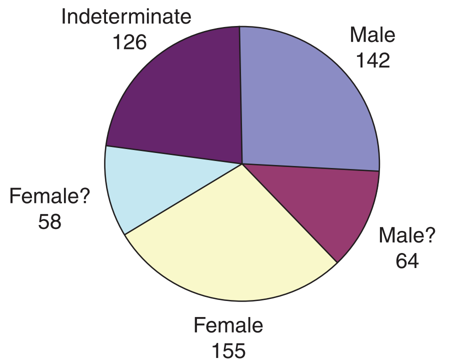

Fig. 5.9 Male, female and unsexed adult distribution for combined Lankhills (n=545)

Age at death

In this section the age distribution of the OA Lankhills individuals is considered. These data are then combined, as far as possible, with Gowland's reassessment of Clarke's Lankhills, to facilitate discussion of the complete assemblage. Gowland used slightly different age categories. In particular this has implications for the older adult categories: her mature adult category 35-49 years is followed by older adult at 50+ years, categories which contrast with the 35-44 years, 45+ years and 60+ years age brackets used at OA Lankhills. The value of dental attrition as an ageing method in this context is also commented upon. Finally the assemblage is compared with other contemporary groups.

Adult age estimation at OA Lankhills was based on multiple indicators both with and without dental attrition. When attrition was excluded the assemblage contained a higher proportion of older adults than other contemporary groups. The variation in age distribution both with and without attrition is illustrated in Fig. 5.11. Partly to facilitate comparisons the final age estimates did incorporate dental attrition as an indicator. Dental attrition was also examined for its value as a sole ageing indicator and the results are discussed below.

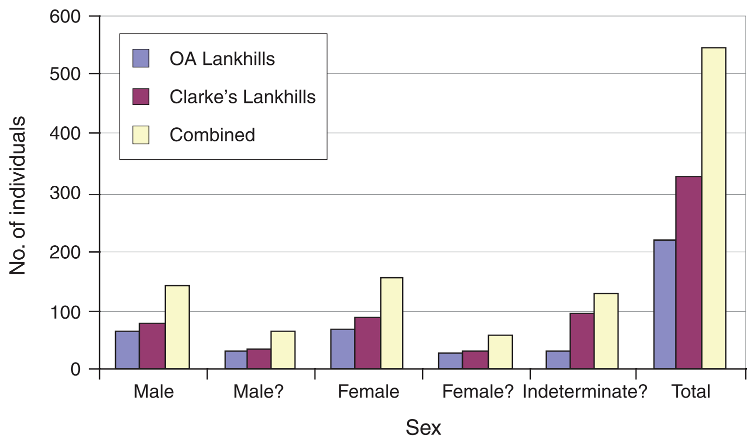

Fig. 5.10 Comparison of data on sex of adult individuals at Lankhills

When attrition was excluded from the process of age estimation the profile showed an aged population with 60 and 20 individuals dying in the older adult (45+ years) and much older (60+ years) categories respectively, with fewer in the young adult (18-25 years) and prime adult categories (26-35 years) - 9 and 20 individuals respectively. This population profile was at odds with that of Gowland and also with those from other contemporary cemeteries. When attrition was incorporated the numbers in the older and much older categories decreased to 48 and 15 with a corresponding increase in the young adult and prime adult categories to 13 and 28. Numbers in the mature adult category increased from 34 to 39.

Among the subadults, most deaths are recorded in the infant (23) and young child (21) age categories. There were seven neonates and foetuses

Table 5.9: Numbers of males, females, unsexed adults and subadults at Lankhills (OA and Clarke (Gowland) combined; n=765), with assessment data from Wessex Archaeology excavation

	M	*M?*	*F*	*F?*	*?*	*SA*	*UU*	*Total*
OA	64 (8.4%)	30 (3.9%)	68 (8.9%)	26 (3.4%)	32 (4.2%)	64 (8.4%)	0	284 (62.9%)
Clarke (Gowland)	78 (10.2%)	34 (4.4%)	87 (11.4%)	32 (4.2%)	94 (12.3%)	138 (18%)	18 (2.4%)	481 (37.1%)
Combined	142 (18.6%)	64 (8.4%)	155 (20.3%)	58 (7.6%)	126 (16.5%)	202 (26.4%)	18 (2.4%)	765
Wessex Archaeology	14*		20*		5	13		52

Note: UU=unaged and unsexed; SA=subadult; *= includes uncertainly sexed individuals

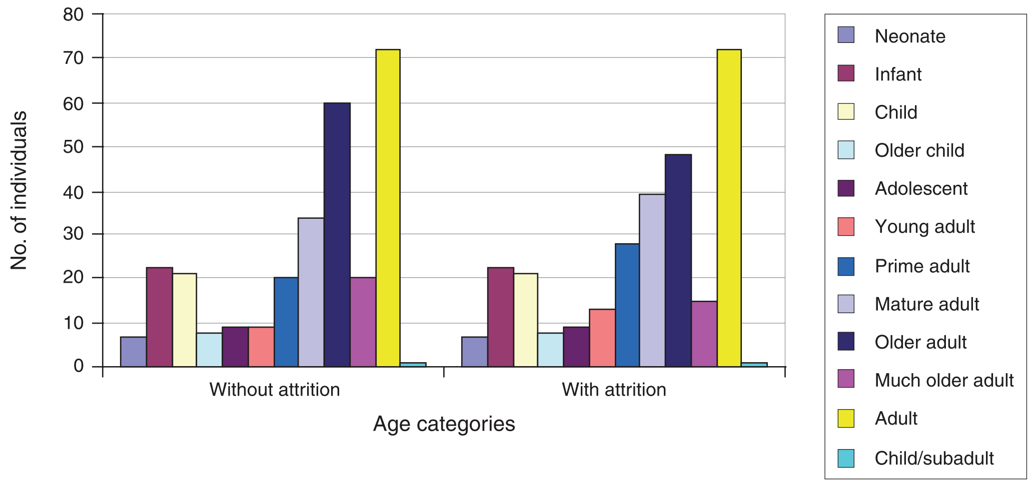

Fig. 5.11 Comparison of age categories at OA Lankhills, both with and without dental attrition as one of the multiple age indicators

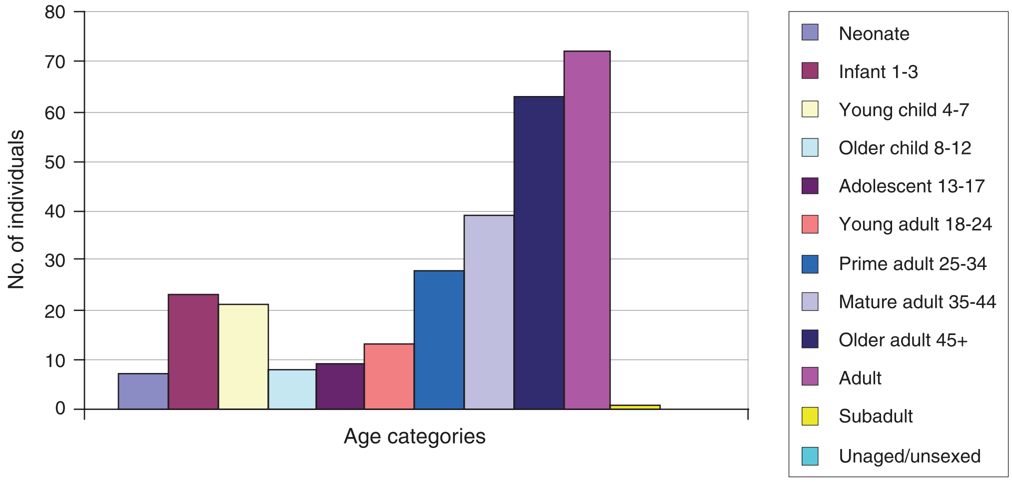

Fig. 5.12 Age distribution at OA Lankhills (n=284)

were absent. The numbers of subadults dying in the older child and adolescent age categories were virtually the same, totalling eight and nine individuals respectively. A single poorly preserved skeleton was assigned to the broad subadult category.

Adults show a marked increase in the number of deaths with the advancement of age. Thus, only 13 individuals died in young adulthood (18-25 years), but this number doubles by the next age category, prime adulthood (26-35 years), and continues to increase with 39 adults in the mature category (36-45 years) until the 45 years + age category. This latter age category accounts for 48 individuals, or 22.8% of all aged adults. A further 15 individuals (7.1%) died over the age of 60 years. Even with the application of dental attrition as one of a number of ageing indicators, the group still appears 'older' when compared with the data recorded by Gowland. This may hint at some form of zoning within the cemetery. A significant number of individuals (72; 32.7%) could not be assigned to an age more specific than 'adult'. These skeletons were poorly preserved and in most cases the skull and pelvis did not survive.

The expected age at death distribution for a pre-industrial population would produce a U-shaped curve, with deaths peaking in infancy and older adulthood, which is the pattern reflected here. In contrast, in modern industrialised countries the number of deaths in infancy and childhood decreases and the distribution becomes skewed to the older age ranges with very few deaths under 45 years. It has been estimated that infant mortality in

Table 5.10: Age distribution at OA Lankhills (n=284)

Age category	*Number of individuals*	*% of aged population*	*% of subadults*	*% of adults*
Neonate 0-1mth	7	3.3	10.3	
Infant 1-3	23	10.9	33.8	
Young child 4-7	21	10	30.9	
Older child 8-12	8	3.8	11.8	
Adolescent 13-17	9	4.3	13.2	
Young Adult 18-25	13	6.2		9.1
Prime Adult 26-35	28	13.3		19.6
Mature Adult 36-45	39	18.5		27.3
Older Adult 45+	48	22.8		33.6
Much Older Adult 60+	15	7.1		10.5
Adult	72			
Subadult	1			
Total	284			

Note: adult and subadult categories are excluded from the % calculations.

Table 5.11: Age distribution at Clarke's Lankhills (n=481)

Age category	*Number of individuals*	*% of aged population*	*% of subadults*	*% of adults*
Neonate 0-1	37	11.6%	33%	
Infant 1-3	23	7.2%	20.5%	
Young child 4-7	30	9.4%	26.8%	
Older child 8-12	8	2.5%	7.1%	
Adolescent 13-17	14	4.4%	12.5%	
Young Adult 18-24	65	20.4%		31.5%
Prime Adult 25-34	63	19.8%		30.6%
Mature Adult 35-49	54	16.9%		26.2%
Older Adult 50+	24	7.5%		11.6%
Adult	114			
Subadult	31			
Unaged/unsexed	18			
Total	481			

Note: adults, subadults, unaged/unsexed are excluded from the % calculations.

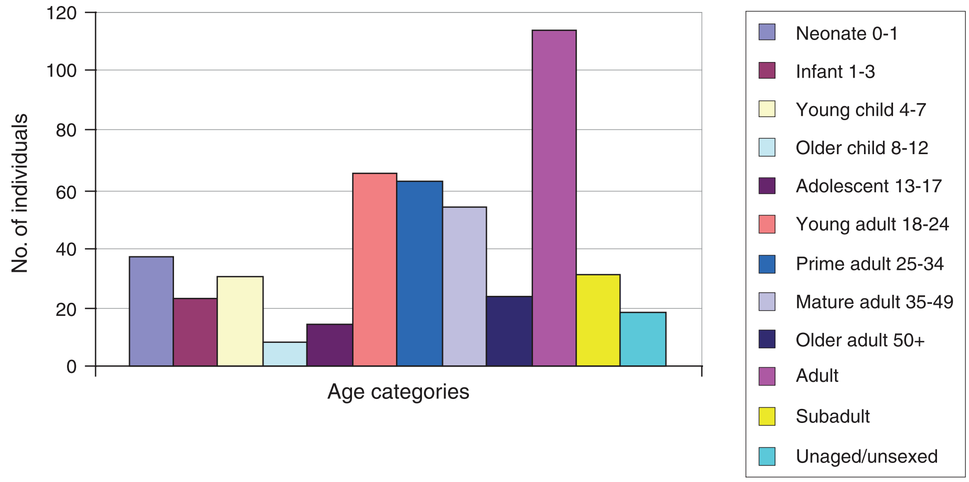

Fig. 5.13 Age distribution at Clarke's Lankhills (n=481)

Table 5.12: Comparison of a range of subadult ageing methods at OA Lankhills

Skeleton number	*Dental age*	*Epiphyseal fusion age*	*Long bone length age*
280	2-4 years	1 year	1.5 years
611	5-7 years	3-6 years	4 years
767	4-7 years	6-9 years	6-7 years
1287	2-4 years	3-6 years	1.5-2 years
1314	0-1 months		38-48 weeks
1339	3-7 years	3+ years	3.5-4 years
1467		?1 year	7 months-1 year
1565	1.75-3.5 years		1 year
1723	0-1 month		42-48 weeks
1731	1-2 years	1-2 years	2 years
1879	4-12 months	C1 year	1-4 months

pre-industrial Europe was approximately 20-30% (Shahar 1990, 149). At OA Lankhills neonates represent 3.3% of the population, which in common with many other contemporary assemblages falls short of the expected number.

Where possible, subadult remains were aged using dental development and epiphyseal fusion; long bone length was also recorded and for two skeletons was the only ageing method available. Where dental age and long bone age could be compared the difference was found to be minimal with the possible exception of skeleton 1287 (Grave 1351) (Table 5.12). This suggests that stunted growth due to malnutrition and ill health among the children was not widespread, and that where deficiencies have been observed these are in fact the rare cases and not the norm.

When estimating subadult age dental development is considered to be most reliable. It must be borne in mind, however, that subadult females are on average 1-6 months ahead of males in development and there are currently no reliable methods to determine sex in subadults (other than DNA analysis, which can still be problematic because of contamination issues), so variation in either dental or long bone age may be determined by sex of the individual.

Subadult growth curves were not established, since the material was more fragmentary and poorly preserved than had been hoped. Tooth dimensions were recorded as a means of establishing a base line for males and females in order to investigate the sex of subadults using discriminant function analysis of the tooth crown dimensions, but the analysis of the data and comparison with the occurrence of grave goods was eventually considered beyond the scope of this current report.

Probable high mortality rates and the under-representation of infants at Romano-British cemetery sites have been alluded to above. Lankhills is atypical to an extent because children are relatively well-represented and the cemetery also has a relatively high frequency of burials with grave goods (Gowland 2001, 153; this chapter; Chapter 7). The levels of infant and child mortality throughout the various periods in the past are unknown. Estimated infant (defined as less than 1 year) mortality figures from modern pre-industrial populations have been found to vary widely, up to approximately 200 per 1000 live births (Hobbs and Kigguridu 1992). Mortality figures remain high for children up until the age of about five years, before gradually decreasing (Weiss 1973). Estimates of infant mortality during the Roman period are usually placed between *c* 25-35% (Frier 1982). Despite the degree of uncertainty surrounding infant and child mortality statistics from Roman Britain, the proportion of children buried at Lankhills still falls short of the numbers one might expect (see Site comparisons below).

The examination of condition and completeness of the subadults at OA Lankhills (see above) did indicate that both were poorer than for males and females. Taphonomic processes, perhaps related to variation in grave depth, are therefore likely to have been a factor contributing to the absence of some younger children, but they cannot be the only explanation. The average depth of subadult graves was 0.60 m while the deepest was 1.30 m. The likely cultural factors responsible for the exclusion of infants from cemeteries are discussed in relation to Clarke's Lankhills (Gowland 2001, 156-157). Literary evidence relating to Rome indicates that an infant only attained an individual social identity on the day that it was named (the *lustratio*), a ceremony that took place on the eighth day after birth for females and the ninth day for males (Weidemann 1989; Rawson 1991). Further evidence indicates that infants were not perceived to have attained true personhood prior to teething and possibly walking and talking (Watts 1989; Philpott 1991).

Among Clarke's Lankhills none of the neonates were buried with grave goods and only a small percentage of infants under one year of age were buried with any good at all (Gowland 2001, 159). This is contrasted by the evidence at OA Lankhills. Two neonates, skeletons 574 and 1554 (Graves 620 and 1547), were buried in coffins with associated grave goods: a carved bone plaque in the former case and a coin and a horse skull in the latter. Seven of the infants also had associated grave goods (skeletons 44, 118, 280, 589, 1143, 1287 and 1485 - Graves 41, 110, 277, 575, 1205, 1351 and 1490 respectively).

When OA Lankhills and Clarke's Lankhills are combined there are 44 neonates or 5.8% of the total assemblage (7 and 37) and 46 infants or 6.1% of the total assemblage (23 and 23). A further 12 neonates and 1 infant were identified among the disarticulated material at OA Lankhills, suggesting the presence of some unmarked or shallow graves (see also Chapter 7 below)

Some variation is apparent when the data for adult age at death for OA Lankhills are compared with those for Clarke's Lankhills. Male deaths exceeded female deaths in the 18-25 years, 45+ years, and 60+ years categories (Fig. 5.13). There were more female deaths in the adolescent (13-17 years) and prime adult (26-35 years) age categories, although the absolute numbers in the former category were insufficient to be meaningful, and the difference may be a reflection of sexual development at that age. More females than males were assigned to the unspecific age category 'adult' (more than 18 years) so the differences could balance out.

The OA assemblage comprised individuals from all age categories and even numbers of males and females although there was some sexual variation within certain age categories (see above). There were significant numbers of mature and older age adults. Most of the subadults were from the infant and young child age groups; neonates (as at many sites) were under-represented and no foetal remains were recovered. Adult females were dying in the younger age categories. These are the prime child-bearing years and in view of the inherent risks associated with pregnancy and birth it is very probable that this had an effect on the age at death of the females. It is possible that males aged upwards of 45 years are slightly over-represented because females gain more robust features with increasing age and for this reason a small number of older females may have been identified as male. This does, however, seem unlikely given the marked sexual dimorphism seen in the assemblage as a whole.

When the data from OA Lankhills and Gowland's Lankhills are considered together (Table 5.13, Figs 5.14 and 5.15) the profile changes. Considerably more females died in the young adult category (18-25 years) while the ratio in the prime adult category becomes much more balanced. There are slightly more females (47) than males (37) in the broad adult category. The remaining age categories are not directly comparable; this is also true of the Wessex Archaeology (2009, 28) assessment data, also summarised in Table 5.13, which are of course only provisional. Although small, it may be significant that this group contained more adult females (20) than males (14).

The combined data show an almost even split between males and females which presumably reflected the pattern within the population (Table 5.13). When divided into age groups the combined

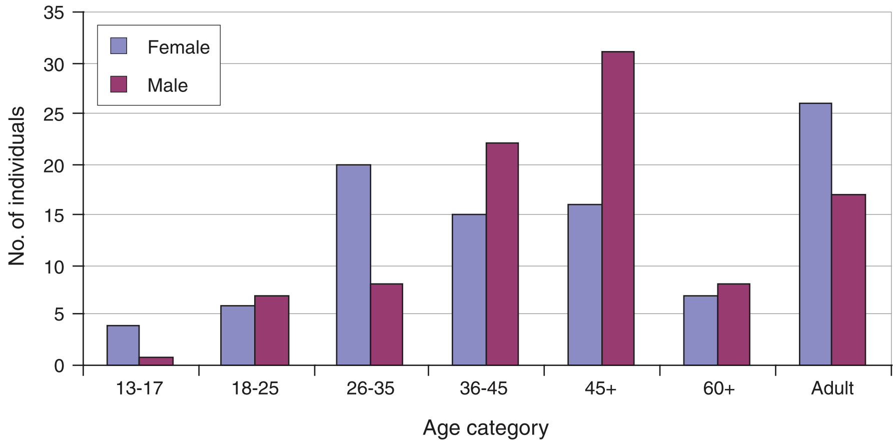

Fig. 5.14 Age at death for males and females at OA Lankhills (n=188)

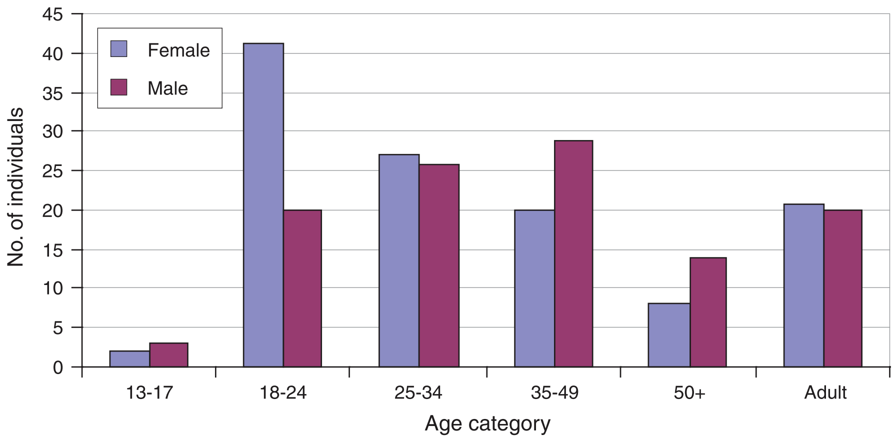

Fig. 5.15 Age at death for males and females at Clarke's Lankhills (n=231)

age and sex data show a clear difference between the males and females. The females predominate in the younger age categories, while the males gradually increase in number, to dominate the 45+ age category.

At Poundbury there were 346 female, 326 male and 24 unsexed skeletons (Farwell and Molleson 1993). This indicates a similar pattern to that seen at Lankhills, and it might be expected that a municipal cemetery, serving a wide area and with no particular dominant population (such as a local army garrison) would contain even numbers of males and females. The Period 2 cemetery at Butt Road, Colchester, however, contained 170 males and 140 females (Pinter-Bellows 1993, 63; the sex of 129 adults was undetermined), giving a ratio of 1.2 males: 1 female. The balance may have been redressed among the adults of undetermined sex. There was a very marked imbalance between males and females at Cirencester South (207 males, 93 females, 62 unsexed individuals). Wells suggested this was most probably because the town was largely given over to retired legionaries and to various Roman officials, many of whom were unmarried (1982, 135), but this interpretation is based upon a view of Roman urbanism that would not be widely accepted today. Male deaths increased with age while female deaths were distributed fairly evenly across the age categories from 18 years onwards. There were only 63 subadults and Wells further suggested that this may have been due to the low number of females in the population (ibid.) although this is perhaps contradicted by the presence of nineteen children below the age of 2 years, 16 (25.4%) of whom were neonates.

Dental attrition ageing

The degree of dental attrition at OA Lankhills was low. Molars were often lightly worn even into the older age ranges with dentine exposure confined to individual cusps. This was also found to be the case at Poundbury (Molleson 1993, 207-9), where a 'within-population' grading system was developed. At Cannington, variation in tooth wear was observed, but severe wear was 'fairly uncommon' (Rahtz *et al*. 2000, 243). In the course of her work Gowland (2002) developed a Bayesian attritional grading system across several Romano-British populations in an attempt to counter the apparent skewing of age profiles on the basis of low levels of tooth wear, but it was not possible to use this for the present assemblage.

The dental attrition method assumes that there was continual erosion of the enamel exposing the dentine during an individual's lifetime. This has been variously attributed to the effects of fibrous or coarse food, sand or grit particles in the diet. Ageing of the adults using dental attrition alone (Miles 1963) produced a peak of incidence in the 18-24 year old group, closely followed by the 26-34 year old group with significant drops in the 35-44 year and 45+ year categories (Fig. 5.16). The method is known to tend to produce a peak age-at-death between 35-40 years (Miles 2001) but this is not the case at Lankhills.

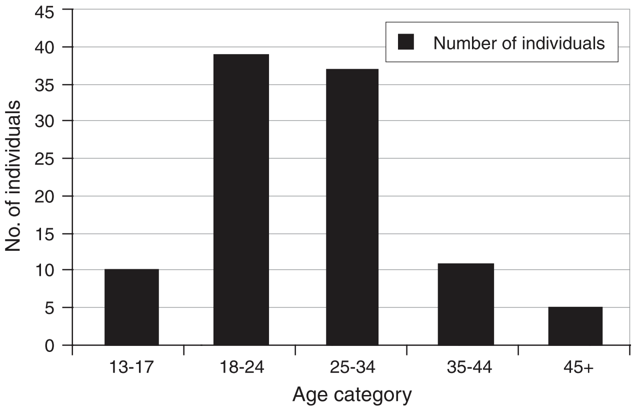

Fig. 5.16 Age ranges based solely on dental attrition at OA Lankhills (n=102)

It is desirable that an age grading system is developed within each population where possible, based on the known age eruption timing of the 1st and 2nd molars. This requires the presence of a minimum number of subadults (32) with the appropriate teeth to allow the creation of baseline data, but there were insufficient skeletons surviving in this category. In order to maximise the multiple indicators methodology (see above) for ageing adults, and to facilitate comparisons with other assemblages, dental attrition was used except where this was the only method. Where dental attrition ageing was more than one category lower than the average of the multiple indicators, the final age, based on the range of the other indicators, was taken to be from the lower end of that range.

Site comparisons

In this section the population profile for Lankhills (OA and Gowland combined) is compared with contemporary populations. Gowland's results suggest a population dying young, with decreasing numbers in the age categories after young adult, whereas the OA results suggest a population living into old age with fewer dying in the younger adult categories. Obviously it is not meaningful to discuss the two groups of material separately as there is no archaeological evidence to suggest that they represent significantly different populations using the same cemetery.

It is possible to combine the data for all age categories up to and including prime adult (25-34 years) and these figures appear in Table 5.13. All categories above 35 years are combined, which is far from satisfactory.

At Poundbury (Table 5.14) while there are fewer neonates (6.3%) the infant peak is much more marked (15.5%). Other notable differences occur in

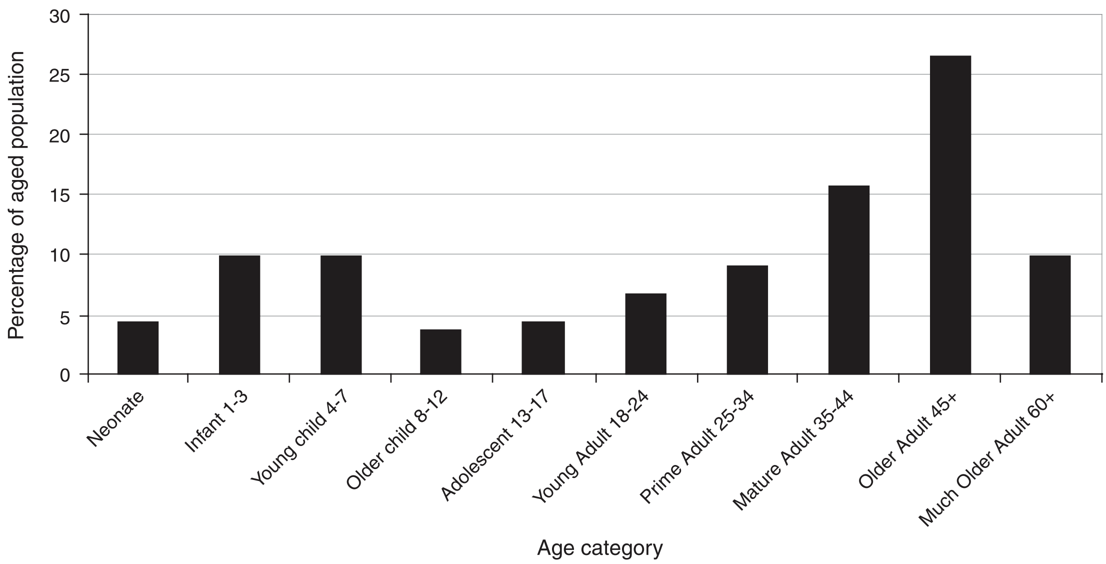

Fig. 5.17 Age distribution at OA Lankhills, shown as a percentage of the population (n=284)

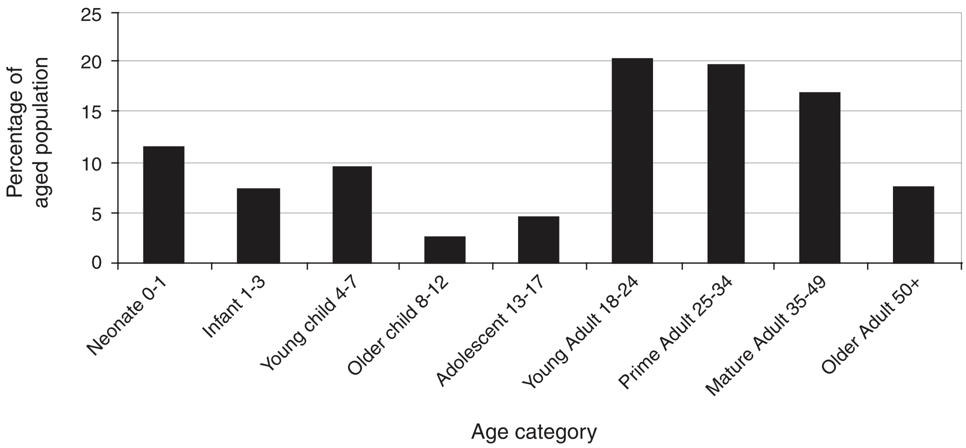

Fig. 5.18 Age distribution at Clarke's Lankhills (n=481)

Table 5.13: OA Lankhills and Clarke's Lankhills, age categories combined (n=765)

Age category	*OA Lankhills*	*Clarke's Lankhills*	*OA and Clarke combined*	*Wessex Archaeology*
Neonate	7 (3.3%)	37 (11.6%)	44 (8.3%)	2
Infant	23 (10.9%)	23 (7.2%)	46 (8.7%)	8
Young child	21 (10%)	30 (9.4%)	51 (9.6%)	
Older child	8 (3.8%)	8 (2.5%)	16 (3%)	2
Adolescent	9 (4.3%)	14 (4.4%)	23 (4.3%)	1
Young adult	13 (6.2%)	65 (20.4%)	78 (14.7%)	7 (18-30 years)
Prime adult (25-34 years)	28 (13.3%)	63 (19.8%)	91 (17.2%)	18 (30-45 years)
35+ years	102 (48.3%)	78 (24.5%)	180 (34%)	9 (45+ years)
Adult	72	114	186	5
Subadult	1	31	32	
Unaged/unsexed	0	18	18	
Total	284	481	765	52

Table 5.14: Age distribution at Poundbury (n=1074)

Age category	*Number of individuals*	*% of aged population*	*% of subadults*	*% of adults*
Neonate 0-1 months	65	6.3	17.7	
Infant 1-3	160	15.5	43.5	
Young child 4-7	54	5.2	14.7	
Older child 8-12	43	4.2	11.7	
Adolescent 13-17	46	4.4	12.5	
Young Adult 18-24	94	9.1		14.2
Prime Adult 25-34	174	16.9		26.2
Mature Adult 35-44	165	16		24.9
Older Adult 45+	192	18.6		29
Much Older Adult 65+	37	3.5		5.6
Adult	44			
Subadult	0			
Total	1074			

Note: adult and subadult categories are excluded from % calculations; the total figure of 1074 comprises late Roman burials only (Roberts and Cox 2003 quote a figure of 1131 for the whole of the Roman period.

Table 5.15: Age distribution at Butt Road (n=575)

Age category	*Number of individuals*	*% of aged population*	*% of subadults*	*% of adults*
Neonate 0-1mth	6	1.5	5	
Infant 1-2	13	3.4	10.7	
Young child 2-4	27	6.9	22.3	
Mid child 5-9	33	8.4	27.3	
Older child 10-14	27	6.9	22.3	
Adolescent 15-19	15	3.8	12.4	
Young Adult 20-30	76	19.3		27.9
Prime Adult 30-50	153	38.9		56.2
Mature Adult 50+	43	10.9		15.8
Adult	152			
Unknown	30			
Total	575			

Note: adult and unknown categories are excluded from % calculations

the young adult category with 9.1% at Poundbury compared to 14.7% at combined Lankhills.

Different age categories were employed at Butt Road (Table 5.15; Pinter-Bellows 1993, 32) which makes comparison difficult, but it is clear that the age distribution is very different, with fairly even numbers of subadults across each category and a peak in the prime adult category. This may suggest that the population were dying young, although the 30-50 years age category is very wide, and makes assessment of this aspect very difficult. There was no peak in the infant (1-2 years) category as seen at the combined Lankhills and Poundbury.

The age distribution at Lankhills reflects relatively high child mortality; those who survived early childhood had a good chance of living into older adulthood which might suggest a relatively healthy and well-nourished population.

Physical appearance of the population

Stature

It was possible to estimate the stature of 69 adults (31.4% of the adult population) from OA Lankhills based on the maximum length of the left femur only. Of these, 53 adults had further long bone measurements (femur, tibia and humerus) which could be combined to determine stature.

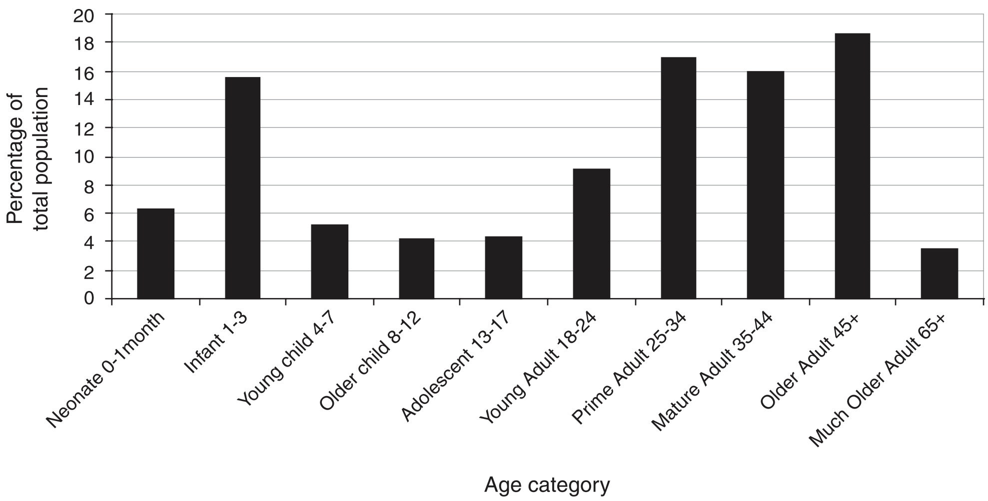

Fig. 5.19 Age distribution at Poundbury, shown as a percentage of the total population (n=1074)

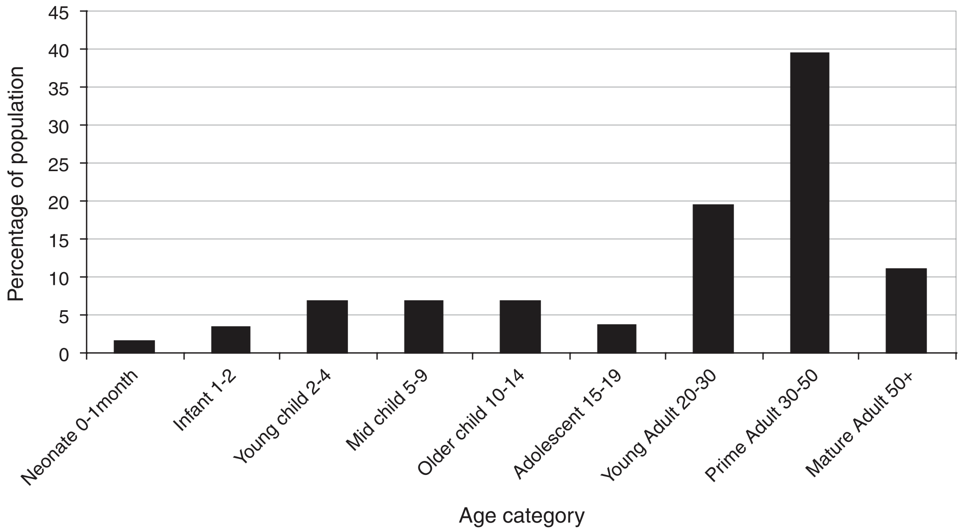

Fig. 5.20 Age distribution at Butt Road, shown as a percentage of the population (n=575)

Measurements using the lower limbs have been shown to be most reliable (Wells 1982, 139), thus only results employing the maximum length of the left femur are presented. However, for comparative purposes those employing any long bone are also given. Male statures ranged from 156.84 cm (5′ 1 7/10″) to 186.83 cm (6′ 1 3/5″) and for females, they ranged from 147.96 cm (4′ 10 3/10″) to 172.16 cm (5′ 7 4/5″).

The difference between the mean heights of males at 168.99 and females at 157.13 was just under 12 cm. The range and means from the OA assemblage are comparable to those for other late Roman sites in Britain (Table 5.16). Data on stature and other metrics are not available for Clarke's Lankhills.

At Poundbury the men were in general taller than the women, most being 1.62-1.72 m (5′4″-5′8″) while most women were 1.58-1.64 m (5′2″-5′5″). Exceptions included three very tall men: grave 40 (1.80 m – 5′11″), skeleton 755 (1.81 m - 5′11″) and skeleton 798 (1.85 m – 6′ 1″). The shortest male skeletons were 159 (1.48 m – 4′10″) and 949 (1.51 m – 4′ 11″). The tallest woman was 1.70 m (5′7″) and the shortest female skeletons 753, 865 and 1353 at 1.51 m (4′11″). It is noteworthy that the distribution for female stature was normal, with low variance, while the male distribution exhibited much higher variance. Molleson (1993, 168) suggested that this may be an indication that males buried in the cemetery were drawn from a wider area than the females, although males are more sensitive to environmental stresses and generally show greater variability than females.

In contrast, at Lankhills the distribution for both males and females was normal (see Fig. 5.21). The smallest man was 1.57 m (skeleton 852, Grave 935) while the tallest was 1.87 m (skeleton 1640, Grave 1638). This man would have looked striking in comparison to the majority of the population. He had been buried with four coins in his left hand. The smallest female was skeleton 1197 (Grave 1270, 1.48 m) while the tallest, skeleton 212 (Grave 210), was 1.73 m. The figures for Cirencester can also be described as normal and are comparable with many early groups (Wells 1982, 140). The same can broadly be said of the skeletons from Butt Road (Pinter-Bellows 1993, 64).

Estimated stature based on measurements of other long bones from individual skeletons (38 male and 30 female) were compared with the estimates based only on left femur measurements in order to see if there were significant differences. The two sets of data compared closely (see Figs 5.21-22). In partic-

Table 5.16: Comparison of estimated statures (cm, rounded) for males and females

Site	*Mean stature Male (no. skeletons)*	*Range male*	*Mean stature Female (no. skeletons)*	*Range female*	*Date*	*Source*
OA Lankhills	169 (38)	157-187	157 (31)	148-172	4th century	
Poundbury	166 (341)	148-185	161 (360)	151-171	Mainly late Roman	Molleson 1993, 167-168
Cirencester	169 (107)	160-182	158 (44)	148-170	4th century	Wells 1982, 139-140
Butt Road (Period 2)	167 (85)	154-190	156 (59)	141-171	Late Roman	Pinter-Bellows 1993, 64, tab. 2.22
Multiple sites	169		159		Roman period	Roberts and Cox 2003, 163

ular the means of the two groups of measurements (eg left femur male mean 168.99 cm, combined male mean 168.01 cm) were very similar. However, the range of stature indicated by the femur lengths alone was greater than that derived from the combined measurements, and the peaks of incidence occurred in different places. The latter characteristic, in particular, could be a consequence of the relatively small sample of measurements.

Craniometry

Skull form is influenced by both genetic and non-genetic factors, the latter including diet, nutrition and climate (Mays 2000, 278). In spite of this, however, there is a strong demonstrable genetic component in cranial variability. The standard range of measurements was taken where possible to calculate indices for adult skulls. Although many

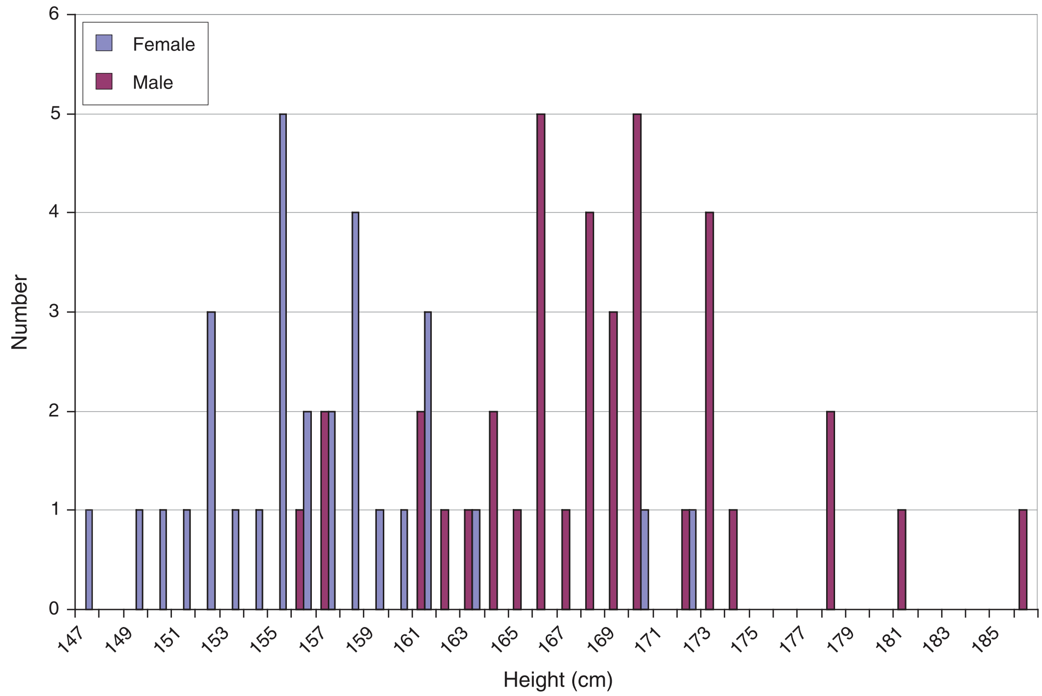

Fig. 5.21 Male and female stature based on left femur measurements only

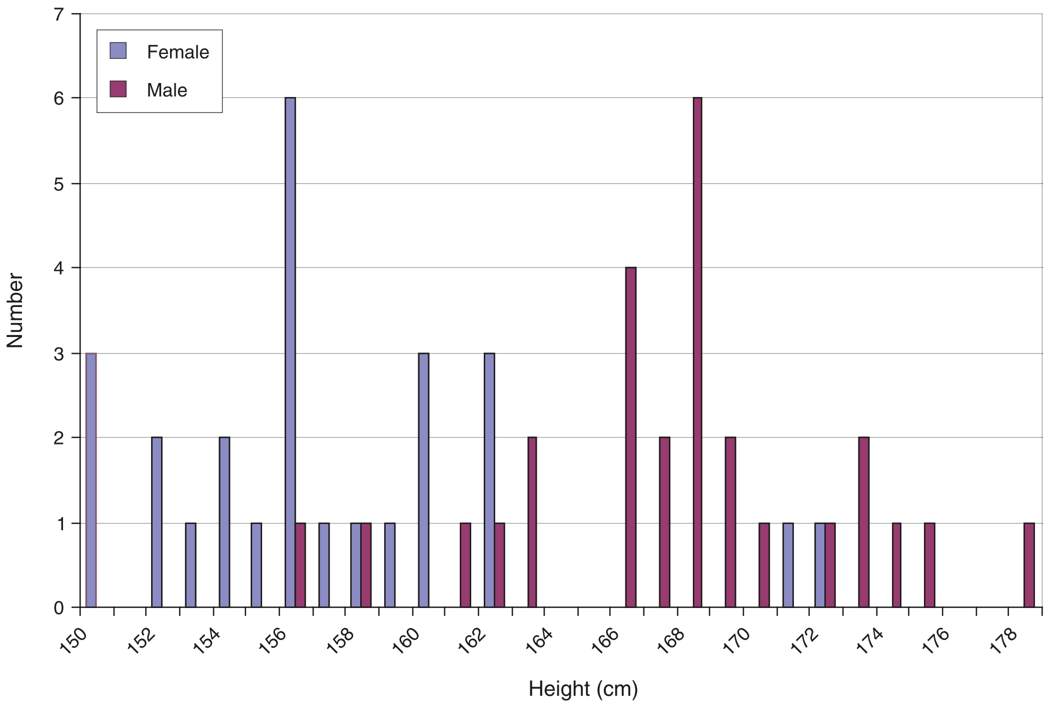

Fig. 5.22 Male and female stature based on multiple long bone measurements

survived they were frequently fragmented and skull reconstruction was beyond the scope of this report. It was possible to calculate indices for 55 skulls (30 males and 25 females).

Where possible the cranial data are compared with those from other contemporary cemeteries. Very few skulls at Cirencester had survived in a good enough condition to be measured without extensive reconstruction (Wells 1982, 137, tables 38-47): it was possible to take measurements on only 66 (45 males and 21 females) out of a total of 293 adult burials.

The cranial index giving the general shape of the skull for 55 adult skeletons at Lankhills is shown in Table 5.17. A range of skull shapes was observed, although most were either mesocranic (medium or average; n=24) or dolicranic (narrow headed; n=21) and fell within the range commonly observed for the Roman period in Britain as represented by a small sample of contemporary late Roman cemeteries (Table 5.18).

It can be seen from Table 5.18 that the ranges are broadly similar across the sites. The apparent divergence within the male range at Lankhills can be attributed to a single outlier with a hyperbrachycranic or very broad headed skull (skeleton 1247, Grave 1325). The people of all these cemeteries had smaller heads than modern British populations (Molleson 1993, 165).

The upper facial index was calculated for 11 males and 7 females (Table 5.19) and showed that the majority had medium (9 individuals) or narrow (7 individuals) faces. The exceptions were a male (skeleton 32, Grave 28) who had a broad face and a female (skeleton 271) who had a very narrow face. Skeleton 32 also had a broad cranial index (brachycranic). Other distinctive combinations of craniofacial indices were observed for skeleton 271 (Grave 272) who had very narrow facial and nasal indices (75 and 41 respectively), but a very broad cranial index (80). The isotope results for this individual suggest a childhood in a warmer climate, although more specific localisation is not possible at present (see Chenery *et al*. below). Indices were also calculated for individuals from Butt Road, Colchester (Pinter-Bellows 1993, 64-7). These suggest a broadly similar distribution of facial types to that of the Lankhills population.

Nasal indices were calculated for 23 males and 17 females at Lankhills using the standards of Broca (Stewart 1942), and are set out in Table 5.20. Most were narrow or average, but three were broad:

Table 5.17: Cranial indices for OA Lankhills

Skull shape	*Cranial index*	*Male*	*Female*	*Total*
Doliocranic (narrow or long headed)	<75	10	11	21
Mesocranic (average or medium)	75-79.9	14	10	24
Brachycranic (broad or round headed)	80-84.9	5	4	9
Hyperbrachycranic (very broad headed)	>84.9	1	0	1
Total		30	25	55

Table 5.18: Comparison of cranial indices

Site	*Male mean (number of skeletons)*	*Male range*	*Female mean (number of skeletons)*	*Female range*
Lankhills	79.48 (30)	70.05-109.44	75.95 (25)	67.67-84.26
Poundbury	76.4 (260)	67.5-84.3	77.1 (279)	68.4-85.3
Cirencester	? (45)	Dolicranic - 19 Mesocranic - 17 Brachycranic – 4	? (21)	Dolicranic - 5 Mesocranic - 10 Brachycranic - 3
Butt Road	75.18 (?)	61.35-89.56	75.94 (?)	54.59-85.63

Key: ?=number or value not known

Table 5.19: Comparison of the upper facial index for OA Lankhills and Butt Road

Upper facial shape	*Upper facial range*	*Lankhills*		*Butt Road*	
		Male	*Female*	*Male*	*Female*
Hypereuryeny (very wide or broad face)	<44.99	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Euryeny (wide or broad face)	45-49.99	1 (9.1%)	0 (0%)	2 (5%)	2 (5.6%)
Meseny (average or medium face)	50-54.99	5 (45.45%)	4 (57.1%)	16 (40%)	11 (30.6%)
Lepteny (slender or narrow face)	55-59.99	5 (45.45%)	2 (28.6%)	19 (47.5%)	17 (47.3%)
Hyperlepteny (very slender or narrow face)	>60	0 (0%)	1 (14.3%)	3 (7.5%)	6 (16.5%)
Total		11	7	40	36

skeletons 134 (Grave 106), 1022 (Grave 1145) and 1894 (Grave 1895, Fig. 5.23). A broad nasal aperture is a feature which can be characteristic of skulls of Negroid populations (Bass 1987, 87) although other Negroid characteristics were absent.

Certainly, in the case of skeleton 1894, the strontium and oxygen isotope analysis points towards an origin in western (eg Wales, the Malverns, Devon or Cornwall) or northern Britain (see Chenery *et al.* below).

The cranial-height index (Table 5.21), used to assess the height of the skull, indicates that most individuals had a medium height skull, although a significant number had low skulls. Out of 34 skulls examined only two individuals had high skulls; skeleton 1289 (Grave 1329, 75.65) and skeleton 55 (Grave 52, 75.8). Comparative figures for the Cirencester Bath Gate assemblage (Wells 1982, 138-9) show similar proportions of individuals in these three groups.

Fig. 5.23 Wide nasal apertures in skeletons 1022 and 1894, the coronal and occipital remain open

Table 5.20: Comparison of nasal indices for OA Lankhills and Butt Road

Nasal index	*Broca Index*	*Lankhills males*	*Lankhills females*	*Butt Road males*	*Butt Road females*
Leptorrhine (narrow)	X-47.9	9 (39.1%)	13 (76.5%)	41 (77.4%)	26 (61.9%)
Mesorrhine (average)	48-52.9	11 (47.8%)	4 (23.5%)	10 (18.9%)	13 (31.0%)
Platyrrhine (broad)	53-X	3 (13.1%)	0 (0%)	2 (3.8%)	3 (7.1%)
Total		23	17	53	42
Mean		48.1	46	44.96	46.04
Range		42.1-54.9	41.4-53	45.99-67.59	34.55-59.34

Table 5.21: Comparison of cranial-height index at OA Lankhills and Cirencester

Skull shape	*Range*	*Lankhills male*	*Lankhills female*	*Cirencester male*	*Cirencester female*
Chamaecranic (low skull)	<70	8	6	13	9
Orthocranic (medium height)	70-74.9	10	7	15	8
Hypsicranic (high skull)	>74.9	1	2	4	0
Total		19	15	32	17
Mean		70.3	72.9		
Range		63.6-75.7	67.2-105.9		

Meric index

It was possible to calculate the meric index for 46 (48.9%) males and 35 (37.2%) females. The meric index is used to measure the degree of anterior-posterior flattening of the femur and bones fall into one of three ranges: platymeric (X-84.9 – broad or flat – from front to back); eurymeric (85.0-99.9) and stenomeric (100.0-X). Bones which fall into the stenomeric range are usually associated with pathology (Bass 1987, 214). Two of the male skeletons within the stenomeric range at Lankhills exhibited pathology in the form of femoral head necrosis (skeleton 434, Grave 535) and rickets (skeleton 451, Grave 590). Female skeleton 1281 (Grave 1350), which also fell within the stenomeric range, exhibited abnormal sacral curvature which could be congenital or metabolic in origin. The remainder exhibited no associated pathology. The measurements are presented separately for males and females (Table 5.22) and are compared with the data from Cirencester and Poundbury (Table 5.23).

Various authors have claimed that platymeria is more common in females than in males and that there is a tendency for it to be more pronounced in the left femur than the right (Brothwell 1981, 89). This is not borne out at Lankhills. At Poundbury the majority of male and female femora were platymeric; a small number were stenomeric (Molleson 1993, 167). This was also the case at Lankhills (see Table 5.22 above). At Cirencester, the majority of individuals were platymeric (132), followed by hyper-platymeric (112) and eurymeric (20).

Cnemic index

It was possible to calculate the cnemic index for 25 (26.6%) males and 27 (28.7%) females. The cnemic index is used to measure the degree of medio-lateral flattening of the tibia and bones fall into one of four ranges: hyperplatycnemic (X-54.9); platycnemic (55.0-62.9); mesocnemic (63.0-69.9) and eurycnemic (70.0-X). The measurements are presented separately here for males and females (Table 5.24).

At Poundbury platycnemia was unusual: 21 (6%) of the females and 34 (11%) of the males had an index of less than 63 (Table 5.26). Half of this group also had squatting facets and these two features can be

Table 5.22: Measurements for male and female left and right femora

	Left femur male (n=39)	*Right femur male (n=46)*	*Left femur female (n=33)*	*Right femur female (n=35)*
Platymeric	68.57143-84.84848 (n=22; 56.4%)	67.5-84.9711 (n=28; 60.9%)	69.11765-82.75862 (n=24; 72.7%)	67.64706-84.93151 (n=27; 77.1%)
Eurymeric	85.71429-97.14286 (n=14; 35.9%)	85.15152-96.875 (n=13; 28.3%)	85.71429-96.66667 (n=8; 24.2%)	85.71429-99.37317 (n=8; 22.9%)
Stenomeric	104.3342-109.375 (n=3; 7.7%)	100-104.8387 (n=5; 10.9%)	127.907 (n=1; 3%)	(n=0)

Table 5.23: Comparison of meric indices with contemporary sites

	Mean			
	Left	*Right*	*Left + Right*	*Range*
Lankhills Male	84.6 (n=39)	84.3 (n=46)	84.5 (n=85)	67.5-109.4
Lankhills Female	82.0 (n=33)	79.8 (n-35)	80.9 (n=68)	67.7-127.9
Cirencester Male	76.6 (n=92)	77.4 (95)	77.0 (n=187)	61.3-92.9
Cirencester Female	74.4 (n=32)	72.6 (n=39)	73.5 (n=77)	62.6-86.7
Poundbury Male			80.7 (n=269)	62.2-100.0
Poundbury Female			78.3 (n=289)	62.5-104.0

Table 5.24: Measurements for male and female left and right tibiae

	Left tibia male (n=21)	*Right tibia male (n=25)*	*Left tibia female (n=21)*	*Right tibia female (n=27)*
Hyperplatycnemic	(n=0)	(n=0)	(n=0)	(n=0)
Platycnemic	62.16216 (n=1; 4.8%)	60.98552 (n=1; 4%)	57.14286-62.85714 (n=4; 19%)	(n=0)
Mesocnemic	67.60563-69.44444 (n=4; 19%)	66.66667-69.44444 (n=4; 16%)	64.61538-68.96552 (n=4; 19%)	64.53523-68.84079 (n=4; 14.8%)
Eurycnemic	72.41379-89.28571 (n=16; 76.2%)	70.58824-80 (n=20; 80%)	70.96774-88 (n=13; 62%)	70-100 (n=23; 85.2%)

Table 5.25: Comparison of cnemic indices with contemporary sites

	Mean Left	Right	Left + Right	Range
Lankhills Male	75.4 (n=21)	84 (n=25)	79.7 (n=46)	61-89.3
Lankhills Female	72.2 (n=20)	64 (n=27)	68.1 9N=47)	57.1-100
Cirencester Male	69.5 (n=86)	69.8 (n=87)	69.7 (n=173)	56.7-89.1
Cirencester Female	67.5 (37)	70.1 (n=35)	68.8 (n=72)	58.9-78.6
Poundbury Male			69.5 (313)	55.0-83.3
Poundbury Female				56.3-87.0

causally linked since retroversion of the knee, as in squatting, may lead to medio-lateral flattening of the tibia (Cameron 1934; Walker 1986). Other possible factors include a response to mechanical stresses on the bone, as a physiological device to economise in the use of minerals for bone formation and as the result of various pathological conditions, though none are wholly satisfactory (Wells 1982, 141). Few individuals at Lankhills were platycnemic, with the majority falling within the eurycnemic range (see Table 5.25). At Cirencester 24 individuals (9.75%) were platycnemic, 90 (36.5%) were mesocnemic and 131 (53.7%), the majority, were eurycnemic.

Handedness

It is well established that muscle mass tends to be greater in the arm on the dominant side in right handed adolescents and adults, and also that the right humerus and right radius tend to be slightly longer and heavier than their counterparts on the left (Steele 2000, 310). During analysis it was observed that the left and right humeri from individuals with both surviving were frequently not the same length.

Table 5.26: Humeral asymmetry

Skeleton No.	Sex	Max. length left humerus	Max. length right humerus	Divergence (mm)
119	F	285	289	4
212	F	342	349	7
489	M	311	318	7
566	M	331	342	11
593	M	311	320	9
702	M	309	322	13
717	M	304	314	10
806	F	295	303	8
908	F	308	323	15
932	M	336	349	13
1103	F	288	297	9
1134	F	295	306	11
1137	M	322	330	8
1281	F	288	294	6
1512	F	273	284	11
1852	M	314	328	14
1882	M	324	333	9

Steele and Mays (1995) concluded that the left humerus undergoes more accelerated growth during later foetal development and therefore that the right hand bias observed must be from mechanical loading in life. In a population left handedness can vary from 2-23% with a male prevalence of 1.27:1 (Steele 2000). The radial length has also been found to be affected and the sum of humeral and radial lengths (arm length) have often been used to determine handedness. The shoulder girdle (humeral head, scapula and clavicle) is also considered to denote side preference (Byers and Myster 2005).

Only 17 pairs of complete humeri (7.7% of adults) were available for study as a consequence of preservation, fragmentation and pathology (see Table 5.26). In all instances the right side was longer than the left (by less than 5 mm in one case, 5-10 mm in 8 cases and more than 10 mm in 8 cases). The mean difference was 9 mm and in one instance the difference was 15 mm (skeleton 908, Grave 960). There was no evidence of variation in muscle attachment sites of these humeri.

It was also possible to examine the left and right radial lengths of six of these individuals (119, 212, 566, 908, 932 and 1882, Graves 99, 210, 610, 960, 965 and 1884 respectively). Four (212, 566, 908 and 932) of the six had a right side bias, ranging from 2 to 8 mm. When the humeral and radial lengths are combined the difference (right side longer) varies from 7 to 19 mm, with a mean of 12.5 mm (Table 5.27). Inglemark (quoted in Steele 2000) found a correlation with side preference for the arm length. The preliminary results of the humeral length analysis therefore suggest that these 17 individuals had a right hand dominance, which is further supported for four of them by the results from measurement of the radial lengths.

Table 5.27: Radial asymmetry

Skeleton No.	Sex	Max. length left radius	Max. length right radius	Divergence (mm)
119	F	207	215	8
566	M	253	255	2
908	F	219	223	4
932	M	257	259	2

Non-metric traits

A range of frequently-recorded cranial and post-cranial non-metric traits was recorded for adult individuals from Lankhills. The traits and their prevalence are presented in Tables 5.28-29. Two cranial traits, the metopic suture and the inca bone, may possibly have run in families (Pinter-Bellows 1993, 65). At Lankhills, the metopic suture was observed in 9.2% of the population (23 out of 250), a similar prevalence to Butt Road (8.6% - 19 individuals) and Cirencester (8.2% - 16 individuals), but rather lower than at Poundbury (43 females - 12.1%, 37 males - 12.1%). None of the skeletons from Lankhills with metopic sutures were buried close to each other.

At Poundbury 14 women (4.3%) and 8 men (2.7%) had an inca bone; at Butt Road this was recorded in 19 individuals (8.6%), and at Cirencester in 16 individuals (8.2%). At Lankhills six out of 239 (2.5%) individuals had an expression of this trait but, as with the incidence of metopic sutures, they are not located in proximity, and occurred across the whole date range of the cemetery. Analysis of strontium and oxygen isotopes from two of these individuals (1227 (Grave 1349) and 1091 (Grave 1135)) suggested that they were local to the Winchester area.

Overall, all non-metric traits had low frequencies in the Lankhills population. For example, while lambdoid wormian bones were the most common of these traits present, their occurrence was much less frequent compared with other sites. At Cirencester 149/239 (62.3%) had lambdoid wormians (Wells 1982, 142, table 51); at Butt Road 69/206 or 33.5% (Pinter-Bellows 1993, 64-5, table 2.25). The frequencies were provided for males and females at Poundbury (Molleson 1993, 168, table 30) and were 150/270 or 55.6% for males and 124/291 or 42.6% for females.

Table 5.28: Cranial non-metrical traits

Trait	*Left n/N*	*%*	*Right n/N*	*%*	*Unsidedn/N*	*%*
Lambdoid wormians	27/239	11.3	39/239	16.3		
Squamo-parietal wormians	0		0			
Occipito-mastoid wormians	1/224	0.5	1/223	0.4		
Coronal wormians	0/247		1/248	0.4		
Anterior condylar canal	2/212	0.9	1/211	0.5		
Bregmatic bone					1/244	0.4
Highest nuchal line					2/245	0.8
Sagittal wormians					2/247	0.8
Metopism					23/251	9.2
Palatine torus					4/231	1.7
Ossicle at lambda					9/242	3.7
Ethmoid foramen anterior	1/212	0.5	0/212	0		
Ethmoid foramen posterior	1/212	0.5	1/212	0.5		
Mastoid foramen	10/238	4.2	10/238	4.2		
Condylar facet	4/219	1.8	3/216	1.4		
Posterior condylar canal	7/210	3.3	6/210	2.9		
Foramen spinosum	4/213	1.9	5/214	2.3		
Posterior condylar facet	1/213	0.5	1/214	0.5		
Supra-orbital foramen	18/243	7.4	15/242	6.2		
Foramen ovale	1/217	0.5	4/217	1.8		
Precondylar tubercle	2/218	0.9	2/218	0.9		
Torus maxillaries	7/234	3	4/233	1.7		
Mandibular torus	3/239	1.3	3/228	1.3		
Auditory torus	3/246	1.2	3/244	1.2		
Foramen huschke	5/229	2.2	3/227	1.3		
Frontal foramen	2/250	0.8	3/250	1.2		
Zygomatic foramen	6/231	2.6	5/231	2.2		
Parietal foramen	19/245	7.8	28/247	11.3		
Fronto-temporal articulation	0/215		1/217	0.5		
Parietal notch	7/217	3.2	3/214	1.4		
Ossicle at asterion	5/217	2.3	3/217	1.4		
Epipteric bone	4/214	1.9	5/214	2.3		
Accessory lesser palatine foramen	6/216	2.8	5/216	2.3		
Acccessory infra orbital foramen	4/235	1.7	3/235	1.3		
Inca bone				6/239	2.5	

Table 5.29: Post-cranial non-metrical traits

Trait	Left n/N	%	Right n/N	%	Unsidedn/N
Double calcaneal facet	47/250	18.8	44/253	17.4	
Vastus notch	14/228	6.1	15/236	6.4	
Exostosis in trochanteric fossa	17/205	8.3	17/209	8.1	
Hypotrochanteric fossa	2/213	0.9	3/217	1.4	
Third trochanter	6/217	2.8	8/217	3.7	
Plaque	7/215	3.3	8/217	3.7	
Poirier's facet	1/214	0.5	1/218	0.5	
Allen's fossa	0/211	0	1/215	0.5	
Sacral accessory facets	0/194	0	1/194	0.5	
Acromial articular facet	6/190	3.2	5/186	2.7	
Supra-scapular notch/foramen	9/176	5.1	6/166	3.6	
Septal aperture	5/203	2.5	2/203	1	
Acetabular crease	2/212	0.9	2/211	1	
Atlas double facet	6/222	2.7	8/205	3.9	
Lateral bridge	1/225	0.4	0/225	0	
Squatting facet medial	4/247	1.6	1/242	0.4	
Squatting facet lateral	14/246	5.7	18/242	7.4	
Supracondylar process	1/215	0.5	2/215	0.9	
Os trigonum	1		Not formally scored		

A child from Poundbury had blocked ears (auditory tori or bone formation in the 'ear holes') and must have been deaf. The child may have been disabled by the condition, and was buried in a prone position (Farwell and Molleson 1993, 187). All the auditory tori seen at Lankhills were extremely small so are unlikely to have impacted upon the hearing of the individuals concerned.

A note on ancestry *by Louise Loe*

Ancestry may be defined as '...the biogeographic population to which a particular individual belongs, by virtue of their genetic heritage' (Barker *et al*. 2008a, 322). Traditional methods for assessing ancestry in human skeletal remains involve the visual assessment of morphological characteristics, primarily in the cranium, to categorise them as either 'whites', 'blacks', 'asians' or of 'mixed' ancestry (Byers 2005). Although this approach oversimplifies the relationship between biological expression and genetic affinity - no distinct skeletal characteristics correspond perfectly to a specific ancestral group - it is a useful method for broadly classifying individuals and characterising a population in terms of its degree of homogeneity.

Recent studies that have combined analyses of skeletal morphology, osteometrics, multivariate statistics and isotopes have highlighted the diversity, rather than the uniformity of Romano-British populations (Leach *et al*. 2009). It was therefore not surprising to observe atypical cranial morphologies among the Lankhills individuals. Routine assessment of ancestry was not undertaken as part of the present work, but during the course of analysis, the skull of one individual (skeleton 566 (Grave 610)) in particular was noted as possessing unusual characteristics compared with the rest of the population (Fig. 5.24).

The individual was an adult male aged 26-35 years. His skull exhibited a low-bridged nose with wide zygomatic bones, a slightly projecting jaw and rounded palate. He also had relatively small brow ridges, a slight concavity in the area behind the bregma on the top of the skull and, in terms of muscle markings, was generally not rugeous.

These features are more consistent with Black and Asian groups than with Caucasians (Byers 2005; Gill and Rhine 1990). They are in marked contrast to the longer, narrower, and high bridged, rugged skulls, also observed in the assemblage and consistent with Caucasoid ancestry.

There were no other individuals whose cranial morphology stood out as markedly as that of skeleton 566, but this may be because a more focused analysis of the assemblage is required. For example, isotope analysis has suggested that skeleton 119 (Grave 99), an adult female, originated from the southern Mediterranean (see Chenery *et al*. below). Interestingly, a preliminary CRANID analysis on measurements taken from this individual's skull has concluded that she may have had Egyptian ancestry (Richard Wright pers. comm.). While her cranial features were, on the whole, consistent with Caucasoid ancestry, she did possess very small, especially gracile features in comparison with the rest of the assemblage (Sharon Clough pers. comm.).

Attribution of ancestry based on skeletal morphology is highly subjective because the range of expression of features means that considerable overlap exists between different ancestral groups.

Fig. 5.24 Skeleton 566. Face and cranium displaying the varied features

Only broad classifications may therefore be achieved. The application of other methods, for example, using metrical data in discriminant function analysis programs, such as CRANID and FORDISC, are required to explore the observations presented here. The observations do, however, serve to highlight the potential of the assemblage to contribute to current thinking on diversity in Romano-Britain through future detailed, systematic assessment of ancestry of the assemblage.

Palaeopathology

Many of the comparative data referred to in this section are derived from Roberts and Cox (2003, 107-63). While those authors acknowledge that in terms of historical records describing much of the Roman Empire there is relatively little that is useful for understanding health and disease at this time (ibid., 107), they attempt to consider evidence from other sources which do potentially provide some insight. The extensive road system, allowing for more communication and contact, would potentially have predisposed people to developing diseases of contact; while southern and eastern Britain were in close contact with Gaul for much of the Roman period, facilitating the appearance of new diseases as a result of exposure of the population to previously unencountered micro-organisms. Furthermore, agricultural intensification may have led to a possible increase in the workload of the population and susceptibility to stress, through infection and/or under-nutrition (ibid., 109). In the present context, the consequences of relatively large populations living in close proximity in an urban setting could also have been considerable, particularly for those members of that population drawn originally from very different, rural settings.

Trauma

The term 'trauma' covers a wide range of injuries and conditions, only a fraction of which will affect the skeleton. Trauma is nonetheless important as the types suffered will relate to lifestyle, occupation and the underlying health of individuals as fractures can also have a pathological cause. Trauma, along with joint disease, may perhaps tell us something about the wear and tear inflicted on the body, although we can never be certain that the changes were caused by a specific occupation or a particular activity. Roberts and Cox (2003, 145) list some of the many activities that people would have undertaken in Roman Britain, some of which could have had consequences for their health which were reflected in the osteological evidence.

Fractures

A fracture is defined as a complete or partial break in the continuity of bone (Roberts 1991, 226). Fractures may result from underlying pathology, repeated stress or acute injury (Roberts and Manchester 2005, 88-91). The majority of fractures that are observed in archaeological human bone are healed. They provide enormous scope for furthering knowledge of the lives of past populations, including their social interactions, activities and socio-economic status. For example, certain types of fracture are indicative of inter-personal violence, others, probably the majority in this context, are the result of accidents (Crawford Adams 1983; Galloway 1999; Walker 1997). Furthermore, the alignment of a fracture and evidence for secondary pathology (among other changes) may indicate quality of diet and treatment (Grauer and Roberts 1996).

The identification of fractures at OA Lankhills was based on macroscopic examination for discontinuity in the normal alignment of bones. Fractures were then classified according to location and recorded with reference to healing status, alignment and evidence for secondary pathology. Fourteen fractures (in skeletons 55, 61, 271, 281, 459, 661, 683, 826, 852, 861, 862, 897, 1127 and 1757) were also examined radiographically.

A total of 39 (13.7%; 39/284 CPR) individuals, all adults, had one or more fractures (Table 5.30). There were more males (25.5%; 24/94) than females (13.8%; 13/94) with fractures, and a further two unsexed adults (6.3%; 2/32). All of the fractures were healed and involved a total of 50 elements. The most frequently fractured element was the rib. Nine individuals (skeletons 212, 522, 623, 683, 939, 1103, 1209, 1361 and 1393, in Graves 210, 570, 695, 790, 995, 1155, 1285, 1437 and 1394 respectively) exhibited 20 separate fractures. Five were adult females and four were adult males. The worst affected was adult male skeleton 683 (Grave 790), who had five left and three right rib fractures. This individual also had a broken nose, two breaks of his right radius and one to his left radius with secondary infection (Fig. 5.25).

Further fractures with associated secondary pathology affected six males and two females, with a total of eight elements. One fractured element had osteoarthritis in an associated joint and three had osteophytes in associated joints. In addition, the left tibia and fibula of skeleton 1327 (Grave 1324) had associated non-specific bone inflammation while skeleton 862 (Grave 930) had osteomyelitis. In 19 individuals (and 19 fracture sites), fractures were mal-aligned; most commonly this affected the nasal bone. Almost half of the fractures were well-aligned.

Fig. 5.25 Skeleton 683. Fractures of the left and right radii, with active infection at the distal end fracture site

Fig. 5.26 Skeleton 1084. Healed depressed cranial fracture, posterior parietal bone

Reduction in long bone length occurred in four instances (skeletons 459, 281, 661, 862 (Graves 475, 263, 665 and 930)), not including two epiphyseal childhood fractures discussed below.

Nasal fractures were the second most common after those affecting the ribs. Seven individuals (skeletons 61, 232, 636, 683, 1274, 1289 and 1852, in Graves 58, 226, 645, 790, 1340, 1329 and 1790 respectively) had broken noses, and in three cases both left and right sides were broken (636, 1274, and 1852). All were males with the exception of female skeleton 61. Nasal fractures can occur as the result of many accidents, but as Wells notes '…this lesion is also one of the most typical results of violent bickering…' (1982, 163) and broken noses are usually the result of interpersonal violence from punches or kicks (Galloway 1999). There were six males with broken noses and one female. With the exception of the three parietal depressed fractures, skeletons 441 (Grave 480, male), 1084 (Grave 1150, female; Fig. 5.26) and 1919 (Grave 1920, female), this is the only possible evidence for violence at Lankhills. There were no weapon injuries or other wounds that could be interpreted as having been caused by direct violence.

Fractures to the tibia were the next most common, affecting six individuals (skeletons 271, 429, 459, 636, 862 and 1327 (Graves 272, 430, 475, 645, 930 and 1324 respectively)).

Six individuals had more than one fracture. Skeleton 61 (Grave 58) had a broken nose (right side) and a fractured right humerus. Skeleton 271 (Grave 272) had a fractured left metacarpal and left tibia. In three cases of multiple fracture it is possible that they were caused by a single event; the left tibia, left fibula and left talus of skeleton 1327 (Grave 1324); left calcaneus and left talus of skeleton 255 (Grave 73); second and third metacarpal of skeleton 1640 (Grave 1638).

Fig. 5.27 Skeleton 861. Ankylosis of the right elbow phalanges

Skeleton 861 (Grave 905), an adult male aged upwards of 60 years, had a completely ankylosed elbow joint at approximately 100-110 degrees with pronation of the lower arm (Fig. 5.27).

The distal radius and ulna were not fused and continued to articulate, but the ulna head and styloid were flattened, porous and with osteophytic lipping. This created an irregular articular surface, the radial surface of which was still smooth and unaffected. Radiography revealed that the area had been impacted, with the ulna head displaced superiorly; no fracture site was visible. This man also had spinal degeneration, osteoarthritis of the right hip and had lost most of the little finger of the right hand, evidenced by apparent amputation of the fifth metacarpal head and inferred loss of the proximal, mesial and distal phalanges (whether deliberate or accidental). It is perhaps noteworthy that this individual had been buried in a prone position without a coffin. Adult male inhumation M from Cirencester (Wells 1982, 161) had a grossly arthritic elbow joint (distal humerus, proximal radius and ulna were all involved with extensive remodelling of articular surfaces). Wells suggested (ibid.) that this may have been a consequence of falling on the elbow and fracturing the distal humerus, which may also have been the case for OA Lankhills skeleton 861.

Fractures which occurred in childhood and involved the epiphyseal plates were possibly the cause of two of the right humeral fractures (skeletons 61 (Grave 58) and 1289 (Grave 1329)). The distal humerus is relatively fragile and fractures occur more frequently in young people, but relatively rarely in adults (Galloway 1999). In skeleton 61 (Grave 58), a 26-35 year old female, the right distal epicondyles of the humerus were malformed (Fig. 5.28). The entire articular surface was at a 45 degree angle and rotated medially 20 degrees with the lateral epicondyle extended. As a

Table 5.30: Fractures observed amongst the adult population (TPR)

	male *left*	*right*	*Total male*	*female* *left*	*right*	*Total female*	*?* *left*	*?* *right*	*Total ?*	*total* *left*	*total* *right*
Parietal	1		1/166	1	1	2/166			0/11	2/171	1/172
			0.6%			1.2%				1.2%	0.5%
Mandible			0/125	1		1/133			0/10	1/136	0/132
						0.8%				0.7%	0.7%
Nasal	4	5	8/95		1	1/62			0/12	4/78	6/77
			8.4%			1.6%				5.1%	7.8%
Clavicle	1		1/53			0/59			0/3	1/54	0/61
			1.8%							1.9%	
Rib	3	2	6/806	3	2	4/633			0/20	6/730	4/729
			0.7%			0.6%				0.8%	0.5%
Humerus		3	3/153		1	1/155			0/13	0/165	4/156
			1.9%			0.6%					2.6%
Radius	1	1	2/147		1	1/124			0/7	1/149	2/129
			1.4%			0.8%				0.7%	1.6%
Ulna		2	2/147		1	1/124			0/7	0/136	3/142
			1.4%			0.8%					2.1%
1st metacarpal			0/90	1		1/66			0	1/71	0/75
						1.5%				1.4%	
proximal phalanx hand		1	1/253			0/240				0/247	1/246
			0.4%								0.4%
sacrum S5			0/18	1		1/18				1/36	
						5.5%				2.7%	
Femur			0/175		1	1/161			0/41	0/189	1/188
						0.6%					0.5%
Tibia	1	3	4/168	1		1/155	1		1/41	3/183	3/183
			2.4%			0.6%			2.4%	1.6%	1.6%
Fibula	1	2	4/131			0/132	1	1	2/21	2/142	3/142
			3.1%						9.5%	1.4%	2.1%
calcaneus & talus	1		1/295			0/304			0/42	1/351	0/350
			0.3%							0.3%	
2nd metatarsal		1	1/129			0/131			0/17	0/140	1/137
			0.8%								0.7%
3rd metatarsal		1	1/129								
			0.8%								

Fig. 5.28 Skeleton 61. Abnormal morphology of the distal end of the right humerus, with left humerus for comparison

result the right humerus was 14 mm longer than the left. The corresponding olecranon fossa was malformed. It is notable that this individual lacked muscle definition in the upper limbs that has been observed on other females in this site. Further skeletal changes in upper limbs may be a result of biomechanical adaptation to the deformity. The shaft of the ulna had an exaggerated curve and the head of the ulna was larger than normal. This individual also had a healed broken nose. Similarly, skeleton 1289 (Grave 1329), a male aged 36-45, had a right humeral shaft which was 62 mm shorter in length compared to the left. The proximal and distal epiphyses were the same size as the left, as were the radius and ulna. There was significantly more muscular activity on the shortened limb in the form of large insertion points and cortical defects.

At Poundbury (Molleson 1993, 200, table 47) the clavicle was the most common fracture site affecting 21 males and 8 females (CPR 15%), followed by ribs at 13% (6 females, 17 males and 1 subadult). True prevalence rates at Poundbury were provided for a sample of 506 skeletons (Molleson 1993, table 55). The overall fracture rate was low at 0.6% (16/2439 bones) for females and 2.2% (63/2916 bones for males) giving a combined TPR of 1.5% (79/5355 bones). In this sample the fibula was most affected (3.5%; 21/603) followed by the clavicle (2.1%; 16/770) and the tibia (1.7%; 14/811).

Compared to Cirencester and Poundbury, fractures were less frequent at Lankhills. Cut marks and injuries were strikingly rare at Poundbury and it was concluded that the people living there during the period of use of the cemetery were at peace and did not indulge in any warfare (Molleson 1993, 203). It was further noted that although those killed in battle might not have been returned home for burial, the injured would have come back, eventually to die and be buried in the cemetery (ibid.).

At Poundbury there was very little evidence for possible domestic violence, although fractures to the forearm, including parry fractures to the ulna, were common. Some of these injuries could have been sustained in warding off blows in a physical attack (ibid.). Twice as many healed fractures were detected on the male skeletons. This was the pattern for all fracture sites except the hand and the femur and for all age groups except the oldest, when the greatest susceptibility to fractures of women over 65 years was apparent.

The most common fractures at Poundbury (Molleson 1993, 204, fig. 118) affected the lower leg and the forearm, a pattern that is seen in recent rural populations (Hamilton 1853). The clavicle and ribs were also frequent sites of fracture, all suggesting that injuries were most often incurred as a consequence of a bad fall. Four females and nine males had multiple fractures; in most cases from the stages of healing and callus remodelling it could be assumed that the injuries had occurred on the same occasion. All the fractures had healed well except one, an impact fracture of the ulna, which had not united and become infected. Most fractures were well aligned and splints must normally have been used to ensure that the limb was straight when it healed, although there were three exceptions where considerable deformity was apparent. At Lankhills and Cirencester some fractures were well healed, while others were not.

Very few fractures were seen at Butt Road (Pinter-Bellows 1993, table 2.28). They comprised two rib, one clavicle, one humerus, six radius, five ulna, five tibia, three fibula and three skull fractures. Skeletons with cranial fractures were all adult females.

The picture at Cirencester was a very different one (Wells 1982, 161). A total of 55 out of 206 males (CPR 26.7%) and 6 out of 91 females (CPR 6.6%) had fractures. Rib fractures were most common: 25 males had a minimum of 77 fractures, 2 or 3 females had 8 or 9 fractures. Adult male skeleton 212 had at least 15 and probably 17 fractured ribs while female 223 had 7 well healed examples. Wells (ibid.) noted that 'Ribs are, of course, often broken accidentally in falls … but direct deliberate violence is also a common cause'.

Soft tissue trauma (myositis ossificans traumatica)

The skeletal evidence for trauma is only a very small proportion of the total range of injury that would have affected the population, such as cuts, abrasions and bruises. For the recognition of soft-tissue injury in skeletal remains, it is necessary for calcification or new bone formation to have occurred within the soft tissue (Roberts and Manchester 1995, 66-67). Tendons and muscle attachments to the bones may occasionally ossify as a result of trauma, for example where a haematoma has been generated in the proximity of the injured periosteum (Aufderheide and Rodriguez-Martin 1998, 26). The resulting mass of woven bone is known as myositis ossificans traumatica. It may occur without obvious skeletal injury and after only minor muscle trauma.

Three individuals, all adult males, displayed evidence for soft tissue trauma. Skeleton 1209 (Grave 1285), a 36-45 year old male, had ossified tissue in the form of an outgrowth at the site of the muscle insertion for the coraco-clavicular ligament, deltoid and trapezius on the inferior surface of the left clavicle. This individual also had several fractured left ribs. A possible ossified haematoma was observed on skeleton 1137 (Grave 1210), a probable male aged 26-35 years. This took the form of raised bone near the soleal crest of the left tibia. In addition, the right tibia had an exostosis measuring 30 x 5 x 4 mm along the interosseous crest on the lateral distal third. These features have been interpreted as soft tissue trauma to the posterior lower legs. Skeleton 1517 (Grave 1515), an adult male aged upwards of 45 years, had an ossified subperiosteal haematoma which had created a pseudo-joint between the distal left tibia and fibula. Periostitis was present on both bones.

Fig. 5.29 Skeleton 1517. Distal tibia and fibula with ossified haematoma

Avulsion Injury

One avulsion injury was observed and involved the left talus bone of skeleton 1488 (Grave 1491), an adult male aged upwards of 45 years. As a result of the injury a small piece of bone (9 x 4 mm) had become separated in life from the concave surface that articulates with the calcaneus. An exostosis in the region of the rectus femoris muscle (a muscle that is located on the anterior aspect of the pelvis) is suggestive of muscle tear in this region.

Amputation

Two individuals showed evidence for amputation of a part of the hand. Whether this was accidental or intentional is uncertain, however, for surgical amputation is very rare in the archaeological record until the 18th century (Waldron 2001, 111). A single male amputee (of a total of 109 individuals – 0.9%) is known from Alington Avenue, Dorchester (Waldron 1989). At Lankhills, skeleton 861 (Grave 905) had lost the right fifth metacarpal head. The remaining shaft of the bone was thinned, with the distal end angled medially. The bone had completely remodelled and bony nodules had formed on the lateral side of the distal end of the shaft. It is unlikely that joint disease was the cause of these changes, as it does not tend to resorb bone in this way. Leprosy is a possible diagnosis, but is extremely unlikely as the rest of the hand is completely unaffected. This individual also had complete ankylosis of the right elbow with pronation of the lower arm, osteoarthritis of the right hip joint and osteophytic growth around the right fourth metacarpal head and proximal phalanx.

Skeleton 134 (Grave 106), a mature adult male, had lost the head/distal end from the fifth proximal phalanx of the left hand. The bone had lost the most distal part straight across (horizontally). The area had remodelled presenting an uneven surface over the stump. The loss is approximately 5 mm when compared with the right side (plus the inferred loss of the mid and distal phalanges). The shaft of the phalanx is thinner when compared with the right, which suggests muscle wastage due to lack of use of the remaining finger.

Evidence for decapitation

The remains of five decapitated individuals were recorded. Two skeletons (1084 (Grave 1150) and 1517 (Grave 1515)) showed unequivocal skeletal

Fig. 5.30 Skeleton 134. Amputation of the left 5th phalanx head, with normal phalanx for comparison

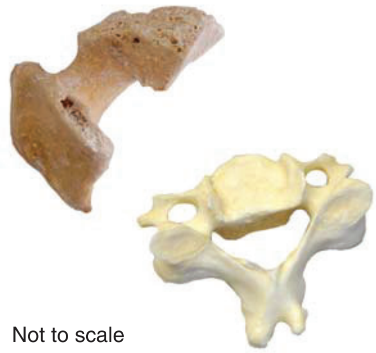

Fig. 5.31 Skeleton 1084. Decapitation cut on cervical vertebrae

evidence for decapitation. A third, 2064 (no grave number), exhibited less convincing skeletal evidence which is discussed in detail below. The cervical vertebrae of skeletons 118 (Grave 110) and 1289 (Grave 1329) did not survive, but the former had the head located over the lower legs (Fig. 2.33) and the head of the latter was placed between the feet (Fig. 2.31).

Adult (26-35 years) female 1084 (Grave 1150) lay in a supine position with the head placed between the knees (Fig. 2.32). The superior portion of the fifth cervical vertebra had been removed by a diagonal cut. The arch was absent, as was the transverse process (Fig. 5.31). The cut could have been made from front or back, though more likely from the front, as the spinous process of the fourth cervical vertebra is unaffected. The bodies of the fourth and sixth cervical vertebrae were damaged anteriorly, but it is uncertain whether this had occurred post-mortem or ante-mortem. This individual had also suffered a blow to the head, evidenced by a healed depressed fracture of the right parietal (Fig. 5.28).

The skull of crouched skeleton 1517 (Grave 1515), an adult male aged upwards of 45 years, had been placed between the legs, near the feet. The possible significance of the association between crouched burial and decapitation is explored in Chapter 7. The fifth cervical vertebral body had been sliced through the inferior surface at 45 degrees (Fig. 5.32); the superior portion was absent from the recovered bones. This occurred peri-mortem, as the compact bone of the body had been bent over and squashed into the spongy bone of the internal part of the body. In addition the third cervical vertebra had a cut mark on the left inferior articular process. The superior portion of this process had been sliced off in an inferior to superior direction, as the surface is bent over, exposing the internal trabecular bone. This indicates that the process of decapitation involved more than one cut through the vertebrae. The spinous processes of the fourth and fifth cervical vertebrae were damaged post-mortem.

Skeleton 2064, a child aged approximately 4-6 years, was identified during post-excavation analysis of disarticulated material associated with adjacent skeletons 1734 (Grave 1735) and 1738 (Grave 1740). The anterior mandible displayed a narrow straight cut mark, measuring 53 mm in the transverse plane, which completely separated the lower margin of the mandible (Fig. 5.33).

The left side of the mandible was most affected, with the cut mark extending from the left side of the mandibular body in line with the first to the second

Fig. 5.32 Skeleton 1517. Decapitation cut on 5th cervical vertebra

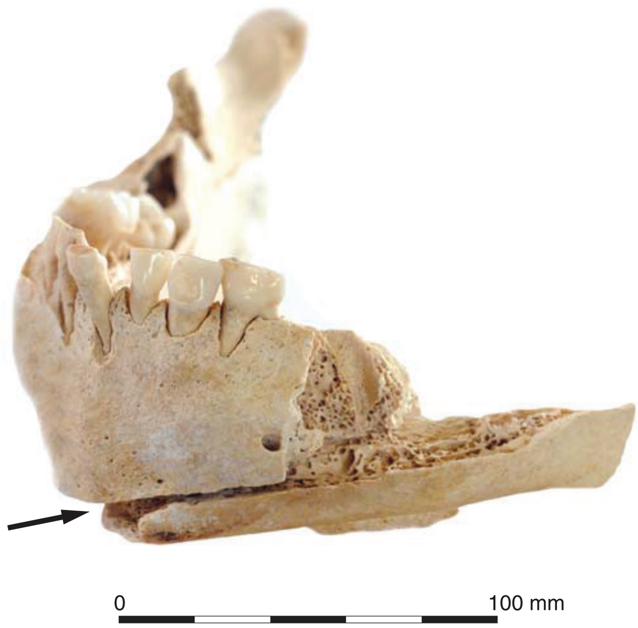

Fig. 5.33 Skeleton 2064. Cut mark to mandible

molar, past the mental eminence to the right side of the mandible, ending abruptly in line with the second deciduous molar. The cut penetrated the full thickness of the anterior mandible, but on the left did not extend all the way to the mandibular angle, stopping 10 mm anterior to it. A small fracture line extends posteriorly from the cut mark. On the right side of the mandible, the most posterior extent of the cut ends abruptly. It suggests that a narrow blade cut into the bone, and was wrenched out breaking the bone in this manner. The injury was peri-mortem as there is inward 'bending' or folding of the margins of the cut. There is a possibility that this injury was inflicted during the process of decapitation, but given that the mandible is not commonly involved this seems unlikely. There is strong evidence to suggest that decapitation was usually carried out after death and with almost surgical precision, most commonly at the level of the third, fourth or fifth cervical vertebra (Harman *et al*. 1981, 166). A probable female adolescent from Baldock in Hertfordshire had six cuts on the anterior aspect of the axis including two on the odontoid process, and this vertebra had eventually been severed through the body (McKinley 1993). The skeleton in grave 379 from Clarke's Lankhills had a horizontal cut to the mandible along the inferior body on the right side, directly below the socket for the canine which had completely removed a portion of bone at the base of the symphysis (Watt 1979, 343). In contrast to skeleton 2064 from OA Lankhills, the skeleton from grave 379 had all surviving cervical vertebrae, the third of which exhibited a cut mark (ibid.)

Occasionally other bones do show evidence of cut marks, for example, the clavicle of inhumation 77 in a Romano-British group from Kempston, Bedfordshire (Boylston *et al*. 2000). Skeleton 1425 at Poundbury exhibited distinct cuts on the proximal surface of the first thoracic vertebra and on the upper surface of the first rib which is the lowest recorded position for any British decapitation (Harman *et al.* 1981). The cuts suggest that the head was removed with one cut taken from front to back (Molleson 1993, 152). The vertebrae of the only other decapitation at Poundbury, skeleton 1425, did not survive. At Cirencester 6 out of 362 individuals (1.7% - 5 males and 1 female) were decapitated (Wells 1982, 194).

Examination of five individuals from Kempston, Bedfordshire (Boylston *et al*. 2000) suggested that cuts on the cervical vertebrae occurred from front to back. The incised nature of the marks suggested careful removal of the head peri-mortem, rather than execution, which was commonly from behind and resulted in a chop mark rather than a cut (ibid.).

Seven individuals from Clarke's excavation were found with their heads by the legs or feet. In addition all exhibited skeletal evidence for decapitation; in four it was located between the third and fourth vertebrae and in one it was on the third vertebra and the mandible (Watt 1979, 343). It was concluded that decapitation took place from the front. These findings are consistent with those for the OA assemblage.

Decapitation was a predominantly rural cemetery phenomenon which was practiced throughout the Romano-British period, although small numbers are also known from urban contexts (Philpott 1991, 77-89). Recent excavations at Little Keep, Dorchester revealed five decapitated individuals among a small group of 29 (17%) inhumations (McKinley 2009, 32). A general distinction can be made between those burials which exhibit skeletal evidence of the practice and those which are identified by the disposition of the head alone. For example, in their recent survey of the skeletal evidence for decapitation Roberts and Cox listed 58 examples (2003, 153, table 3.29) while Philpott (1991, 77) cites more than 70 sites in England. Possible interpretations of the practice of decapitation are discussed in some detail in Chapter 7.

Spondylolysis

Spondylolysis, a failure of the laminae to fuse to the pedicle producing a floating vertebral arch that bears the inferior articular processes, is usually a lumbar trait, particularly affecting the fifth vertebra (Waldron 1992, 177). While the fourth lumbar vertebra can also be affected it is rarely seen elsewhere in the spine. The condition affects 4-8% of modern populations and may be slightly more common in males than females (Aufderheide and Rodriguez-Martin 1998, 63). It may result from a combination of a congenital weakness in the bone and repeated trauma from bending and lifting (Roberts and Cox 2003, 80). There is a considerable body of evidence to show that there is at least a familial tendency to the condition and there is also much to support the traumatic origin. Thus modern opinion supports an intermediate view, that the condition results from a combination of a hereditary dysplasia of the *pars interarticularis* and the stresses imposed upon the lower lumbar spine by the load on it consequent upon assuming an upright posture (Waldron 1993a, 180).

Five skeletons at OA Lankhills had this condition (CPR 5/284; 1.8%; Table 5.31). In three skeletons the changes involved the fifth lumbar vertebra, while in the other two the sixth lumbar vertebra was involved. The majority of skeletons have only five lumbar vertebrae; the occurrence of a sixth is a relatively uncommon skeletal variant. The true prevalence rate for spondylolysis of the fifth lumbar vertebrae is 3.5% (3/85), while for the sixth lumbar vertebrae it is 60% (3/5 vertebrae).

At Poundbury the condition was observed in 16 females and 11 males (Molleson 1993, 187). Six males and one female at Cirencester exhibited the condition, mostly in the fifth lumbar, though in skeleton 320 the fourth and fifth were affected while in skeleton J it was the third and fourth (Wells 1982, 145). The condition was not present at Butt Road. Spondylolysis was seen in 49 individuals (0.9% of

Table 5.31: Skeletons with spondylolysis

Skeleton number	*Site of spondylolysis*	*Sex*
93 (Grave 89)	L5 bilateral	Female
661 (Grave 665)	L6 bilateral	Female
861 (Grave 905)	L6 left transverse process	Male
1223 (Grave 1300)	L5 bilateral	Male?
1232 (Grave 1080)	L5 bilateral	Male

Table 5.32: Prevalence of os acromiale

Skeleton number	*Os acromiale affected side*	*Sex and age*	*Age*
77 (Grave 69)	L & R	Female	18+ y
93 (Grave 89)	L only	Female	26-35 y
593 (Grave 675)	L & R	Male?	18-25 y
661 (Grave 665)	L, R not observable	Female	36-45 y
852 (Grave 935)	R only	Male?	60+ y
1022 (Grave 1145)	R only	Male	45+ y
1156 (Grave 1220)	R only	Male	45+ y
1223 (Grave 1300)	R, L not observable	Male?	36-45 y

the total) within the samples for the whole of the Roman period reported by Roberts and Cox (2003, 151, table 3.26).

Os acromiale

Os acromiale is a condition of the scapula where the acromion does not fuse at the normal time (18-20 years) and remains separate (Scheuer and Black 2000). Eight skeletons (3.6%; 8/220; Table 5.32) from Lankhills had os acromiale: three females (3.1%; 3/94) and five males or probable males (5.3%; 5/94).

In two skeletons the condition was bilateral (skeletons 77 (Grave 69) and 661 (Grave 665)) so the possibility of a repetitive activity involving both shoulders is raised. Os acromiale is reported in 10 individuals out of 308 (3.3%) during the Roman period (Roberts and Cox 2003, 152, table 3.29) though none are from the late urban cemeteries used for comparison here. There has been a suggestion that it can occur when people perform a particular action involving the shoulder and arm respectively from an early age, which prevents fusion. For example, many cases were observed among males thought to have been archers from an early age, who drowned aboard the Tudor warship *Mary Rose*. Archery is just the sort of activity that may lead to the condition as it involves a particular action of the arm and shoulder in a repetitive manner. In modern populations the prevalence of os acromiale ranges from approximately 2-6% (ibid.).

Congenital and developmental anomalies

Congenital diseases are conditions that originated during prenatal growth and development. They can be caused by genetic defects or by factors which affect the foetus during its development, such as malnutrition. It has been estimated that around 40% of congenital conditions affect the skeleton (Aufderheide and Rodriguez-Martin 1998, 51). The full range of diseases that could be placed under this heading is very large, ranging from very slight skeletal changes that are not detrimental and may not be noticed by the affected individual, to serious defects that are incompatible with life (Brickley *et al.* 2006, 103). At the less serious end of the spectrum it is difficult to draw a clear distinction between conditions that might be classified as non-metric traits and those that might be considered congenital diseases or conditions. All congenital and developmental conditions recorded that were not on the list of non-metric traits selected for systematic recording are considered here.

Abnormalities involving the axial skeleton

The lumbo-sacral border, at the bottom of the spinal column, is the most frequent and variable site for abnormalities. There were three examples of sacralisation of the fifth lumbar vertebra. This is when the lumbo-sacral border shifts in a caudal (downwards) direction, which means that the fifth lumbar vertebra becomes assimilated with the sacrum by either complete or incomplete fusion. The condition was identified in skeletons 559 (Grave 560) 917 (Grave 1035) and 1219 (Grave 1295); in all cases the assimilation was partial. Shifting of the lumbo-sacral border in the form of lumbarisation was observed on a further five skeletons (12 (Grave 10), 212 (Grave 210), 522 (Grave 570), 566 (Grave 610) and 1156 (Grave 1220)). This occurs when the border shifts cranially and the first sacral segment becomes detached or partly detached to become more like a lumbar vertebra. In all cases the lumbarisation was partial. Minor segmental shifts in the spinal column are relatively common and would have had little impact on the affected individual (Brickley *et al.* 2006, 103).

Both conditions increase in frequency in the Roman period compared to the preceding Iron Age. Roberts and Cox recorded 15 cases of lumbarisation out of 1785 (0.3%) and 72 cases of sacralisation out of 2939 (1.2%). In these cases 13 (0.2%) and 55 (1.0%) respectively of the total sexed adults were affected. This increase 'is probably, however, purely the result of more burials producing the evidence and not an increase in factors that may lead to congenital disease' (Roberts and Cox 2003, 115, tables 3.5-6).

Bifid (or cleft) neural arches were also observed in the OA assemblage, in the second cervical vertebra of skeleton 451 (Grave 590). Shifting of the lumbosacral border and bifid neural arches are common variations and would have had no consequence for the health of individuals involved (Barnes 1994, 119; Scheuer and Black 2000, 200).

Another axial abnormality was developmental delay of the left spinous process of the second cervical vertebra in skeleton 1532 (Grave 1528).

Although the left and right sides of the process had fused at the base, the left process was significantly shorter. Bifid neural arches represent a minor delay in the development of the neural arch and occur when the two halves come together but fail to coalesce (Barnes 1994, 119). These low levels of spinal abnormalities suggest a population with low genetic susceptibility to such abnormalities and with access to a diet sufficient in folic acid and zinc, deficiencies in which can be related to these abnormalities (ibid.).

Spina bifida occulta

Spina bifida occulta is not to be confused with spina bifida where the spinal cord is exposed and death follows rapidly after birth. Spina bifida occulta is commonly a defect of one or more pieces of the sacrum but may occur at other points of the spine, and, although the spinal cord is exposed, in life it would have been bridged by cartilage or membrane. The condition is of no significance to the affected individual who would have functioned normally (Roberts and Manchester 1995, 36). Two posterior neural arches of the sacral segments (S1 and 2) of skeleton 1481 (Grave 1479) were bifid, or incompletely fused (spina bifida occulta), constituting a single case out of 86 sacra that were observed (1.2%; Table 5.33). The modern incidence is between 5% and 25%. At Butt Road there were seven cases of spina bifida occulta (2.2%); most involved S1 only (5 individuals), but involvement of S1 and S2 (one individual) and S1-S5 (one individual) was also noted (Pinter-Bellows 1993, 66). At Poundbury there were 18 examples (six juvenile, five female, seven male) where all the sacral vertebrae or the first and last three were cleft (Molleson 1993, 187). There were five examples (four males and one female) at Cirencester (Wells 1982, 144). Roberts and Cox reported 58 cases or 1% (47 or 0.8% of the total number of sexed adults) for the whole of Roman Britain (2003, 115, table 3.7). They suggest that, along with trends in sacralisation and lumbarisation, the apparent increase in the incidence of spina bifida occulta in the Roman period results from the availability of a larger sample, in which these conditions are more readily detected, rather than that there was an increase in factors that may have led to congenital disease (ibid.).

Table 5.33: Incidence of spina bifida occulta in the late Roman period

Site name	*Total no.*	*Affected*	*M*	*F*	*?*	*J*	*CPR%*
Lankhills	284	1	1	0	0	0	0.4%
Cirencester	362	5	4	1	0	0	0.3%
Butt Road	575	7	4	3	0	0	1.2%
Poundbury	1131	18	7	5	0	6	1.6%
Total	2352	31	16	9	0	6	1.3%

Other abnormalities

The hooks of the left and right hamate bones of skeletons 661 (Grave 665) and 1156 (Grave 1220) were absent (hypoplastic hamulus). This is a rare congenital variant (Anderson 2000).

The left and right navicular bones of skeleton 566 (Grave 610) in the region of the tuberosity had an epiphysis which is the attachment site of the tibialis posterior tendon. This had remained as a separate ossicle (os tibiale externum), a feature found in 5-10% of the modern population (Scheuer and Black 2000, 462). The persistence of the separate bone usually leads to inflammation of the overlying skin due to pressure from shoes. The articulating surface of the distal head of the right first metatarsal had a small patch of new bone growth measuring 6 x 2 mm on the medial ridge of the inferior (plantar) articular surface. This may represent bony response to soft tissue damage, perhaps involving a sesamoid bone.

The left and right navicular of skeleton 1219 (Grave 1295) had an extra facet for the calcaneus, which lacked the anterior facet, thereby creating articulations along lines that are not normally present. In addition, the left distal tibia of this skeleton had a large exostosis where the fibula articulated.

The left calcaneus of skeleton 616 (Grave 690) on the anterior superior articular surface for the cuboid had a crescent-shaped defect in the most anterior border. The surface of the defect looked like a possible pseudo-articulation, as it was porous with smooth edges to the holes. This is most likely a developmental anomaly.

Scaphocephaly

Skeleton 1026 (Grave 1070) was of a young child aged approximately 4-7 years who had suffered from scaphocephaly, which is characterised by premature fusion of the sagittal suture. In this case the sagittal suture was completely obliterated, the lambdoid suture was partially open and the coronal suture was completely closed (Fig. 5.34). The condition creates an abnormally long and narrow skull with a cephalic index below 70 combined with widening and elevation of the frontal, prominent bosses, also exhibited by this skeleton. This is the most common form of premature fusion affecting the skull, with a male predilection (Aufderheide and Rodriguez-Martin 1998, 52). The head would have appeared misshapen, perhaps with a sagittal ridge running from front to back and the face may have appeared slightly lopsided. It is noteworthy that this child, presumably a girl as she was buried with two bracelets and a ring, had been placed in a prone position in the grave.

Four cases of scaphocephaly were observed at Poundbury: two were adult females, one an adult male and one a subadult (Molleson 1993, 187).

Fig. 5.34 Skeleton 1026. Scaphocephaly, note the absence of the sagittal suture whilst the coronal and occipital remain open

Familial cases of the condition do occur but the role of genetic factors is not clear (Aufderheide and Rodriguez-Martin 1998, 52).

Circulatory disorders

Perthes' disease

This is a condition of the femur, usually affecting one side, seen predominantly in male children aged 3 to 10 years of age. It is caused by blockage of the blood supply to the femur head which leads to death of the bone structure (Aufderheide and Rodriguez-Martin 1998, 84). The femur head develops a characteristic mushroom shape with a corresponding shallow acetabulum and a shortened and widened femoral neck. It may produce pain and later joint disease as a complication. Changes that involved the right hip joint of skeleton 109 (Grave 35), a probable male aged upwards of 45 years, were consistent with Perthes' disease (Fig. 5.35). There was also a large amount of degeneration of the joint in the form of osteoarthritis, which is secondary to the necrosis of the epiphyses.

Femoral head necrosis

This condition occurs when the blood supply to the femoral head is limited or cut off, often a consequence of fracture or dislocation. The result is necrosis or bone death and with continued pressure the head morphology becomes flattened into a mushroom shape. Skeleton 434 (Grave 535), a probable male aged upwards of 45 years, had possible necrosis of the left hip with secondary osteoarthritis (Fig. 5.36). The bones were examined radiologically to determine the depth and extent of the lesions. The results were consistent with the macroscopic examination, showing extensive destruction of the femoral head and acetabulum. The eburnation and osteophytes are indicative of long standing osteoarthritis secondary to the infec-

Fig. 5.35 Skeleton 109. Perthes' disease of the right femoral head

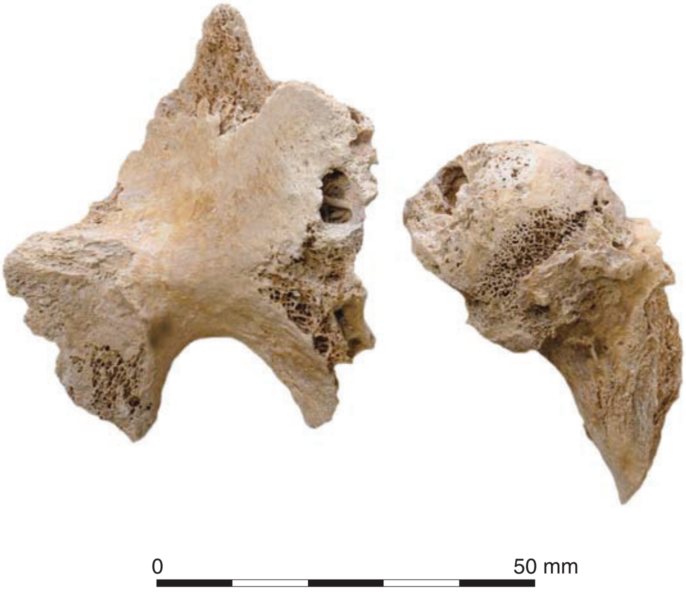

Fig. 5.36 Skeleton 434. Necrosis of the left femoral head

tion. Possible alternative diagnoses are septic arthritis or tuberculosis.

Scheuermann's disease

Scheuermann's disease (juvenile kyphosis) is a deformity which develops in adolescents and particularly favours males (Scheuermann 1921). The apex of the curvature usually falls in the area of the eight to tenth thoracic vertebrae. The underlying cause is probably extrusion of disc (nucleus pulposus) material, mostly into the adjacent vertebral bodies (Schmorl's nodes), followed by anterior narrowing of the disc space and subsequent growth disturbance in this area of the end-plate, resulting in some degree of wedging. The location of the wedge vertebrae usually coincides with the apex of the curvature. Since, of course the curvature cannot be appreciated on the skeleton, the presence of one or several adjacent wedge vertebrae and of round or oblong defects near the centre of the vertebral end-plate, corresponding to the location of the disc herniation, would be the main findings (Ortner and Putschar 1981, 323).

This condition is characterised by osteochondritic erosion of the anterior-superior aspects of the vertebral bodies, which results in loss of height often leading to curvature of the spine (Aufderheide and Rodriguez-Martin 1998, 87). The onset usually occurs between 12 and 18 years. Skeleton 616 (Grave 690), a male aged 26-35, had a depression 23 x 10 mm on the superior anterior body of the fourth lumbar vertebra. The depression was 5 mm deep and had an irregular surface. The annular ring was not affected. This feature may indicate Scheuermann's disease, though it is unusually low down in the lumbar vertebrae. In skeleton 614 (Grave 640), estimated to be about 13 years old, there was a marked indentation on the anterior aspect of the superior surface of the first lumbar vertebra. The annular rings had not yet formed. This may indicate Scheurmann's disease as the individual was in the appropriate age range for onset and the feature is located in the right area. Few vertebrae survived and the diagnosis is a tentative one. Neither skeleton showed signs of wedging of vertebrae. A single example is mentioned by Roberts and Cox (2003, 151) but no details are given.

Fig. 5.37 Vertebral defects, perhaps Scheurmann's disease, in skeletons 614 and 616

Osteochondritis dissecans

Osteochondritis dissecans is classified along with other, so-called osteochondroses, such as Scheuermann's disease of the spine, Osgood-Schlatter's disease of the knee and Perthes' disease of the hip. They all involve fragmentation and collapse of the joints and all affect young individuals, especially males in the first year of their life (Roberts and Manchester 1995, 87). Osteochondritis dissecans has both a traumatic and circulatory disturbance aetiology. It is seen in increasing frequency during the Roman period in knee joints (11 individuals out of 2721 or 0.4% of the total) and may be related to trauma during work (Roberts and Cox 2003, 151, table 3.27).

In this condition necrosis occurs in a small focal area of diarthrodial joints and results in partial or complete detachment of a segment of the subchondral bone and articular cartilage. The condition is common in adolescents and young adults and the knee is the most commonly affected area. Osteochondritis dissecans was present on the anterior surface of the left and right lateral condyles of the femora of skeleton 1232 (Grave 1080), an adult male aged upwards of 45 years. The lesions were oval in shape, 20 x 12 mm, and in both femora occurred on the lateral side. There were two definite cases (out of 575 – CPR 0.3%) at Colchester (Pinter-Bellows 1993, 91, fig. 2.44b) and one adult male (out of 1131 – CPR 0.1%) at Poundbury (Molleson 1993, 188). The only symptom of the condition would have been slight discomfort.

Small ovoid depressed lesions which look similar to osteochondritis dissecans are commonly found on the first proximal phalanx articular surface for the first metatarsal. These were identified on three individuals (skeletons 741 (Grave 770), 917 (Grave 1035) and 1557 (Grave 1555)). A further lesion occurred on the second metatarsal proximal articular surface of skeleton 1094 (Grave 1140). Other lesions which looked like osteochondritis dissecans were found on the left talus of skeleton 776 (Grave 805) and the left distal tibia articulating surface of skeleton 1902 (Grave 1900).

Joint disease

Diseases affecting the joints and their surrounding structures are often the most frequently recorded conditions in both archaeological bone and the modern population (Rogers 2000, 163). A wide range of different conditions was recorded and these are considered below.

In all 822 individuals had evidence of joint disease for the Roman period (14.4% of the total and an increase from the 5.3% rate of the Iron Age) in the sample analysed by Roberts and Cox (2003, 145). Spinal osteoarthritis was seen in 405 individuals (7.1% or in 311 sexed adults of 3620 – 8.6%) which is a decrease on the Iron Age rate of 23.2%. However, 479 individuals had extra-spinal joint disease, or 8.4% of the total (or 459 of 3620 sexed adults – 12.8%), which is an increase from 4.6% in the Iron Age. In all 256 upper joints and 279 lower joints were also affected (Roberts and Cox 2003, tables 3.22-23), with 17 and 16 individuals suffering respectively from rib and tempero-mandibular joint disease (Roberts and Cox 2003, tables 3.24-25).

Degenerative joint disease

This refers to bone formation (osteophytosis) and resorption (porosity and subchondral cysts) on and around joint surfaces. It also encompasses new bone formation around the margins of the vertebral bodies. These changes are a normal accompaniment to age; in addition they may occur in response to pathology, for example, osteoarthritis and ankylosing spondylitis or trauma.

Osteophytosis or porosity was observed around at least one joint margin in 21 individuals (summarised in Table 5.34). Some of these individuals also had osteoarthritis on other joints (see below). The degenerative joint disease mainly affected the upper body, particularly the shoulder joint (involving the humeral head, clavicle and scapula). There were two instances of degeneration at the temporo-mandibular joint (TMJ); this joint involvement is usually secondary to extreme lateral extension of the mandible in an effort to approximate several teeth during mastication where there has been extensive tooth loss (Aufderheide and Rodriguez-Martin 1998).

A total of 48 (45.3%; 48/106) individuals had vertebral osteophytosis. Table 5.35 below details the distribution along the spine and by sex, which shows that it was much more prevalent in males than females in all vertebrae but markedly so in the thoracic vertebrae. It seems likely that adult males were regularly involved in an activity/activities which predisposed them to the development of osteophytosis.

Intervertebral disc disease (degenerative disc disease)

This condition is characterised by coarse pitting on the superior and inferior surfaces of the vertebral bodies (Rogers and Waldron 1995), changes which are presumed to reflect degeneration of the intervertebral disc reflecting age-related wear and tear. This pitting is commonly associated with marginal osteophytes and is mostly found in the mid and lower cervical, upper thoracic and lower lumbar vertebral regions. This was observed on 31 individuals; 16 males, 14 females and 1 unsexed adult. The cervical vertebrae were the most affected (61/411; 14.8%), in particular the fifth and sixth. Smaller quantities of thoracic (39/319; 12.2%) and lumbar vertebrae (32/497; 6.4%) were affected, involving the mid thoracic region and all of the lumbar. The superior surface of the first sacral body was also affected (7/69; 10.1%). Broadly equal numbers of men and women were affected (see Table 5.36) although a preponderance of male cervical vertebrae were involved. Severity of the condition is detailed in Table 5.37.

Table 5.34: Skeletons affected by degenerative joint disease

Skeleton number	*Sex*	*Age*	*Area affected by Osteophytosis (OP) or Porosity (PO)*
25 (Grave 22)	M	36-45 y	Left sterno-clavicular joint (OP)
95 (Grave 97)	M	45+ y	Left and right glenoid fossa (OP) and right sesamoid (OP)
212 (Grave 210)	M	60+ y	Right humerus rotator cuff (OP). Left TMJ (PO).
232 (Grave 226)	M	36-45 y	Calcaneal/talar joint (OP)
244 (Grave 243)	M	45+ y	Left and right TMJ (PO)
271 (Grave 272)	F	26-35 y	Carpal metacarpal joint (trapezius and metacarpal 1) (OP).
284 (Grave 242)	F	60+ y	Left wrist joint (distal radius and ulna) (OP)
489 (Grave 550)	M	45+ y	Wrist joint (left metatarsal 1 and 2) (OP)
661 (Grave 665)	F	36-45 y	Right glenoid fossa (OP). Right hip (acetabulum (PO) and femoral head (OP))
683 (Grave 790)	M	36-45 y	Left knee (OP).
812 (Grave 855)	M?	45+ y	Right hip joint (acetabulum) (OP)
852 (Grave 935)	M?	60+ y	Right elbow joint (ulna trochlear notch) (OP)
1084 (Grave 1150)	F	26-35 y	Right knee (distal femur) (OP)
1119 (Grave 1175)	M	45+ y	Left and right rotator cuff (OP)
1137 (Grave 1210)	M?	26-35 y	Glenoid cavity L & R (OP). Right hip (femoral head and acetabulum) (OP). L and R knee (patellae) (OP). R ribs x4 facets (OP), L rib x1 (OP)
1173 (Grave 1240)	F	60+ y	Right shoulder (humeral head) OP)
1247 (Grave 1325)	M	36-45 y	Left shoulder (OP)
1621 (Grave 1619)	F	26-35 y	Left and right medial clavicles (PO). Left and right TMJ (mandibular condyles PO). Rib (OP)
1697 (Grave 1805)	M	26-35 y	Left and right shoulder (glenoid cavity) (OP). Rib (OP)
1802 (Grave 1810)	M	36-45 y	L & R shoulder (scapula glenoid fossa and humeral head) (OP)
1852 (Grave 1790)	M	60+ y	Right humeral head (OP)

PO=porosity OP=osteophytes TMJ= tempero-mandibular joint, L=left, R=right

Table 5.35: True prevalence rate of spinal osteophytosis for males and females

	No. with osteophytosis Cervical vertebrae n/N	*Thoracic vertebrae*	*Lumbar vertebrae*	*Sacral S1*	*Total*
Male	68/207 (32.9%)	122/174 (70.1%)	82/329 (24.9%)	8/34 (23.5%)	280/744 (37.6%)
Female	26/191 (13.6%)	58/134 (43.3%)	40/258 (15.5%)	4/34 (11.8%)	128/617 (20.7%)
Total	94/398 (23.6%)	180/308 (58.4%)	122/587 (20.8%)	12/68 (17.6%)	408/1361 (30%)

Table 5.36: True prevalence rate of intervertebral disc disease

	No. with intervertebral disc disease Cervical vertebrae n/N	*Thoracic vertebrae*	*Lumbar vertebrae*	*Sacral S1*	*Total*
Male	36/207 (17.4%)	23/174 (13.2%)	14/239 (5.9%)	3/34 (8.8%)	76/710 (10.3%)
Female	23/191 (12%)	16/134 (11.9%)	18/258 (7%)	4/34 (11.8%)	61/583 (9.8%)
Unsexed	2/13 (15.4%)	0/11	0/0	0/1	2/25 (8%)
Total	61/411 (14.8%)	39/319 (12.2%)	32/497 (6.4%)	7/69 (10.1%)	139/1318 (10.5%)

Table 5.37: Severity of intervertebral disease

	Cervical			Thoracic			Lumbar			Sacral S1			
Grade	1	2	3	1	2	3	1	2	3	1	2	3	Total
Male	12	10	14	8	11	4	8	4	2	0	1	2	76
Female	5	11	7	8	4	4	9	6	3	0	2	2	61
Unsexed	1	1	0	0	0	0	0	0	0	0	0	0	2
Total	18	22	21	16	15	8	17	10	5	0	3	4	139

Schmorl's nodes

Schmorl's nodes are depressions observed in the end plates of vertebrae. The exact cause of the lesions is unclear and there is some debate as to whether they are caused by a herniation of material from the intervertebral disc (Rogers and Waldron 1995, 27) or whether the herniation of material is secondary to necrosis beneath the end-plate (Peng *et al.* 2003, 879). However, whatever the exact pattern of events in disruption of the vertebral end-plates and herniation of disc material, such nodes have been linked to physical activities, such as contact sports (Resnick and Niwayama 1988, 1530) and to acute trauma (Fahey *et al.* 1998). The lower thoracic and upper lumbar vertebrae are most commonly affected in archaeological bone (Rogers and Waldron 1995, 27) and this pattern is reflected at Lankhills (Table 5.38).

Schmorl's nodes were observed on the vertebrae of 37 adults (TPR 35%; 37/106); 23 males (TPR 62.2%; 23/37), 12 females (TPR 32.4%; 12/37) and two unsexed adults (TPR 66%; 2/3). They were most common on the thoracic vertebrae. No less than 78.7% of male thoracic vertebrae were affected in comparison with 38.1% of those in females. Similarly 29.5% of male lumbar vertebrae were affected, compared to 8.9% of female lumbar vertebrae.

Schmorl's nodes are very common in both modern and archaeological populations. Clinically, they usually present no symptoms, affect males more than females and typically appear in adolescence when bone is relatively supple (Hilton *et al.* 1976; Kelley 1982). Their cause may be multi-factorial, but in the palaeopathological literature greater emphasis is placed on their association with repetitive trauma to the spine, usually occurring over a long period of time (Waldron 2007, 94).

The incidence of Schmorl's nodes recorded in Roberts and Cox's survey increases from 1% in the Iron Age to 4.8% (272 individuals, or 179 of 3620 sexed individuals – 4.6%) in the Roman period. A total of 495 out of 2793 vertebrae (17.7%) from four sites of this period were affected with Schmorl's nodes (Roberts and Cox 2003, table 3.21). If the association with repetitive trauma is correct these figures, and those from Lankhills, suggest an increase in the intensity of physical labour for some individuals, with a consequent increase in the predisposition of joints to degeneration.

Vertebral ankylosis

Vertebral ankylosis is the fusion of at least two vertebrae at the centrum, or at the transverse/superior/inferior processes. This can be caused by significant osteophytic growth in a superior and inferior direction, because of a congenital predisposition or as a result of trauma. The examples listed here in Table 5.39 are considered to be caused by osteophytic growth and not as a result of ankylosing spondylitis or other conditions.

Osteoarthritis

Osteoarthritis is almost certainly the most commonly observed of all the joint diseases recorded in the archaeological record. It is primarily a disease of the cartilage which affects the synovial joints. When the cartilage has disintegrated the underlying bone at the joint surface can come into contact and joint movement will eventually result in polishing of the bone surface (eburnation).

Table 5.38: True prevalence of Schmorl's nodes for males and females

	Number with Schmorl's nodes Cervical vertebrae		Thoracic vertebrae		Lumbar vertebrae	
Male number of vertebrae	1/207 (0.5%)	Superior 0 Inferior 1	137/174 (78.7%)	Superior 62 Inferior 75	97/329 (29.5%)	Superior 57 Inferior 40
Female number of vertebrae	0/191 (0%)	Superior 0 Inferior 1	51/134 (38.1%)	Superior 12 Inferior 39	23/258 (8.9%)	Superior 11 Inferior 12
Total	1/398 (0.25%)		188/308 (61%)		120/587 (20.5%)	

Table 5.39: Details of ankylosed vertebrae

Skeleton number	*Ankylosed vertebrae*
281 (Grave 263)	T6-7, T8-9
434 (Grave 535)	T11/12 across the entire centrum
812 (Grave 855)	T12/L1, L1/2 across entire centrum
861 (Grave 905)	C2/3- across right centrum and right inferior/superior processes, C6/7 - centrum only
1137 (Grave 1210)	T10/11 – right centrum
1271 (Grave 1310)	C2/3 transverse processes
1640 (Grave 1638)	L5/S1 centrum left side
1697 (Grave 1805)	T11/12 centrum left side
1882 (Grave 1884)	C2/3 - transverse processes only, C3/4 - centrum and transverse processes

C= cervical vertebrae, T=thoracic vertebrae, L=lumbar vertebrae

Osteoarthritis is very strongly age-related, but there are other contributory factors which include activity patterns and trauma as well as a genetic predisposition to the condition. It is frequently observed in the spine. The changes associated with osteoarthritis include eburnation, pitting of the joint surface and bone growth which occurs around joint margins. At least two of the changes (porosity, bony contour change and/or osteophytes) need to be present in order to diagnose osteoarthritis unless eburnation, which is pathognomic of the disease, is present. The criteria used in the diagnosis of osteoarthritis for this assemblage are those defined by Rogers and Waldron (1995, 43-44).

In modern populations there is a tendency for women rather than men to display a higher prevalence of osteoarthritis (Waldron 1993b, 67). Sites with individuals in the much older age category might be expected to have a higher prevalence of osteoarthritis. Modern investigations of the prevalence of osteoarthritis reported by Waldron (ibid., 68) have produced results that are significantly

Table 5.40: Summary of skeletons with extraspinal osteoarthritis

Skeleton number	*Sex*	*Age*	*Joint affected*	*Changes*
212 (Grave 210)	?Female	60+	Left IPJ	OP, PO
232 (Grave 226)	Male	36-45	Sterno-clavicular joint	OP, PO
271 (Grave 272)	Female	26-35	Talar-calcaneal joint	OP, PO
284 (Grave 242)	Female	60+	Left IC joint	EB
451 (Grave 590)	Male	45+	Left shoulder	EB, PO, OP
489 (Grave 550)	?Male	45+	Left IC	EB, PO, OP
522 (Grave 570)	Male	60+	Left and right elbow	EB, PO
623 (Grave 695)	?Female	45+	Right elbow joint	EB, PO
661 (Grave 665)	Female	36-45	Left and right knee	EB, PO
683 (Grave 790)	Male	36-45	Left hip	OP, PO
852 (Grave 935)	?Male	60+	Right elbow	EB, OP
861 (Grave 905)	Male	60+	Right Hip. Right elbow	EB, PO; OP
1119 (Grave 1175)	Male	45+	Right hip. Left hip	PO; EB, OP
1137 (Grave 1210)	?Male	26-35	Rib-vertebral joint	OP, PO
1209 (Grave 1285)	Male	36-45	Right distal IP	EB, OP
1232 (Grave 1080)	Male	45+	Left and right knee	EB, OP
1247 (Grave 1235)	Male	36-45	Left shoulder	OP, PO
1258 (Grave 1335)	Male	60+	Right 1st CMC	EB, PO, OP
1274 (Grave 1340)	Male	45+	Left and right 1st CMC	EB, PO; OP
1304 (Grave 1302)	Female	60+	Left shoulder	EB, OP
			Right elbow	EB, OP
1598 (Grave 1599)	Female	45+	Right hip. Right MCP	EB, PO; OP
1621 (Grave 1622)	Female	26-35	Right 1st MTP joint	EB, OP
			Right 1st CMC Joint	OP, PO
1882 (Grave 1884)	Male	45+	Right TMJ	OP, PO, & new facet
1934 (Grave 1930)	?	Adult	Left hand IP	OP, EB

PO=porosity, OP=osteophytes, EB=eburnation, IPJ=interphalangeal joint, IC=intercarpal joint, CMC=carpal-metacarpal joint, MCP=metacarpal-phalangeal joint, TMJ=tempero-mandibular joint higher than those obtained from previous analyses of archaeological bone.

Extraspinal osteoarthritis

Twenty-four skeletons (CPR 10.9%; 24/220 adults) showed evidence for extraspinal osteoarthritis and among them 11 different sites were affected: one sterno-clavicular, one talar-calcaneal, three wrist joints, three shoulder joints, four finger joints (two interphalangeal and two carpo-metacarpal), one toe joint (metatarsal phalangeal), four hip joints, two knee joints and four elbow joints. All probably involved individuals who were over the age of at least 30 years, while 15 of the 24 individuals were aged upwards of 45 years (Table 5.40). The disease was observed in 15 males (62.5%; 15/24), 8 females (33.3%; 8/24) and one unsexed individual (1/24 4.1%). The CPR for the assemblage was 8.5% for females (8/94), 15.9% for males (15/94), and 3.1% for unsexed adults (1/32). True prevalence rates for individual joints appear in Table 5.41. Due to the small size of the group affected no attempt has been made to assess age/sex related associations.

Adult female skeleton 661 (Grave 665) had bilateral osteoarthritis affecting both knees, a condition that Molleson (1993, 200) suggested was due to prolonged kneeling or squatting. Skeleton 661 also had a lateral squatting facet.

Table 5.41: True prevalence rate of osteoarthritis by joint

Joint	*No. observed/ observable (N/n) Left*	*No. observed/ observable (N/n) Right*	*TPR left*	*TPR right*
TMJ	0/153	1/158		0.6%
Sterno/clavicular	1/37	2.7%		
Shoulder	3/98	0/98	3.1%	0%
Rib/Vertebra	1/115	0.9%		
Hip	2/77	3/75	2.6%	4.0%
Knee	2/137	2/141	1.5%	1.4%
Elbow	1/82	5/84	1.2%	6.0%
Wrist	3/86	3/88	3.5%	3.4%
Hand	2/117	2/119	1.7%	1.7%
Ankle	0/161	0/160	0%	0%
Foot	0/175	1/172	0%	0.6%

The prevalence of osteoarthritis increases markedly with age (Rogers and Waldron 1995). It is therefore not surprising that, given the number of individuals from Lankhills who were over the age of 45 years, 23.8% (15/63) of these were diagnosed as having the disease. Where degenerative joint disease was identified it is possible that this might have developed into osteoarthritis, but the joint observations were not consistent with the characteristics laid out by Rogers and Waldron (1995).

Spinal osteoarthritis

Spinal osteoarthritis was observed on the apophyseal joints (facet joints) and was more common in the cervical spine than elsewhere. Its occurrence was nearly evenly divided between females and males (seven females, eight males) (Table 5.42). Several skeletons had osteoarthritis at more than one place on the spine, for example in skeleton 1137 (Grave 1210) it occurred at C7-T1 and L5-S1. The true prevalence rate for vertebrae with osteoarthritis (number observed to have osteoarthritis against the number of vertebrae available for observation) was 1.7% (TPR 28/398) for cervical vertebrae, 4.6% (TPR 14/308) for thoracic and 1.2% (TPR 7/587) for lumbar vertebrae. A total of 49/398 (3.8%) of vertebrae were affected. Nearly twice as many female cervical vertebrae were affected. Conversely nearly three times as many male thoracic vertebrae and over four times as many male lumbar vertebrae were affected. This is strongly suggestive of different activity patterns. These men may have been engaged in more physically strenuous activities.

Diffuse idiopathic skeletal hyperostosis (DISH)

DISH is a systemic disorder in which additional bone is deposited around a number of joints of the body, largely due to the ossification of surrounding ligaments. Its specific aetiology is unknown, but it appears to be associated with obesity and Type 2 diabetes (Rogers and Waldron 1995, 48), so the condition is most frequently observed in populations that had access to rich food and experienced low levels of physical exercise (Roberts and Cox 2003, 311). Clinical analysis has demonstrated that the condition is often painless and frequently no symptoms are apparent during the life of the

Table 5.42: True prevalence of spinal osteoarthritis for males and females

	No. with spinal osteoarthritis			
	Cervical Vertebrae	*Thoracic Vertebrae*	*Lumbar Vertebrae*	*Total*
Number of males	4	3	4	
No of vertebrae involved male	11/207 (5.3%)	11/174 (6.3%)	6/329 (1.8%)	28/710 (3.9%)
Number of females	6	2	1	
No. of vertebrae involved female	17/191 (8.9%)	3/134 (2.2%)	1/258 (0.4%)	21/583 (3.6%)
Total	28/398 (7%)	14/308 (4.6%)	7/587 (1.2%)	49/1293 (3.8%)

affected individual (Aufderheide and Rodriguez-Martin 1998, 97). Where symptoms do occur these can include pain, aching and stiffness (Roberts and Manchester 2005, 160). In modern populations the condition is widely reported to have an incidence of between 6% and 12% although many studies are based on individuals in hospitals. It is normally found in those over the age of 50 and men are more often affected than women (Rogers and Waldron 1995, 48). Typically, DISH begins with ankylosis of the mid-thoracic spine, due to ossification of the anterior longitudinal ligament and paraspinal tissues. This produces a dripping candle-wax appearance along the right side of the vertebral bodies (Roberts and Manchester 2005, 159-60). Ossification at tendon and ligament attachment sites may be seen at many locations in the body, and ossification of cartilage in the neck and ribs is also commonly seen in the disease (ibid., 160).

For the Roman period as a whole Roberts and Cox (2003, 138, table 3.15) record 23 cases (0.4% of the total burials). The presence of DISH may indicate that some people had access to a rich diet that predisposed them to this condition. A total of 11 males out of 1131 individuals (CPR 1%) at Poundbury had DISH (Molleson 1993, 194). All were mature or old males; typically there was ankylosis of the sacro-iliac joint and some whiskering of the iliac crest as well as well as significant spondylitic changes in the lumbar spine with fringe osteophytes, spurs and osteoarthritis in the posterior joints. Molleson notes that although DISH is presumed to be a metabolic disorder and might be expected to 'run in families' the cases at Poundbury were not grouped in the cemetery.

At Lankhills three skeletons (out of 85, or 3.5%) had thoracic vertebrae with the characteristic 'candle-wax' appearance. Survival of torsos was poor (see above) so the condition may well be under-represented. As at Poundbury, these burials were widely separated spatially.

In skeleton 281 (Grave 263), an adult male originally assigned to the older (45+) age category but placed in the mature adult (36-45 year old) group on the basis of dental attrition ageing, the fifth through to the eleventh thoracic vertebrae were affected. However, the ninth thoracic vertebra had osteophytic growth inferiorly from the inferior body at the costal facet, extending 15 mm on the left side. Extensive osteophytes were present on the third, fourth and fifth lumbar vertebrae as well as the vertebral ends of the left and right ribs (Fig. 5.38).

In skeleton 812 (Grave 855), a probable male aged over 45, DISH was evident in the twelfth thoracic and first and second lumbar vertebrae. The twelfth thoracic vertebra was broken and was the only surviving thoracic. The 'candle-wax' effect covered the entire ?surviving body of the twelfth thoracic vertebra. To conform to the clinical description of DISH, at least four adjacent thoracic vertebrae should be fused, but it is common in skeletal material to find skeletons which obviously have DISH in which less than four vertebrae are fused (Rogers and Waldron 1995, 51).

A further male over 45 years, skeleton 1271 (Grave 1310), also had DISH. This affected four thoracic bodies with the candle-wax-like deposit completely bridging from one to another. There was osteophytosis on the other surviving vertebral bodies and ankylosis of the second and third cervical vertebrae. Fusion can also occur in the cervical and lumbar regions though it is not limited to the right hand side (Rogers and Waldron 1995, 47). The spine of this individual was extremely poorly preserved and individual vertebrae were difficult to identify. None of the skeletons at Lankhills exhibited involvement of the sacro-iliac joint.

Samples from two of the three individuals afflicted with DISH (skeletons 281 (Grave 263) and 1271 (Grave 1310)) were submitted for isotope analysis. The existence of DISH has been used in

Fig. 5.38 Skeleton 281. Diffuse idiopathic skeletal hyperostosis (DISH)

palaeopathological studies to suggest the presence of higher status groups within certain populations (Waldron 1985; Rogers and Waldron 2001; Jankauskas 2003; Müldner and Richards 2007a). Because of the link between this condition and diabetes and obesity, it is interesting to examine whether these two people had a different diet from the other individuals at the site. It was noted that they are enriched in both carbon and nitrogen compared to the majority of the population which could indicate that they consumed a higher proportion of animal protein, perhaps particularly marine fish, than other people. It may be noteworthy that at *c* 181.8 cm (*c* 5′ 11.5″) skeleton 281 was close to the upper end of the range for male stature at Lankhills.

Skeleton 281 also has a markedly lower oxygen isotope signature than the others sampled. It is at the very edge of the UK range and which makes an origin in western Britain very unlikely and origins elsewhere in Europe are suggested including certain regions of Belgium (Ardennes) or Western Germany (Rheinisches Schiefergebirge), which are dominated by Palaeozoic terrains (Lecolle 1985; Asch 2005). The isotope analysis of skeleton 1271 is suggestive of an upbringing in Britain, which is interesting as application of Clarke's terminology in relation to grave goods identified this individual as potentially 'Pannonian'.

Other joint disease

Skeleton 903 (Grave 955), a probable female aged upwards of 18 years, has erosive lesions all over the heads of all five metatarsals in both left and right feet (Fig. 5.39). The proximal phalanges are affected to a lesser extent as are the sesamoids. Other joints of this skeleton, of which only the lower half survived, are not involved, but osteophytoses around joint margins and large enthesophytes were observed. These erosive lesions were radiographed to determine their depth and extent. The lesions are

Fig. 5.39 Skeleton 903. Erosive lesions at the joint surfaces of the right metatarsals

bilateral and all the metatarsals are involved, which would appear to rule out gout or hallux valgus. Equally, there is very little osteophytic growth accompanying the lesions, so osteoarthritis or psoriatic arthritis can also be discounted. Rheumatoid arthritis may be considered as a possibility, but since there were no hands or hips to examine, this cannot be confirmed. The fact that the lesions were both marginal and central makes rheumatoid arthritis unlikely. Rheumatoid arthritis would have caused stiffness of the joints, particularly in the mornings, swelling and pain around the affected joints (Gupta 2004). Septic arthritis is also a possibility, but this usually results in joint fusion and is rarely bilateral. In conclusion this is a seronegative osteoarthropathy.

Two individuals had ankylosis of all or part of the sacro-iliac joint. Skeleton 1197 (Grave 1270), a female over 60 years, had bilateral fusion of the sacro-iliac, though other joints throughout the body are devoid of any degeneration. As the spine was available for examination and there was no ossification of the annulus fibrosa, ankylosing spondylitis was discounted as a possible interpretation. The fact that the femora were of distinctly different lengths (11 mm) may have resulted in the anterior-posterior orientated tibial condyles and the thickening observed on the right tibia shaft. Muscle adaptation was observed on the leg and the femoral heads were more superior and laterally orientated. This has possibly caused the sacro-iliac joint to ankylose to support the unusual gait.

Skeleton 1277 (Grave 1345), a male aged 36-45, had complete ankylosis of the right sacro-iliac joint. There was complete fusion of the sacral ala and the auricular surface (Fig. 5.40). The left pelvis was not fused but the auricular surface was degraded with macroporosity and osteophytosis on the superior margin. No vertebrae survived. Further erosive lesions which were observed on the tarsal bones (but not on the metatarsals) correspond with an unidentified seronegative arthropathy (Fig. 5.41).

In summary, the levels of osteoarthritis and degeneration of the joints observed among the individuals at Lankhills was relatively minor, perhaps reflecting a population experiencing low levels of physical demand. No less than 77 females and 109 males at Poundbury had *severe* degenerative joint disease (Molleson 1993, 201, table 51). Indeed, given the number of older individuals in the Lankhills population a higher level would have been expected. Where changes were seen they were mostly in adults in the mature and older age categories. It was not uncommon for individuals in the older age range to have joint surfaces that were completely unaffected by degeneration. The causes of osteoarthritis and joint degeneration are multifactorial, a combination of genetic predisposition, activity levels, diet and age. Age is considered a dominant factor in degeneration of joints but in

Fig. 5.40 Skeleton 1277. Fusion of the sacroiliac joint, the right side is shown

Fig. 5.41 Skeleton 1277. Cortical defects on the tarsals

contrast there are also people known as 'bone formers', whose joints respond to stress by forming bone. All these factors mean that it is impossible to determine that a particular activity is responsible for the pattern and levels of osteoarthritis seen, although there are clear male and female differences suggesting that some activities may be linked to gender.

It should be noted that the bony changes observed by the osteologist do not necessarily give an indication of the pain, swelling and limited use of the joint felt by the individual. The modern clinician diagnoses osteoarthritis on the basis of symptoms and is unable to examine the dry bone changes. The correlation between the severity of bony change observed in an individual and the pain or range/limit of movement felt in life therefore remains uncertain.

Non-specific infection

Non-specific infections include periostitis, osteitis and osteomyelitis. Periostitis refers to a new layer of bone that is laid down under an inflamed periosteum (the fibrous sheath that covers bone in life). It is identified on the surface of dry bone as porous, layered, new bone. When the cortical bone (bone just below the surface) becomes inflamed, the condition is referred to as osteitis, and when a cloaca or sinus is present to allow the drainage of infective material from the marrow cavity, the changes are classified as osteomyelitis. It is not possible to determine, from dry bone, the micro-organism responsible for osteomyelitis, which is why it is classified as non-specific infection. The most common cause of osteomyelitis is secondary infection, which spreads from the primary infection focus to the bone via the bloodstream. It may also result from direct infection of a bone penetrating injury, in which infection enters the bone from the skin surface. Osteomyelitis can be fatal, but it can also be longstanding and heal. Symptoms include fever, pain and immobility.

Periostitis and osteitis may arise not only as a consequence of non-specific infection, but also from other conditions of a metabolic, neoplastic or traumatic nature (Resnick and Niwayama 1995). Diagnosing osteitis in dry bone involves demonstrating the involvement of the cortical bone and thus radiology is required for this. This also applies to osteomyelitis if a sinus is not visible. For the present analysis routine radiography was not undertaken and therefore lesions were classified as periostitis, unless a sinus was identified, in which case osteomyelitis was diagnosed.

Periostitis was observed on one or more bones of 10 males out of 94 (CPR 10.6%), eight females out of 94 (CPR 8.5%) and two adults of undetermined sex out of 32 (CPR 6.3%) with a total adult CPR of 9.1% (20 out of 220 adults; for TPR figures see Table 5.42), and four subadults out of 64 (CPR 6.3%). In common with other archaeological populations the most frequently affected bone at Lankhills is the tibia, probably because its anterior aspect is prone to recurrent mild trauma, being close to the skin's surface. Varicose veins and consequent ulceration of the lower leg causing low-grade inflammation are also a common cause of tibial periostitis among older individuals. This and mild trauma are the most likely explanations for the cases observed here.

In two individuals periostitis was secondary to trauma. Skeleton 683 (Grave 790), a 36-45 year old male, had periosteal new bone associated with a fracture involving the left radius (Fig. 5.25). Periostitis was also present on the head of the left ulna. In skeleton 967 (Grave 1020), a female aged 36-45 years, the fractured fifth sacral vertebra had associated periosteal new bone (Fig 5.42). Skeleton 683 had both active and healed lesions while skeleton 967 had only active ones.

Table 5.43: Non-specific infection rates by sex (TPR)

Bone	*Male*	*%*	*Female*	*%*	*Total*	
Rib	5/806	0.6	4/633	0.6	9/1439	0.6
Pelvis	1/19	5.3	0/28		1/47	2.1
Femur	1/175	0.6	1/161	0.6	2/336	0.6
Tibia	9/168	5.4	7/155	4.5	16/323	5
Fibula	1/131	0.8	1/132	0.8	2/263	0.8
Total	17/1299	1.3	13/1109	1.2	30/2408	1.3

Fig. 5.42 Skeleton 967. Fracture to the sacrum 5th body

Table 5:44: Subadult periostitis

Skeleton number	Age	Part affected	Stage of healing	Endo/ecto cranial lesions	Orbit lesions	Other pathology
74 (Grave 38)	10-14 years	Left and right tibiae, right fibula, left humerus	Striated new bone - active			
404 (Grave 445)	1 month (0-6 m)	8 Ribs, vertebrae	Layered new bone – active	Ectocranial and endocranial capillary-like lesions	Left orbit severe	Profuse reactive bone growth over entire remaining skeleton
1467 (Grave 1464)	12 months (1-3 y)	11 Rib sternal ends, radius, clavicle, humerus				Skeleton in general porosity at epiphyses and muscle insertion sites
1565 (Grave 1567)	3-7 years	Left tibia	Striated new bone – healed			Left tibia slightly more bowed medio-laterally than right

Four subadults had periostitis (Tables 5.44 and 5.45), affecting 12 elements. Endocranial and ectocranial lesions were present on subadult 404 and one orbit had severe lesions which were not cribra orbitalia, and are as yet unidentified (Fig. 5.43). The subadult periostitis appears to be more commonly related to a systemic infection (?scurvy) rather than an isolated one, except in skeleton 1565 (Grave 1567) where only the left tibia is affected.

There are few data on prevalence of periostitis in other contemporary populations. Roberts and Cox (2003, 126-7) provided data for only two sites. At Kempston, Bedfordshire (Boylston and Roberts 2000) 25% of tibiae (30 of 120) and 12.2% of fibulae (14 of 115) were affected. At Kingsholm, Gloucester (Roberts 1989) 24.2% (15 of 62 tibiae were affected and 17.2% of fibulae were affected. Wells (1982, 181) noted that, with the exception of periodontal disease affecting the teeth, there was very little evidence for infection at Cirencester. A total of 26 individuals out of 362 (CPR 7.2%; 18 males, 7 females, 1 unsexed) had periostitis involving 53 bones (36 tibiae, 17 fibulae (ibid.).

Fig. 5.43 Skeleton 404. The left orbit has profuse densely organised bone growth which is not the porosity of cribra orbitalia

Only two skeletons, of a 13-17 year old (1902, Grave 1900) and a mature adult male aged 36-45 years (862, Grave 930), were confirmed as having osteomyelitis (Fig. 5. 44). Skeleton 1902 had proliferative new bone which penetrated the cortex involving the right distal humerus. In children the cortical bone is thicker and the cancellous bone more dense, presenting more resistance to metaphyseal subperiosteal abscess formation (Aufderheide and Rodriguez-Martin 1998, 173). Skeleton 1902 did not have a visible cloaca such as is usually required for diagnosis, but given the young age of the individual this may not be unusual. A different

Table 5.45: Subadult periostitis (TPR)

Bone	TPR	%
Clavicle	1/22	4.6
Femur	0/70	
Fibula	1/49	2
Humerus	2/58	3.5
Radius	1/49	2
Tibia	3/69	4.3
Ulna	0/48	
Ribs	19/323	5.9
Total	27/688	3.9

Fig. 5.44 Skeleton 1902. Osteomyelitis of the distal humerus possible scurvy

Fig. 5.45 Skeleton 862. Radiograph showing healed fracture of left tibia

diagnosis, of osteitis, is proposed. There were no obvious changes that associated this infection with trauma. This skeleton also had periostitis involving the proximal right ulna, proximal left radius and the posterior aspect of the distal right femur (these elements have been counted above). Skeleton 862 had two cloacae (confirmed by radiograph) associated with a healed oblique fracture of the left tibia (Fig. 5.45). A single possible case was identified at Cirencester, in adult female inhumation 146 (Wells 1982, 182).

Sinusitis

Sinusitis is characterised by new bone deposits in the maxillary sinus (Fig. 5.46). It is difficult to calculate the true prevalence rate of nasal or sinus infections: unless techniques such as endoscopy or radiography are used it is only when damage and breaking of the skull has occurred that these areas can be inspected and changes recorded. Factors that can lead to the development of sinusitis include smoke, environmental pollution, dust allergies and upper respiratory tract infections (Aufderheide and Rodriguez-Martin 1998; Roberts and Manchester 2005, 175-6). Considerable air pollution, such as could be caused by working with fire (smithing, cooking, firing kilns), or by dust or animal hair, could be a major contributing factor. Congenital predisposition for sinusitis can also play a role, as can pregnancy, malnutrition and a wide variety of infections. The condition is classed as chronic sinusitis (when seen on bone) if it lasts more than three months. Symptoms can include facial pain, fever and generalised malady. There was some evidence at Lankhills that the condition was linked to problems with dental health.

The following results were observed by the authors and by Karen Bernofsky in the course of the latter's thesis research into sinusitis. Some sinuses were only observable using an endoscope.

Sinusitis was observed in a total of 26 individuals (CPR 9.2%, Table 5.46). The lesions varied in form from a single spicule within the maxillary cavity, to copious amounts of new bone growth. Eighteen left and 24 right maxillae had sinusitis; of the latter 16 were bilateral. The TPR rates for sinusitis were 22.5% for the left and 30% for the right (18/80 and 24/80 observable maxillary sinuses respectively). In several cases the sinusitis was most likely caused by dental disease, where the infection from an abscess or carious cavity had found its way into the cavity. Five individuals also have rib lesions on the visceral surfaces, three healed and two active, which may suggest a respiratory system infection.

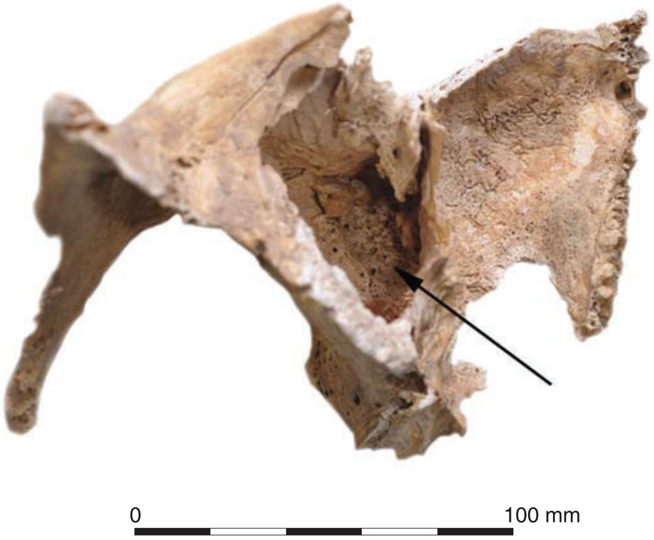

Fig. 5.46 Skeleton 1103. Spicules and spidery new bone deposits indicative of sinusitits

In their summary of osteological evidence from Roman Britain Roberts and Cox (2003, 112) reported a slight increase in frequency of sinusitis to 0.6% (of 5716 individuals, or 0.9% or 32 of 3260 sexed adults) compared to none in the Iron Age (but 0.7% in the Bronze Age). The Roman instances affected 36 individuals from 9 sites, with a CPR of 1.8%. The results from Lankhills appear high when compared with other data, but this is almost certainly because of the special attention that was paid to recording sinusitis in this assemblage. At Cirencester there were seven cases out of 362 (CPR 1.9%; four males, three females) (Wells 1982, 181). At Butt Road 10 out of 575 individuals were affected (CPR 1.7%; five males, five females) (Pinter-Bellows 1993, 79).

Skull lesions

Inflammation on the endocranial surface may arise in response to a number of conditions, including chronic meningitis, trauma, anaemia, neoplasia, scurvy, rickets, venous drainage disorders and tuberculosis (Lewis 2004). The following descriptions of endocranial and ectocranial lesions are not diagnostic of a particular disorder.

Skeleton 1857 (Grave 1859), 5-10 months old at death, had woven new bone deposited within the central portion of the endocranial surface of the occipital bone (Fig. 5.47). The lesion covered an area measuring 40 mm x 30 mm. New bone deposition had caused thickening of the surface. Some smoothing of the central part of the lesion suggested that healing may have been occurring. In addition, the ectocranial surface of the left and right frontal bones was overlaid with a thin layer of fine grained grey active new bone. Similar lesions are present on the ectocranial surface of the squamous part of the occiput, just below the lambda. Here the bone appeared as a clearly separate deposit of woven bone overlying the ectocranial surface. Plaques of thin new bone were also present on fragments of parietal bone with some reduction in porosity in places, suggesting some healing.

Table 5.46: Individuals affected by sinusitis (n=26)

Skeleton number	*Sex*	*Age*	*Left sinus*	*Right sinus*	*Rib lesion*
50	Female	45+ y	Present	Present	
61	Female	26-35 y	Present	Present	
212	?Female	60+ y		Present	Present
281	Male	36-45 y	Present	Present	
476	Female	36-45 y		Present	
522	Male	60+ y	Present	Present	
559	Female	45+ y	Present	Present	
682	Male	45+ y	Present	Present	
717	Male	Adult	Present		
792	Female	Adult		Present	
938	Male	36-45 y	Present	Present	
956	?Male	45+ y	Present	Present	
967	Female	36-45 y	Present	Present	
1022	Male	45+ y		Present	
1103	Female	45+ y	Present	Present	
1137	?Male	26-35 y	Present	Present	
1156	Female	45+ y		Present	
1197	Female	60+ y		Present	
1214	Female	36-45 y	Present	Present	
1219	Male	45+ y		Present	
1258	Male	60+ y		Present	Present
1361	Female	Adult	Present	Present	Present
1532	?Female	26-35 y	Present	Present	Present
1637	Female	36-45 y	Present	Present	
1640	Male	45+ y	Present	Present	
1852	Male	60+ y	Present		Present

Skeleton 1098 (Grave 1130), 5-12 months of age at death, had web-like porous bone in the central part of the endocranial surface of the occipital bone, corresponding to Lewis's (2004) lesion type 1, the aetiology of which is unknown. Frontal, parietal and occipital cranial fragments had ectocranial lesions and layered fibrous new bone growth. A small amount extended to other parts of the skeleton which had lost all density (Fig. 5.48).

Rib lesions

One of the most common lesions associated with pulmonary tuberculosis is new bone formation on the inner (visceral) surface of the ribs. Periostitis involving the visceral surfaces of ribs was observed on six skeletons from Lankhills (skeletons 212, 1209, 1361, 1393, 1532 and 1852 (Graves 210, 1285, 1437, 1394, 1528 and 1790 respectively)). There were three men and three women, and no less than three were aged upwards of 60 years. In three of these cases the periostitis is associated with a fracture (1209, 1361, 1393) and in one (212) with a fracture and soft tissue damage. The periostitis in these instances is unlikely to be from pulmonary disease and the fractures are included in the appropriate section.

The changes in the remaining two skeletons (1532 and 1852) have been classified as non-specific pulmonary disease because on their own they are not enough to allow a diagnosis of pulmonary tuberculosis (Santos and Roberts 2001). Skeleton 1532 had both healed and active lesions while those affecting skeleton 1852 were active. Tuberculosis may be diagnosed if the lesions are accompanied by spinal collapse and deformity, but this was not seen in the Lankhills skeletons (Fig. 5.49).

In the Roberts and Cox sample there was an increase to 0.8% in the Roman period (from 0.3% in the preceding Iron Age) of inflammatory changes to the ribs (45 individuals in total or 36 (1%) of 3620 sexed adults). Examples were seen at Cirencester South (Wells 1982, 181; Manchester and Roberts

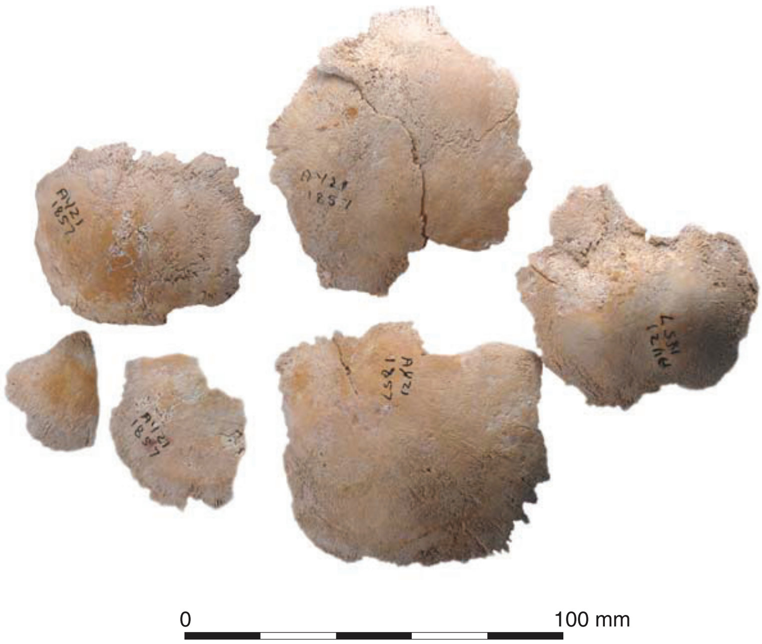

Fig. 5.47 Skeleton 1857. Ectocranial skull lesions

Fig. 5.48 Skeleton 1098. Porous new bone layer on cranium

Fig. 5.49 Skeleton 1532. Rib lesions

1986), while sinusitis was present at Butt Road, Colchester (Pinter-Bellows 1993, 79). At Cirencester eight out of 362 individuals were affected (CPR 2.2%; two males, three females, three subadults). The presence of rib lesions along with sinusitis perhaps suggests that internal living environments were polluted by smoke, or it could possibly reflect a climatic deterioration. Alternatively it may indicate that people were living in close contact with one another and transmitting respiratory infections such as pneumonia (Roberts and Cox 2003, 112, table 3.1-3.2).

Capasso (quoted in Roberts and Cox 2003, 112) reported on the possibility of the impact of indoor pollution on skeletons from Herculaneum in Italy dated to AD 79. He noted the presence of inflammatory lesions of the ribs and found an 11.6% frequency (no numbers given). Animal and vegetable oils were, he says probably burnt in terracotta lamps, but cooking techniques and burning fuel may also have predisposed these people to respiratory problems (Capasso 2000).

Skeleton 1061 (Grave 1944), a child aged 6-7 years, had diffuse, fibrous periostitis involving the left and right ulnae (anterior proximal shaft just inferior to the articular surface), left ribs (predominantly on the anterior shaft adjacent to the head) and the left and right femora (posterior aspect to the side of the linea aspera). There was no involvement of the vertebral column. This individual also had cribra orbitalia (in the left orbit only) and enthesophytes and cortical defects on the humeri and femora. A diagnosis of tuberculosis is favoured here because of new bone formation affecting the ribs. These formations occur more frequently in pulmonary tuberculosis than any other pulmonary disease (Matos and Santos 2006). This suggestion is supported by the occurrence of the diffuse periostitis of the long bones, which in subadults has been identified as related to tuberculosis (Santos and Roberts 2001). Alternative diagnoses include respiratory infection such as bronchitis and pneumonia; heart failure and carcinomas have also been found to produce rib lesions (ibid.). Mary Lewis (pers. comm.) suggests that the Lankhills lesions are similar to those found on some of the subadults from Poundbury which are now believed to have been caused by tuberculosis.

Tuberculosis is a disease of overcrowding. It usually has its onset in childhood. Infected children can become infected adults, and often acquire their infection from the adult population. Tuberculosis is a chronic infectious disease caused in humans by *Mycobacterium tuberculosis.* It can infect the lungs, lymph nodes, skin, intestines and in some cases the joints. Once infection is established, the primary lesion may lie dormant after a brief inflammatory response, and may only become active later in life (ibid.). In the skeleton, tubercular lesions (granulomata) display minimal bone formation and marked osteoporosis in the affected limb. The femur and tibia are the long bones most commonly affected and new bone formation on the shafts of the long bones has also been identified (Santos and Roberts 2001). Skeletal tuberculosis only occurs in around 3-5% of people with the disease (Resnick 1995, 2462), but this figure may be higher for subadults.

Poor housing and nutrition, close contact with infected animals and humans, poverty, climate and occupation have all been cited as causative factors (Lewis 2007, 148). Accommodation of humans and animals in the same building allows transmission of zoonotic disease in addition to attracting parasitic vectors of disease and initiating allergies. Zoonotic diseases are not particularly frequent in the Roman period but we do see the first published cases of tuberculosis at this time. It is contracted via the lungs from other humans or animals, or through the intestinal tract (from infected meat and milk); both are possible at this time and imported cattle may have helped spread the disease from the continent. Concentrations of people in large settlements and at relatively high population densities would have allowed droplet spread of this infection. Roberts and Cox (2003, 118-119, table 3.8) record 12 cases out of 5716 (0.2%) for the Roman period and most are males. One example comes from Cirencester (Wells 1982, 181) and two come from Poundbury (Molleson 1993, 190). A further two males and one female skeleton from an early Romano-British site in Essex had tuberculosis (J McKinley pers. comm.).

Metabolic conditions

The basic staple diet was bread (less likely porridge; Cool 2006, 74-6) supplemented by meat, fish, fruit and vegetables, which for many would have been both adequate and suitably balanced to prevent dietary deficiency diseases (Roberts and Cox 2003, 140). However, metabolic diseases are seen in the Roman period, indicating that for some their diet was less than adequate.

Rickets

Rickets are the skeletal changes resulting from a deficiency of vitamin D (a prohormone rather than a true 'vitamin') which is essential for proper mineralisation of newly-formed bone (Brickley *et al*. 2006). It is mainly produced internally from ultraviolet light reacting with 7-dehydrocholesterol (Lewis 2007, 119). Some foodstuffs contain vitamin D which contributes to maintenance of the correct level, but in humans the level is maintained primarily by exposure to sunlight. Vitamin D levels affect the absorption and mobilisation of calcium and phosphorous. The uncalcified osteoid, laid down on the growth plate during the remodelling process, causes bones to 'soften' and they become susceptible to bowing deformities. The weight of the body on limbs used for mobility (femur, tibia and fibula in a walking individual, and the humerus, radius and ulna in a crawling child) causes them to become bent medio-laterally or anterior-posteriorly. After the first six months of life, existing stores of vitamin D are depleted and thus exposure to sunlight is needed to make up dietary deficiency.

Rickets may be diagnosed in archaeological skeletons based on the manifestations described by Ortner and Mays (1998) and the additional features observed by Brickley *et al*. (2006, 132). A typical presentation would involve bowing deformities of the lower limbs and occasionally the upper limbs. They would be bowed medio-laterally or anterior-posteriorly. The early changes of rickets are subtle,

Fig. 5.50 Skeleton 977. Diffuse porosity and new bone growth on the entire infant skeleton

comprising expansion and fraying of the rib ends and distal long bones, the characteristic bowing occurring when weight-bearing begins. The radiographic features are coarsening and diffuse osteopenia of the trabecular structure and cortical tunnelling and, where bowing occurs, thickened cortical bone on the concave side of the deformity.

Changes believed to be associated with vitamin D deficiency were observed on five skeletons, two adults (one male, one female) and three subadults. Skeleton 977 (Grave 980), aged 4 months-2 years, (ie at a stage when most children are at least crawling and a few are walking or standing for long periods) may have had rickets with anaemia (Fig. 5.50). There was profuse widening of the cortex of all the extant skeletal elements to produce porous, light-weight bones. There was also 'hair-on-end' (porotic hyperostosis) bone across the ecto-cranium (frontal, parietal, occipital and temporal). The endocranial surface was not affected. The mandible and long bones did not survive for examination. The left orbit had severe grade 5 cribra orbitalia. The bones were examined radiologically, but were too thin and porous to produce a viable result. An alternative diagnosis of ICH (infantile cortical hyperostosis) was considered as a possibility, but none of the diagnostic bones were present.

Skeleton 1034 (Grave 1125), 9-12 months old, had the characteristic bowing of femora which were slightly flared at the distal end (Fig. 5.51). The ribs at the medial/sternal end were wide, fat and oval in shape. The changes were subtle, though considered out of the range for normal development and diagnostic of rickets.

Skeleton 20 (Grave 18), a 13-17 year old female, exhibited signs of possible childhood rickets. The left tibia bowed medio-laterally more than the right. The sacrum curved excessively to become horizontal at the level of sacral bodies 4 and 5, thus creating a bend of 90 degrees (Fig. 5.52). The pelvis and sacrum are known to be affected by rickets, especially when an individual spends long periods of time seated, which would occur if they were deficient in vitamin D before they could walk. In this instance it is possible that the deformity was sufficient to obstruct the birth canal. This individual also had cribra orbitalia, cribra femora and dental enamel hypoplasia.

Two adults, skeletons 1512 (Grave 1510) and 451 (Grave 590) displayed evidence for limb deformity, which may have been caused by rickets in childhood. Skeleton 1512, a 26-35 year old female, had bowed radii, ulnae, humeri, femora and tibiae. The

Fig. 5.51 Skeleton 1034. Possible juvenile rickets represented by anterior posterior bowing of the femora

Fig. 5.52 Skeleton 20. Extreme angulation of the fifth sacral body possibly as a result of childhood rickets

bones were bowed in either the medio-lateral or anterior-posterior plane to varying degrees. The upper limbs were especially bowed. The proximal and distal epiphyses of the tibiae were slightly flared, which is another change seen in rickets. Skeleton 451, a male 36-45 years old, had tibiae that were slightly bowed in the anterior-posterior plane.

Scurvy

The development of scurvy is linked to a deficiency of vitamin C (ascorbic acid) which can be obtained from a wide range of foods, in particular fruit and vegetables. However, there are many circumstances, particularly among past populations, which may have resulted in this deficiency. Although many of the appropriate food types can be stored, levels of vitamin C will decrease rapidly if not replenished. Scurvy is more prevalent in regions with cooler climates and is generally associated with times of hardship and famine (Brickley 2000, 185).

Cases of scurvy have rarely been recorded in archaeological material (Brickley 2000), probably partly due to the ephemeral nature of many of the associated skeletal changes, but also because in the past it has rarely been considered as a differential diagnosis during the study of human bone. Two examples of scurvy (0.03%) are mentioned by Roberts and Cox (2003, 142) in their discussion of the Roman period, but no details are given. These low figures may suggest that adequate levels of vitamin C were being ingested at this time or that the condition was not considered as a possible diagnosis in recorded assemblages.

Vitamin C is important for the formation of connective tissue. Lack of vitamin C increases susceptibility to haemorrhage during normal movement, such as chewing or eye motion. In infants and small children undergoing rapid growth a bout of scurvy will result in defective connective tissues and blood vessels, making them particularly vulnerable to haemorrhage. Haemorrhage causes an inflammatory response in bone, particularly at sites where connective tissues lie close to bone. Rapid growth of the subadult skeleton means that skeletal changes associated with scurvy are visible on subadult bone far sooner than they are on adult bone. Experiments have shown that healthy adults saturated with vitamin C can take up to six months to develop the first signs of scurvy (Maat 2004). Scurvy most commonly occurs in infants between 6 months and 2 years of age (Lewis 2007, 127). Clinical symptoms in children include irritability, painful legs and anaemia (see Stuart-Macadam 1989 for a detailed discussion).

Many of the skeletal changes relating to scurvy are the result of an absence or reduction in the amount of bone matrix formation, as vitamin C is essential for the formation of collagen, hence bone changes will be clearer where rapid bone formation was taking place, and are consequently far more marked in infants than adults. However, many changes affect soft tissues and so are absent from the archaeological record (Brickley 2000, 185).

Scurvy is diagnosed in dry bone by the presence of non-specific bone inflammation, increased porosity and/or new bone formation (the bony reaction to haemorrhage), ante-mortem tooth loss, periodontal disease, haemorrhage into joints and radiopaque lines on radiographs of long bones (Roberts and Manchester 2005, 235-7). In particular, increased porosity and/or new bone formation involving the skull, namely the sphenoid, orbits, zygomatic bones, palate, alveolar sockets and coronoid processes of the mandible (Fig. 5.53), are

Fig. 5.53 Skeleton 8. Porosity on the maxilla and mandible possibly indicative of scurvy

Table 5.47: Skeletons with lesions that may be symptomatic of scurvy

Skeleton number	*Age*	*Cranial lesions*	*Post-cranial lesions*
8 (Grave 6)	10-12 months	Porosity on alveolar bone in region of deciduous molar. Increased porosity on the whole superior and inferior surfaces of basi-sphenoid external surfaces of both maxillae and hard palate. Squamous part of temporal bone posterior to auditory meatus shows the most obvious changes, with an area 29 mm x 25 mm showing increased porosity and grey new bone growth on the ectocranial surface. The endocranial surface shows more sieve-like lesions.	Anterior-posterior bowing of the left and right tibia shafts
221 (Grave 231)	12 months	Left and right orbit layered new bone growth across the upper part of the orbit with some minor porosity. Left and right greater wing of sphenoid on outer surface layered new bone growth minor porosity. Maxilla alveolar sockets thin and porous. Occipital bone lateral margins on left and right side small patch 13 x 10 mm hair-on-end formation of bone. Very occasional minor porosity on ecto-parietals. Endocranial increased vascularity.	
829 (Grave 890)	6-7 years	Endocranial lesions (new bone) over occipital protuberance. Parietal layered new bone and capillary-like lesions on frontal bone. Cribra-like lesion in orbits. Microporosity on alveolar bone in region of deciduous molar, mandibular ramus porosity, wing greater sphenoid porosity.	
1083 (Grave 1370)	6-12 years	Endo- and ectocranial lesions. Right parietal ectocranial macroporosity particularly around the sutures for frontal and occipital, does cross suture lines. continues onto the occipital at lambda area. Right temporal bone has lost some surface post mortem, so tentatively appears to also have the macroporous lesions on the ectocranial surface. Pars basiliaris also has macro and microporosity ectocranially. Endocranially capillar-like lesions are observed on right parietal and occipital near lambda and squamous temporal. These are small islands of new bone growth irregularly located. Pars basilaris has microporosity on the endocranial surface	
1314 (Grave 1317)	Neonate	Endocranially frontal bone porous new bone growth. Orbit new bone layer	

typical in this disease (Ortner *et al.* 1999; Ortner and Erickson 1997) although some are similar to those produced by infections and anaemias (Brickley 2000, 185).

Five subadult skeletons at Lankhills exhibited skeletal changes that *may* have been caused by scurvy. These are detailed in Table 5.47.

Cribra orbitalia

Cribra orbitalia is identified on dry bone as thinning of the compact bone of the orbital roof (the eye socket) in combination with increased porosity. These lesions are believed to reflect the presence of iron deficiency anaemia (Stuart Macadam 1991). Iron deficiency may arise as a result of a number of factors including a lack of iron in the diet, the inability to absorb the iron in the diet (for example a lack of vitamin C makes it harder to absorb iron), parasitic infestation in the gut, malaria, and lead poisoning (ibid.). For the Lankhills assemblage the presence or absence of cribra orbitalia was scored employing the criteria defined by Stuart Macadam (ibid.).

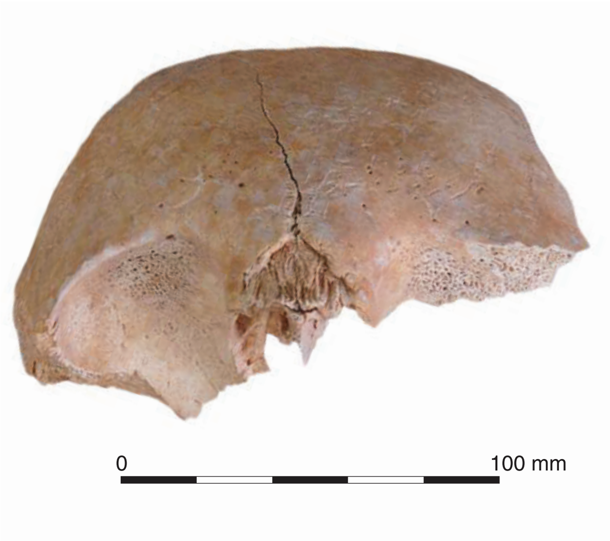

Fig. 5.54 Skeleton 829. Cribra orbitalia

A total of 26 adults (CPR 12.1%) had lesions consistent with cribra orbitalia (Fig. 5.54) in 21 left orbits and 18 right orbits (TPR 17.3% 21/121 and 15.1% 18/119). Subadults with cribra orbitalia numbered 14 (CPR 21.9%) and between them they had 14 left orbits (TPR 73.7%; 14/19) and 10 right orbits (TPR 58.8%; 10/17) which were affected. Adult males were less affected than females, having a true prevalence rate of 14%, (9/64) compared with a true prevalence rate of 33 % (18/53) for females (Tables 5.48-50)..

At Poundbury the lesions were observed in 29% of skulls (TPR 27.7% of females and 24.4% of males) (Stuart-Macadam 1991). At Butt Road, 9.9% of individuals with orbits had lesions (26 people) and nearly half of these were subadults (11). At Cirencester (Wells 1982, 186) the true prevalence rate for males was 19.9%, for females 13.9% and for subadults 35.1%.

Roberts and Cox (2003, 140, table 3.17) record a total of 460 individuals with cribra orbitalia in their Romano-British sample (8.05% of the total burials, or 305 of 3620 sexed adults – 8.4%. This is an increase from the Iron Age rate of 5.4%. It is unlikely that this represents low iron intake, as meat played a significant part in the diet for many at this time. It could be indicating that high pathogen loads induced this condition, or even that lead ingestion was responsible.

Table 5.48: Occurrence of cribra orbitalia

Category (Stuart-Macadam 1991, 109)	*Adults* Left orbit	Right orbit	Total	*Subadults* Left orbit	Right orbit	Total
1	5	4	9	2	1	3
2	3	4	7	2	2	4
3	8	6	14	7	5	12
4	3	2	5	0	0	0
5	1	0	1	3	2	5
Total	20	16	36	14	10	24
% of observable orbits	15.5%	12.8%		73.7%	58.8%	

Table 5.49: Cribra orbitalia in subadult individuals

Category (Stuart-Macadam 1991, 109)	*Left orbit*	*Right orbit*	*Total*
1	2	1	3
2	2	2	4
3	7	5	12
4	0	0	0
5	3	2	5
Total	14	10	24
% of observable orbits	73.7%	58.8%	

Table 5.50: Occurrence of cribra orbitalia by age category and number of individuals

Age category	*Frequency*	*Percentage within age category (TPR)*
Infant	4/23	17.4%
Child	6/21	28.6%
Older child	0/8	0%
Adolescent	4/9	44.4%
Young adult	2/13	15.3%
Prime adult	6/28	21.4%
Mature adult	7/39	18%
Older adult	6/48	12.5%
Adult	6/72	8.3%
Total	41/284	

Neoplastic disease

Button or ivory osteoma

This is a benign tumour which most commonly occurs on the outer table of the skull, usually on the frontal and parietal bones, although it may also appear on other bones of the skull vault to a lesser extent. It usually presents as mature lamellar bone, circular in shape, raised above the outer table of the cranium and measuring no more than 20 mm across (Ortner and Putschar 1981, 368).

Five skeletons (61 (Grave 58), 240 (Grave 237), 435 (Grave 530), 1201 (Grave 1275) and 1209 (Grave 1285)) had six button osteomas. Three are on the frontal bone and the other three on the left parietals (skeletons 61, 240, 1201). Skeleton 435 had two osteomas on the frontal bone while skeleton 1209 had one (Table 5.51).

Roberts and Cox (2003, 114) reported 32 individuals with button osteomas for the whole of the Roman period (1.14% compared with 0.3% in the Iron Age). There were four examples respectively from Cirencester (Wells 1982, 183) and Butt Road (Pinter-Bellows 1993, 87).

Table 5.51: Prevalence of button osteomas in the late Roman period

Site name	*Total no*	*.Affected*	*M*	*F*	*?*	*J*	*CPR%*
Lankhills	284	5	2	3	0	0	1.8%
Cirencester	362	4	3	1	0	0	1.1%
Butt Road	575	4	2	2	0	0	0.5%
Total	1221	11	7	6	0	0	0.9%

Other pathology

Hyperostosis frontalis interna

Hyperostosis of the endocranial surface of the frontal bone of the skull can occur during and just after pregnancy, apparently as a result of altered pituitary hormone secretion. Prominent thickening and formation of nodules of new bone on the frontal bone also occurs in post-menopausal females (Roberts and Manchester 1995, 182, fig. 8.11). It has been suggested elsewhere that these changes are probably also the result of altered pituitary gland secretion of hormones and that they almost always only occur in ageing females (Ortner and Putschar 1981, 294). Henschen (1949, 85) estimated that the female to male ratio was close to 100:1. It is rarely reported in archaeological populations.

Five skeletons at Lankhills had this condition: four were female, one aged upwards of 45 years (skeleton 454, Grave 585), one aged upwards of 60 years (skeleton 1173, Grave 1240) and the others aged only as 'adult' (skeletons 562 (Grave 620) and 1094 (Grave 1140)); the fifth skeleton (986, Grave 1050) was of a probable male aged upwards of 18 years.

Fine pitting on ectocranial surface

Six adult individuals exhibited 'orange peel effect' fine pitting/porosity and a lumpy contour on the parietal and occipital bones of the skull. This may represent healed or minor porotic hyperostosis, but may also be indicative of a scalp infection or the long-term presence of head lice. Three were males and three were females, two were prime adults (skeletons 917 (Grave 1035) and 1532 (Grave 1528)) and four were mature adults (skeletons 612, 702, 1134 and 1289 (Graves 630, 705, 1190 and 1329 respectively)).

Thickened cranium

Skeleton 1913 (Grave 1915), an adult male aged upwards of 45 years, had a thickened cranium. This is a symptom found in Paget's disease (see above), but alone is not diagnostic. Thickening of the skull can occur as part of the ageing process.

Ossified cartilage

There were 11 males and three females (25, 55, 212, 281, 451, 554, 616, 683, 917, 1119, 1209, 1219, 1393 and 1852 (Graves 22, 52, 210, 263, 590, 600, 690, 790, 1035, 1175, 1285, 1295, 1394 and 1790 respectively)) with ossified thyroid cartilage and two males (skeletons 25 (Grave 22) and 1209 (Grave 1285)) with ossified cricoid cartilage (the ring-shaped cartilage at the lower end of the larynx). The rib costal cartilage was also frequently ossified in these individuals. Ossification occurs towards the end of the second decade and there is a gradual increase with advancing age. Although no direct correlation can be demonstrated (Scheuer and Black 2000), all the individuals here were adults in at least their fourth decade.

Cribra femora

This lesion, most commonly seen on subadults, is located on the anterior of the femoral neck just

Fig. 5.55 Skeleton 20. Bilateral cribra femora, anterior porosity inferior to the femoral head

inferior to the head. It is very similar to cribra orbitalia in appearance. It has been commonly reported in European samples, and an attempt has been made to demonstrate a link between cribra orbitalia, cribra femora and cribra humeri (Miquel-Feuchet *et al.* 1999). It is suggested that cribra femora is due to a deficiency of magnesium which is needed for cartilage growth (ibid.). This lesion may be a result of malnutrition, hence the link to cribra orbitalia, which can be indicative of iron deficiency.

Cribra femora was observed on three individuals at Lankhills (skeletons 20 (Grave 18, Fig. 5.55), 507 (Grave 545) and 1114 (Grave 1170)). The first two of these were adolescents (13-17 years of age) and the third was a female 26-35 years old. Only skeleton 20 also had cribra orbitalia; this individual possibly also had childhood rickets which suggests generalised malnutrition. Skeleton 507 had endocranial lesions and skeleton 1114 had a lytic lesion on the right distal humeral epiphysis.

Dental health

Examination of dental health and rates of dental disease can provide some evidence for diet. Poor dental health is in part related to poor dental hygiene but is most likely to be associated with the consumption of carbohydrates, and particularly sucrose. During the Roman period honey and sapa were used as sweeteners, fruits containing sucrose were eaten and there is also evidence of imports of sugar-containing foods (Moore and Corbett 1973, 141) such as figs, dates and grapes from the Continent. Several classical texts refer to cleaning of the oral cavity and toothpicks are frequently mentioned. Although there are no examples of fillings, people obviously did have carious teeth and there were inhalation recommendations (such as henbane) to rid the teeth of worms thought to cause cavities.

Some 646 individuals of 5716 in the total Romano-British sample recorded by Roberts and Cox (2003) have some evidence of dental disease (11.3%, or 367 – 10.1% of 3620 sexed adults) which is an increase from the previous Iron Age of 7.5% (Roberts and Cox 2003, 130-1, tables 3.10-11).

A total of 4341 teeth from 232 skeletons survived at Lankhills: 1764 from 90 females, 1665 from 88 males, 202 from 8 unsexed adults and 710 from 46 subadults.

Dental caries

Caries are cavities that result from the demineralisation of teeth when they are attacked by acids that develop when bacteria ferment food sugars, especially sucrose. Caries affected 83 adult dentitions (CPR 37.7%), or 214 out of 3631 permanent teeth (TPR 5.9%) that were examined. The TPR for 32 males was 4.7% (79/1665 teeth) compared to 7.5% for 49 females (132/1764 teeth). The TPR for two unsexed adults was 1.5% (3/202 teeth). Five subadults, all with deciduous teeth, had carious lesions: 12 out of 710 (TPR 1.7%) erupted deciduous teeth were involved.

TPR rates observed elsewhere were 15.8% at Poundbury, 5.1% (167/3251 teeth; 55 males, 26 females) at Cirencester South, 4.8% at Cirencester North (16/331 teeth) and 3.9% at Butt Road (217/3277 teeth), while the overall rate for 29 Romano-British sites (Roberts and Cox 2003, 131, table 3.10) was 7.5% (2179 of 29,247 teeth). The caries rate at Poundbury was particularly high (Molleson 1993, 183) and it was suggested that this was in part related to the presence of a relatively high proportion of older adults in the group. There was no difference in male and female rates, in contrast to the situation observed at Lankhills where the rate was rather higher in females (see above).

Dental calculus

Calculus is a build-up of mineralised dental plaque, which can result from a high protein diet and poor dental hygiene. It was observed on 63 adult dentitions (CPR 28.6%), or 1645 out of 3429 permanent teeth (TPR 48%). Calculus deposits were heavy on 123 teeth. There was a marked difference between males and females. A total of 29 males had a TPR of 28.7% (477/1665 teeth) compared to 34 females with a TPR of 66.2% (1168/1764 teeth).

Calculus is seen in 481 individuals (8.4% of 5716), or in 405 sexed adults of 3620 (11.2%) in Roberts and Cox's (2003) sample and was more common than in the Iron Age. In terms of absolute frequency for five sites where data are available, 43.4% of 3923 teeth (1702) had calculus. This strongly suggests either that people were not cleaning their teeth or they were consuming a high protein diet, or both. Some people today have to undergo regular scaling of plaque from their teeth because their oral chemistry makes them prone to plaque build-up. At Cirencester South 104 out of 362 individuals (CPR 28.7%) had calculus (Roberts and Cox 2003, table 3.11).

Skeleton 522 (Grave 570) had extreme deposits of calculus on the upper left third molar, extending 6 mm from the buccal side of the tooth. A periapical granuloma with external drain in the region of the upper left first premolar may have caused pain and led to some reluctance to chew on that side. Skeleton 1852 (Grave 1790) had calculus on the occlusal surfaces of teeth from the right side, suggesting a lack of mastication on the right side of the mouth prior to death, which was almost certainly related to the presence of a large abscess cavity on the right maxilla (Fig. 5.56). The dentition of skeleton 1640 (Grave 1638) had a comparable build up of calculus (Fig. 5.57) and an associated abscess. Calculus can obscure other dental conditions, thereby biasing observations. Further bias can occur because calculus tends to drop off the denti-

Fig. 5.56 (above) Skeleton 1852

Fig. 5.57 (left) Skeleton 1640. Heavy calculus deposit

tion. It may also prevent caries from occurring (Waldron 2001, 127). The overall rate of calculus for the Roman period (Roberts and Cox 2003) per individual was 8.4%. TPR data (above) give a figure of 43.4% of teeth, a rate similar to that observed at Lankhills.

Two adolescent skeletons (skeletons 20 (Grave 18) and 74 (Grave 38)) with adult teeth had calculus, of which skeleton 20 had two teeth with heavy calculus deposits. A child aged approximately 5 years, disarticulated skeleton 2064, had flecks of calculus on eight teeth.

Periapical cavities

These are identified as openings or holes in the periapical bone of the mandible or maxilla at the apex of the tooth root. They arise as a result of inflammation of the dental pulp which can occur as a result of trauma, caries or attrition. Depending on severity, these cavities may contain granulation tissue (a 'granuloma'), a fluid filled sac (a 'periapical cyst') or a pus-filled sac (an 'abscess'). Granulomas and periapical cysts are usually asymptomatic. Abscesses, however, may result in a persistent fever, a general feeling of being unwell and, when they burst and discharge their contents, halitosis. Acute abscesses may lead to osteomyelitis (bone infection) which in turn may be fatal causing, for example, septicaemia (Roberts and Manchester 2005, 133).

Forty-five periapical cavities were observed from 27 adult individuals (CPR 12.3%), comprising 32 granulomas (1.1% of all skeletons with surviving tooth sockets), nine abscesses (0.3% of all skeletons with surviving tooth sockets) and four cysts (0.1% of all skeletons with surviving tooth sockets). At Butt Road (Pinter-Bellows 1993, 84) 13% of individuals had an abscess (0.7% per tooth), and at Cirencester 1.2% of erupted tooth positions had an abscess/granuloma (Wells 1982, 149), affecting 37 individuals. This is the same rate as at Lankhills. A TPR of 3.9% for 29 sites is noted by Roberts and Cox (2003) and Freeth (1999) recorded a TPR of 1.1% for females and 1.4% for males from three Roman cemetery populations.

A single subadult (skeleton 113 (Grave 111), aged 9-13) had an apical cyst involving the periapical bone around the upper right second deciduous molar.

Periodontal disease and ante-mortem tooth loss (AMTL)

Inflammation of the soft tissues of the jaw (gingivitis, or gum disease) subsequently transfers to the bone (periodontitis). The resulting resorption of bone can result in ante-mortem tooth loss as the roots are exposed. Ante-mortem tooth loss may also result from abscess development secondary to caries, periodontal disease secondary to calculus formation, pulp exposure and abscess formation secondary to severe attrition, dental intervention ('pulling' teeth) and trauma.

A total of 871 (TPR 24%) tooth sockets out of 3631 that had survived for examination exhibited the vertical bone loss and porosity associated with periodontal disease. Fifty-nine individuals were affected, 26 of whom had a very high level of periodontal disease (classed as severe or grade 4; Ogden 2005). More males (TPR 28.5%; 28 males; 475/1665 sockets) than females (TPR 21.5%; 30 females; 380/1764 sockets) were affected. A CPR of 12.3% of individuals is recorded by Roberts and Cox (2003), but no true prevalence rate figures are available for their dataset.

Three subadults were affected by periodontal disease (TPR 0.6%; 4/710; skeleton 113 (Grave 111) aged 9-13 years, skeleton 767 (Grave 835) aged 4-9 years and skeleton 447 (Grave 540) 5-7 years. A single adult tooth socket and two deciduous tooth sockets showed resorption of bone over 5 mm.

Eighty-three adults had lost 562 out of 3644 teeth ante mortem (TPR 15.4%). Skeleton 1341 (Grave 1351), a mature adult female, exhibited the highest rate of ante-mortem tooth loss in the assemblage with 30 out of 32 teeth (TPR 93.8%).

Dental enamel hypoplasia

Dental enamel hypoplasia (DEH), identified as lines, pits or grooves on the enamel surfaces of the teeth, was observed on 50 adult individuals (CPR 22.7%), predominantly on the lower incisors and canines. These features affected 295 out of 4005 teeth (TPR 7.3%). Of the 46 subadults with observable teeth, 16 (34.8%) had defects which affected 123 teeth. All of the defects involved permanent teeth with the exception of one subadult who had defects involving the deciduous teeth (skeleton 829 (Grave 890)). Defects were highest among adolescents (66.7%) and prime adults (47.4%) (Table 5.52).

Dental enamel hypoplasia occurs as a result of disruption to the growth of the dental enamel during childhood. The disruption may be caused by numerous factors, childhood illness and malnutrition being among them. Because of its multifactorial aetiology, DEH is regarded as a non-specific indicator of physiological stress during childhood

Table 5.52: Dental enamel hypoplasia by age category (CPR)

Age category	*n/ N*	*% of individuals affected*
Young child	8 / 21	38.1
Older child	2 / 8	25
Adolescent	6 / 9	66.7
Young adult	4 / 14	28.6
Prime adult	9 / 19	47.4
Mature adult	14 / 33	42.4
Older adult	18 / 77	23.4
Adult	5 / 70	7.1

(eg Roberts and Manchester 2005, 76-7). Less than a quarter of the population were affected by dental enamel hypoplasia which suggests that the majority were well nourished in childhood and not exposed to high disease loads.

At Butt Road DEH was observed on the teeth of 64 individuals, giving a CPR of 27.2% of individuals with teeth (Pinter-Bellows 1993). A lower CPR of 6.7% of individuals is recorded from 29 sites, with a TPR of 9.1% of teeth affected from 6 sites, among those studied by Roberts and Cox (2003), but it is not clear if these values combine data for adults and subadults.

Abnormal wear patterns

Extra masticatory wear was observed on the upper central incisors of adult male skeleton 642 (Grave 650) aged upwards of 18 years. These two teeth had significantly more wear compared with other teeth from the dentition and were associated with granulomas. Occlusal wear was advanced, with dentine exposure which may have predisposed to the granulomas. Adult female skeleton 1361 (Grave 1437) aged upwards of 18 years also displayed extra masticatory wear on the upper teeth, including the incisors, canines and premolars (Fig. 5.58). These teeth were worn down to the dentine and the central incisors were worn medio-laterally into a 'V' shape. In both cases it was not possible to refine age estimates and the possibility that the individuals were considerably older may have a bearing on the degree of wear. The wear patterns could be related to some sort of activity, for example, medial-lateral movement of a thin cord would create such an effect.

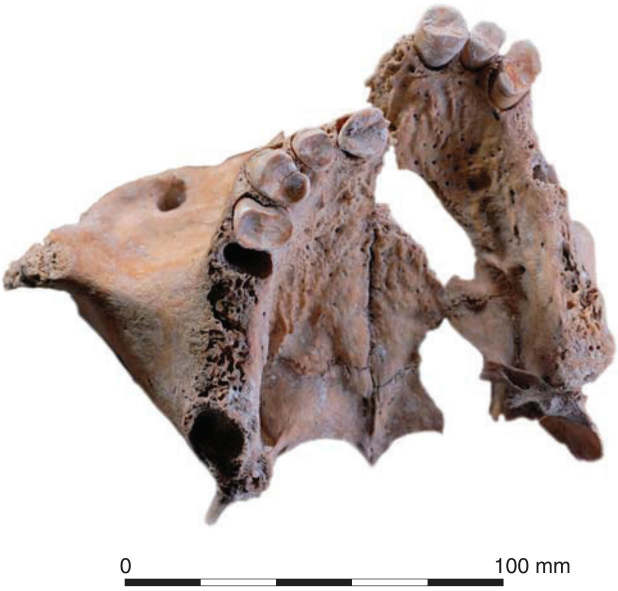

Fig. 5.58 Skeleton 1361. Abnormal wear on maxillary teeth

Dental anomalies

The genetics of most skeletal traits are not well established, but a number of dental anomalies have been shown to 'run in families' (Berry 1978; Brook 1984). These include enlarged and supernumerary teeth, reduced and missing teeth (hypodontia or agenesis), and invaginated incisors, including shovel shaped and palato-gingival grooves (Molleson 1993, 168). A range of anomalies was observed among the skeletons at Lankhills and these are summarised below (Table 5.53).

The identification of these anomalies was based on the descriptions provided by Turner, Nichol and Scott (1991). The most frequent anomaly was agenesis of the third molar, but in the absence of radiology it is possible that in some of the 26 cases recorded the tooth may simply have been unerupted. Care is needed to distinguish between agenesis and impaction, or loss through injury or disease, which may leave little sign on the alveolar crest. The third molars are the most frequently missing teeth followed by upper second incisors, upper or lower second premolars, lower first incisors, and upper or lower first premolars (Hillson 1996a, 113).

Missing third molars were also the commonest dental anomaly at Poundbury (as in other archaeological populations). Just over a third of the sample (39%) (selected for completeness of the dentition) had agenesis of at least one third molar (Molleson 1993, 168, table 29) which is three times the frequency found in modern material (12.7%) (Shin 1975). The frequency of third molar agenesis at Cirencester was 24.3% for males and females combined, with a slightly higher frequency among the females (27.8%) than the males (22.9%) (Wells 1982, 150). The high frequency of dental anomalies in general at Poundbury led Molleson to suggest a strong genetic relationship within the Poundbury population (1993, 168). This is not borne out by the frequency of dental anomalies at Lankhills.

Skeleton 1637 (Grave 1907) had an unerupted tooth lying on its side within the hard palate of the maxilla located where the second right incisor should be.

Crowding and rotation was exhibited by 7 and 13 skeletons respectively. Irregularity and overlapping of the anterior teeth is so common as to be almost normal. Some are merely twisted out of position, but others are wholly displaced to the lingual or labial side (Hillson 1996a, 112). At Cirencester 24 individuals had some crowding, always of the anterior teeth, and in a few cases this was severe (Wells 1982, 150).

Six teeth were impacted. Properly, impaction implies that the tooth remains inside the jaw and does not emerge into the mouth at all, but there are many variations and a tooth may erupt sideways into its neighbour, presenting one of its crown sides uppermost. The most commonly impacted tooth is the third molar, especially the lower, followed by

Table 5.53: Number and type of dental anomalies observed

Number of individuals	*Skeleton Numbers*	*Dental anomaly*
6	20, 435, 1061, 1133, 1289, 1870	Shovelling
7	1552, 61, 119, 616, 1477, 1894, 3002	Crowding
5	77, 119, 593, 1637, 1902	Impaction
2	108, 1271	Enamel pearl
4	1621, 77, 451, 1284	Peg molar
13	1557, 271, 429, 522, 579, 1498, 616,683, 741, 1038, 1084, 1621, 1894	Rotation
1	271	Transposition
1	1133	Carabelli's cusp
26	55, 84, 259, 271, 281, 451, 566, 616, 642, 652, 683, 741, 806, 879, 908, 914, 956, 1114, 1137, 1281, 1481, 1532, 1552, 1621, 1640, 1734	Agenesis of the third molar

the upper canine (Hillson 1996a, 113). Roberts and Cox (2003, 162, table 3.31) record 977 examples for the Roman period and pose the question – did the affected individuals suffer or was there treatment available if the tooth became infected?

Neighbouring teeth may swap position (transposition). This is generally associated with some degree of irregularity and/or rotation (Hillson 1996a, 113). Skeleton 271 (Grave 272) exhibited this condition. Skeleton 1133 (Grave 1355) had an additional cusp on the mesiolingual corner of the left upper first molar, known as a Carabelli's cusp. Hillson (1996a, 85) classifies this as a non-metrical variation.

In incisors and sometimes in canines, the marginal ridges can be especially prominent and enclose a deep fossa in the lingual surface. This is known as shovelling and is also classified as a non-metrical variation (Hillson 1996a, 86). Shovel-shaped incisors were seen in six cases at Lankhills and in three dentitions at Cirencester (Wells 1982, 150).

An enamel pearl is a separate nodule of enamel covered by an enamel cap which is sometimes present on the root surface of upper premolars and molars. Enamel pearls are particularly common in teeth with fused roots, especially on mesial or distal surfaces of permanent upper second and third molars (Hillson 1996a, 98), and occurred in two skeletons at Lankhills. Four individuals had peg-shaped molars at Lankhills, while two cases were reported at Cirencester (Wells 1982, 150).

Disarticulated human skeletal remains from grave contexts

Disarticulated human remains were recovered from 89 graves, noted in the grave catalogue in Chapter 3 above. Further details of the material by context can be found in the project archive. These remains ranged from a single tooth to near complete skeletons. Nine contexts contained the remains of two individuals while one context contained three. Grave 755 contained disarticulated elements of three adults, consisting of three skulls and postcranial elements of two elderly females and a male. Here the additional skulls were placed towards the edges of the grave cut. Grave 1350 contained two probable male adults represented by repeated foot bones. Grave 1907 had parts of at least one adult male and one adult female based on the presence of a whole female skull, another cranium and many postcranial elements. In total 74 adults (10 males and 6 females) were represented by disarticulated remains, along with 14 subadults, 1 infant and 12 neonates.

Disarticulated human remains from contexts other than graves

Very small quantities of human bone, often comprising only a single bone or tooth, were recovered from topsoil and from nine contexts other than graves. These are detailed in the project archive. All the material derives from adult individuals.

Discussion

The preceding sections have presented the results of the osteological analysis of 284 skeletons from OA Lankhills. Demographic data from the recent work on Clarke's Lankhills (Gowland 2001; 2002; 2004) has been combined with OA Lankhills to facilitate a meaningful examination of the cemetery as a whole. Where possible, information has been compared to that from other contemporary cemetery groups, although for some categories of information the data are either unavailable or not in a compatible format.

One of the main aims of the analysis has been to attempt to illuminate the life experiences of the individuals who formed the cemetery population instead of merely presenting a series of tables and statistics. Rather than viewing the skeleton as a fixed biological entity we should view skeletal information as the product of an individual interacting within a social as well as physical environment in a dynamic way (Gowland 2004, 136). For example, frequency and occurrence of particular pathologies are likely to relate in some way to the age, sex and social status of the individual. Different occupations and activities will have led to different exposure to trauma, joint disease and infection. An obvious example is the role of young women who are actively engaged in childbirth. Access to a better diet, and perhaps medical treatment will also have been dictated in part by age, sex and position within society. Clear evidence at OA Lankhills has been identified for differences between males and females in the frequency of joint diseases, which may reflect gendering of work-related activities, and has also been seen in the occurrence of trauma, particularly fractures.

Skeletal condition and completeness have clear implications for the level of information that can be recovered, particularly in relation to pathologies, and may mean that they are under-represented. A detailed consideration of condition and completeness has concluded that preservation of adult males and females was good on the whole, but less so for subadults. Detailed data on pathology are not yet available for Clarke's Lankhills although there is useful assessment information relating to some aspects of the material (Gowland 2004. 140).

It is due to the paradoxical nature of palaeopathology that the very individuals who exhibit signs of infection may in fact be the healthier ones in a society. This is because pathological skeletal changes demonstrate that an individual had a sufficiently strong immune status to withstand a disease process long enough for the bones to become affected. Adolescent female skeleton 20 (Grave 18) showed signs of vitamin D deficiency, possible iron deficiency anemia and unspecified childhood illness which led to the development of enamel defects in the teeth. She also suffered from a condition known as cribra femora, similar in appearance to cribra orbitalia, which has been linked to a deficiency of magnesium. This combination of conditions may suggest generalized malnutrition, which the girl survived into her teenage years.

Many of the individuals at OA Lankhills lived to a good age and so must have been in relatively good health. The analysis of the carbon and nitrogen isotopes suggests that everyone at OA Lankhills had some access to animal protein. There were no differences when adults of different age categories were examined. Males did, however, have a slight enrichment of both carbon and nitrogen, although this was deemed not to be significant and therefore unlikely to reflect any substantial differences in dietary practices between the sexes. It was concluded that overall the population had ready access to multiple sources of animal protein, including, for some at least, small amounts of marine fish, and that they were generally adequately nourished.

It is clear from the skeletal evidence that some individuals would have appeared physically different or debilitated to their contemporaries. These include skeleton 1026 (Grave 1070), who suffered from scaphocephaly (premature closure of the sutures of the skull). This child, thought to be a girl since she was buried with two bracelets and a ring, would have looked odd, with a slightly lopsided face and a misshapen head. She had been buried prone without a coffin and it is tempting to link the choice of burial position with her disability, although the fact that she was accompanied by jewellery suggests that this was not necessarily a mark of disrespect.

Skeleton 1197 (Grave 1270) was an old woman aged at least 60 years in whom both hip joints had fused. In the absence of any contradictory evidence it is suggested that this fusion may have occurred because one of her legs was slightly shorter than the other with some modification of the lower legs; the femur heads were angled slightly outwards (laterally) and in front of the body (anteriorly). The hip joints may have fused over time as a means of supporting her slightly unusual gait. In contrast to the child discussed above she was buried within a coffin, in a supine position, wearing hobnailed shoes and accompanied by an antler comb.

Skeleton 861 (Grave 905) was an adult male at least 60 years old who had also been buried in a prone position without a coffin. He was wearing a pair of hobnailed shoes though there were no accompanying grave goods. Most of his right little finger had been amputated (whether accidentally or deliberately). Most noticeable though would have been his deformed right arm, probably caused by falling on the elbow and fracturing the humerus. The elbow was completely fused at approximately 100-110 degrees with pronation of the lower arm and

Fig. 5.59 Skeleton 861. Osteoarthritis of the right femoral head

there was much associated degenerative change. Clearly the activities this man could perform would have been dictated by the restricted movement caused by this injury. He exhibited a range of degenerative change associated with old age including spinal osteophytosis (all vertebrae), Schmorl's nodes (affecting all eight of his lowest vertebrae), eburnation (on the fifth and sixth cervical vertebrae of the neck), fusion (ankylosis) of four of seven cervical vertebrae and osteoarthritis affecting his right hip joint. This latter condition may have developed in response to trauma (Fig. 5.59).

In common with the injury to the arm it too was on the right side and the left hip joint was unaffected. He had lost at least 16 of his teeth, had calculus (tartar) and advanced periodontal (gum) disease. Clearly, many of these changes, with the exception of the right arm and the right finger, could be age-related. However, when the skeletal evidence from 861 is considered alongside that of other prone burials (skeletons 661, 686, 919, 1026 and 1281 (Graves 665, 735, 970, 1070 and 1350 respectively)) interesting patterns can be observed. Isotope analysis suggests that four of these individuals (skeletons 661, 919, 1026 and 1281) had a diet slightly depleted in carbon and nitrogen when compared to the rest of the population (see Cummings and Hedges below). This evidence combined with the mode of burial has led to the inference that these individuals may have been of low or even servile status (see Chapter 7). The skeletal data add considerable weight to this inference. All five of the adults had medium to severe degenerative changes, particularly in the spine, and bad dental health. Skeleton 1026, the child with scaphocephaly discussed above, also suffered from probable iron deficiency anaemia. Skeleton 1281 may have suffered from rickets, while skeleton 661 had a poorly healed fracture to the left side of her jaw (Fig. 5.60). Galloway (1999) suggests that this fracture location has a 4:1 male dominance and the most common cause is in fistfights. This woman also had degeneration of her shoulder, hip and knee joints.

It has been argued that cultural information concerning the life of an individual (osteobiography) can be obtained by examination of their skeletal remains (Robb 2002) and that it should therefore be possible to examine a single burial within a cemetery and use the skeletal and material variables to build a social picture of an individual life experience (Gowland 2004, 139).

As an example, this approach was used (ibid.) in the examination of skeleton 283 from Clarke's Lankhills. The skeleton was of an adult male aged 35-49 years who was buried supine with planks placed over the body rather than in a proper coffin. Clarke (1979, 61) considered that the grave was too short and therefore probably unfinished, and that the burial rite was intrusive on the basis of number of grave goods, presence of broken objects and use of planking (ibid., 391). This man was one of only three with osteomyelitis (the addition of two examples from OA Lankhills takes the CPR to 0/7%, 5/765). There was no evidence of trauma to the infected right shoulder so it could have been

Fig. 5.60 Skeleton 661. Healed fracture of the mandible left side

caused by the presence of pyogenic bacteria. The infection was advanced and a weeping ulcerated lesion may have been visible at the surface of the skin, causing severe discomfort and debilitation. This man also had severe osteoarthritis in both elbows with eburnation in identical areas on left and right sides, suggesting that he undertook a specific activity involving the use of both arms in a similar motion. This is likely to have been carried out prior to the development of the debilitating infection evidenced by the osteomyelitis. Severe degeneration in the mid and lower spine is suggestive of a strenuous lifestyle. Skeleton 283 also had a healed fracture of the right fibula, one of 14 fractures from Clarke's Lankhills, only two of which were in females. This led to the suggestion that the risk of fracture must be related to gender and therefore to gendered roles (Gowland 2004, 143).

To what extent did urban living predispose a population to infection? The rate of periostitis at OA Lankhills was low when compared to other Roman populations (see above). Only 5.6% of observable bones were affected (54/2808). Marginally more men (TPR 1.3%; 17/1299) than women (TPR 1.2%; 13/1109) were affected, which agrees with observations for Clarke's Lankhills (Gowland 2004, 143). It was also noted at Clarke's Lankhills that females tended to exhibit periosteal new bone growth in a greater variety of skeletal elements and it was argued (ibid.) that this may indicate either a different pattern of immune response to similar 'health stresses' between the sexes (cf Redfern 2002) or differential exposure to such stresses according to gender. This was not seen at OA Lankhills.

Twenty-one adult individuals, 15 men and six women (CPR 9.6%), had degenerative change to joints other than the vertebrae. The joints of the upper body were mostly affected, the only four exceptions being in one hip, two knees and one ankle. The pattern of vertebral osteophytosis is interesting. It was much more marked in men than women for all vertebrae, suggesting that men were regularly involved in an activity or activities that predisposed them to develop the condition. This pattern is also reflected in the distribution of Schmorl's nodes. While the number of adults who suffered spinal osteoarthritis is small, nonetheless something of a trend can be observed. Cervical vertebrae were affected more in women while thoracic and lumbar vertebrae were more affected in men. This broadly equates with Gowland's results which suggest that in general men had more degenerative changes than women, and that the more severe changes in the men tended to be in the lower spine. The variation between the sexes suggests that these men were involved in more physically strenous activities, perhaps related to manual labouring rather than trade.

The rate of fractures at OA Lankhills was quite low, but some patterns can still be discerned. All fractures were healed, though not necessarily in alignment: some were noticeably deformed (skeletons 61, 861 and 1289 (Graves 58, 905 and 1329)). The number of men with fractures outnumbered women by almost two to one. Ribs were most commonly fractured with a total of 20 fractures among 9 men and women. Skeleton 683 (Grave 790) had five left and three right rib fractures. He also had a broken nose and breaks to both left and right arms and it is tempting to suggest that he may have been something of a fighter, although all of his injuries could equally have been caused accidentally. The most common cause of rib fractures is direct injury such as a fall against a hard object (Adams 1987, 107). Noses were the next most common fracture site and all were in males with the exception of skeleton 61 (Grave 58), a female aged 26-35 years. Only six tibiae and five fibulae had been broken. There were three depressed skull fractures, all of which were exhibited by women.

It is important to consider how peoples' lives might have been affected by the diseases or injuries that they suffered. A small number of people must have suffered terribly from toothache, which even today with the use of painkilling medicine can be difficult to bear. Skeleton 1640 (Grave 1638), a man aged upwards of 45 years, at 1.87 m was the tallest person in the cemetery and would certainly have appeared quite striking to his contemporaries. At the time of his death he had four severe dental abscesses, all apparently linked to advanced tooth decay. The pain must have been too extreme for him to bear chewing, on the right side at least, as evidenced by the considerable build up of calculus there (Fig. 5.57). This man also had spinal degeneration affecting the upper and lower vertebrae but not those in the middle. At some point he had fractured two of the metatarsals in his right foot and while the bones had healed, both were misaligned with 'kinks' in the shafts. This contrasts with the preliminary findings on Clarke's Lankhills (Gowland 2004, 143) which suggest that fractures tend to be well-aligned, indicating some form of treatment; this is thought to be a general characteristic of fractures in the Roman period (Larsen 1997, 152).

A number of the morphological features of the skull of adult male skeleton 566 (Grave 610) suggest that he may have been of Black or Asian rather than Caucasian origin, in contrast to the vast majority of the population. This observation is tentative and recommendations for further work are discussed in the final section. Osteologically, this skeleton was otherwise unremarkable. He was buried supine within a wooden coffin and without grave goods.

Strontium and oxygen isotope analysis has identified a group within the assemblage whose isotopic signature is clearly not British and suggests that they originated in an area with a hot and/or arid environment, perhaps on the southern side of the Mediterranean. This small group included a young adult female, skeleton 119 (Grave 99), with cranial characteristics which suggest a possible origin in Egypt on the basis of preliminary analysis using the CRANID programme (Richard Wright pers. comm.).

Carbon isotope analysis suggests that infants may not have been exclusively breastfed, which could have led to malnourishment, and perhaps contributed to their early deaths. Four of the infants under the age of two (skeletons, 8, 221, 404 and 1314 (Graves 6, 231, 445 and 1317 respectively)) show evidence of health problems including cribra orbitalia, infantile cortical hyperostosis and scurvy, all of which are related to vitamin deficiency.

Generally speaking the population did not appear to have suffered from a high disease load, although again some patterns can be discerned. There were more females with cribra orbitalia than males, and slightly more with dental enamel hypoplasia, although the pattern is reversed for infection, fractures and joint disease. Almost twice as many women as men had cribra orbitalia. The highest rates of cribra orbitalia were in the adolescent (44.4%), young child (28.6%) and young adult categories, while for DEH it was adolescents (66.7%), prime adults (47.4%) and mature adults. The dominance of joint disease, spinal disease and fractures in males is likely to reflect division of labour between the sexes, with males involved in slightly more physically strenuous activities, although the overall low rates point to a lifestyle which did not involve a great deal of hard manual activity.

There were no specific infections among the adult population, which suggests that living conditions were not particularly crowded. The incidence of tuberculosis, for instance (of which there was a single possible case), increases with poor living conditions, poor nutrition and social deprivation. The rates of sinusitis were low and the majority of cases were in elderly people over the age of 60 years.

The dental health of the Lankhills population was probably a little better than average when compared to that of people in contemporary sites. Where comparable the dental disease rates for this population are the same as or lower than at other sites. Dental health can be linked to the more general health of the individual, which it appears was quite good for this population. As a component of this it is significant that low levels of dental attrition reduced the risk of exposure of dentine to bacterial attack. Dental disease is also specifically an indicator of diet. Lack of oral hygiene combined with ingestion of carbohydrates (particularly sucrose) will lead to higher rates of dental disease. Nevertheless, despite the increased availability of carbohydrates in the Roman period, and the evidence for a varied diet suggested by the carbon and nitrogen isotopes (see below), the generally good condition of the Lankhills teeth was notable, indicating good physical health.

Health problems as a result of living in towns may be indicated by length of life, disease and achieved stature, but determining whether a person was stress-free and happy is much more difficult (Addyman 1989, 245). During the Roman period, rural to urban migration could have provided the potential for people to contract new diseases that they had never previously been exposed to, and in theory they may have been living in poor housing with inadequate diets and exposed to new pathogens (Roberts and Cox 2003, 123). The evidence at OA Lankhills would seem to contradict this impression. Perhaps we should be asking how 'rural' in character this population was. All the evidence suggests a group in good health, almost all of whom had access to an adequate diet and a significant number of whom lived well into old age. The majority were perhaps relatively well-off and engaged for the most part in trade-related activities rather than physically stressful manual labour.

Future potential of the assemblage

The Lankhills assemblage has enormous potential for future research, far exceeding the scope of this project. It has been possible using the work of Gowland (2002) to look in depth at demographic data for the population as a whole which numbers 765 individuals. At the time of writing data on skeletal and dental pathology were not available although some useful observations based on assessment data have been published (Gowland 2002; 2004) in advance of more detailed analysis (Stuckert forthcoming) and these are touched upon above.

Diagnosing the osteological sex of subadults is notoriously problematic and is usually not attempted. However, given the large size of this population and the numbers of children with permanent dentition, it is possible that discriminant function analysis based on the crown dimensions of permanent teeth of subadults may be a means of addressing this problem. Some preliminary work was done and the results seemed promising, although this type of work is not routinely undertaken in standard osteological reports. A fairly high proportion of children at Lankhills were buried with grave goods and it would be useful to test these associations with estimation of osteological sex using tooth dimensions.

There is scope for extending the level of metric analysis carried out to date on the assemblage. It was possible to calculate stature for 69 individuals using the femur only. In the absence of complete major long bones, body stature can be estimated from the mid-line length of the metacarpals according to the method developed by Meadows and Jantz (1992), and the maximum length of the calcaneus and talus (Holland 1995). During analysis it was observed that there was marked sexual dimorphism within the assemblage, a feature also seen at Poundbury (Molleson 1993, 165). It would be useful to explore this further through far more detailed metric analysis than a standard skeletal report allows.

Skulls, or parts of skulls were present in a total of 246 graves. Of that number there were 90 male and 89 female skulls. Many were fragmented and could not be reconstructed as part of this analysis. It was possible, therefore, to calculate indices for only 55 adult skulls without undertaking extensive reconstruction. Data on the numbers and condition of the skulls from Clarke's Lankhills are not currently available, but there is much potential to increase the data set. Tentative observations have already been made on the basis of some cranial indices, including the identification of three individuals with a particularly broad nasal aperture, a feature which can be characteristic of skulls of Negroid populations (Bass 1987, 87). The isotope analysis has demonstrated that at least one of these individuals is likely to have originated in western or northern Britain. These findings underline the desirability of much further work on isotope analysis of this assemblage. Results of work recently made available as part of the Diaspora project hosted by the University of Reading have demonstrated that a high status burial of the second half of the 4th century from York was that of an adult female of African origin. This clearly counters the assumption that all Blacks in Roman Britain were low-status male slaves.

During the course of skeletal analysis, it was observed that compared with the rest of the population the skull of adult male 566 had unusual characteristics, which are more consistent with Black and Asian groups than with Caucasians (see Loe above). As only broad classifications can be achieved through observation of skull morphology alone it is recommended that other methods such as CRANID and FORDISC which use metrical data in discriminant function analysis programs are required to supplement them. The possible southern Mediterranean origins of female adult 119 suggested by a combination if isotope analysis and preliminary work using CRANID (see above) indicate that this assemblage has the potential to contribute significantly to our understanding of population diversity in the Roman period.

The OA Lankhills group appears 'older' when compared with Gowland's analysis of Clarke's Lankhills. As the two groups represent presumably a single population this fact hints at possible zoning within the cemetery, with more of the older individuals being buried in the area of the OA excavations. Other aspects of variability between the two main excavated samples may be seen when the osteological evidence os compared with that of the associated objects, for example in the different occurrences of grave goods with neonates and infants. The combined demographic data form an excellent basis for examining these and many other cemetery variables.

CREMATED HUMAN BONE *by Ceridwen Boston and Nicholas Marquez-Grant*

Introduction

Thirty features within the excavated area contained deposits of cremated human bone, and a further three included very small undiagnostic fragments of burnt bone where the species could not be determined. The assemblage comprised five urned and 13 un-urned burials, seven possible *busta* and five small deposits of redeposited cremated remains. The status of these last is uncertain and they are excluded from the catalogue of cremation burials in Chapter 3. No deposits of pyre debris were recovered, with only one non-*bustum* deposit (context 857) containing sufficient charcoal to suggest a small dump within a large pit (847). Otherwise, there was no evidence to suggest that surface pyres were located within the excavation area. The absence of pyre debris does not preclude the presence of pyre sites in the area. Alternatively pyre debris may not have been considered to be a necessary inclusion within deposits.

The cremation graves were discovered in two major clusters within dense areas of intercutting features. As a result, a number were truncated by later cremation or inhumation graves. Others had suffered damage from modern construction and service trenches within the area. The stratigraphical and artefactual chronology of the two clusters suggests that one was very early in the burial sequence at Lankhills while the second was very late. Nevertheless, both groups are rare in dating to the late Roman period, when the rite of cremation had largely been superseded by inhumation burial. This is also true of the possible *busta* at Lankhills; these are more commonly found in early Roman contexts in Britain, although they are not exclusively of this date range (eg Struck 1993b, 92).

Methodology

The un-urned cremated bone deposits were recovered as bulk soil samples and were subsequently wet-sieved and flots collected for charred plant analysis. Human bone, charcoal, artefacts and faunal remains were retrieved from the wet-sieved residues that had been sorted into fractions of >10 mm, 10-4 mm and 4-2 mm.

Four urned burials (766, 1055, 1255 and 2060) were lifted intact and their contents excavated in the laboratory by an osteologist. The urns were excavated in 20 mm spits, with a plan recording the spatial arrangement of bone, pyre and grave goods at each level. Written descriptions were also made, including maximum fragment size, colour, identified bone element, the presence of charcoal, burnt soil, and pyre and grave goods contained within the vessel.

Osteological analysis on the washed bone was undertaken in accordance with guidelines set out by the IFA (McKinley 2004c). The minimum number of individuals (MNI) was calculated by counting the presence of repeated bone elements (eg left proximal femur) and differences in age and sex characteristic of fragments within each deposit.

The same sex and age categories and standard methods that were employed in skeletal age and sex estimation of the inhumations at Lankhills (see Clough and Boyle above) were applied to the cremated remains. Ectocranial suture was used only as a complementary method, as this method has been shown to be unreliable on its own (see Key *et al.* 1994; Lynnerup and Jacobsen 2003). Metrical analysis involved measuring cranial vault thickness, which has been employed in estimating biological age, although there are several problems inherent in this approach (see McKinley 2000b). Measurements were taken with a sliding calliper to the nearest 0.01 mm. Non-metric traits (see Clough and Boyle above) were scored as present or absent. Identification of pathological changes followed the same procedures outlined by Clough and Boyle (above).

Deposit types

Deposit types were defined using the criteria set out by McKinley (2000c), which are summarised in Table 5.54. The Lankhills assemblage contained the remains of five urned burials, 13 un-urned burials and seven possible *busta*. Five groups of redeposited cremated remains may have been remnants of truncated burials. There were no dumps of pyre debris, and the possible *busta* were the only indication that cremation had taken place within the excavation area.

Seven possible *busta* were identified at Lankhills, although McKinley (2000c) does warn that identification of this deposit type may be problematic, and some of the Lankhills examples may not be unequivocally assigned to this category (Table 5.54). *In situ* burning is certainly apparent with typical salmon-pink colour changes to the sides and top of the graves. Where the cremated bone was collected in a number of samples from head to foot of the grave (four graves), *in situ* burial could be demonstrated. The bone appeared to be laid out on a spread of charcoal, and charcoal and *in situ* nails suggest that the pits were wood-lined or contained the bases of wooden platforms on which the corpse had rested on the pyre. Burnt wooden linings with nails hammered into the walls of the pit were present at Brougham, Cumbria (Cool 2004, 465).

Results

Disturbance and condition of bone

The cremated bone deposits are summarised by category in Table 5.55. The condition of the cremated bone from Lankhills is good. Trabecular bone is well-preserved, resulting in a high proportion of recognisable elements. Non-representation of bone could reflect deliberate selection of the

Table 5.54: Definitions of cremation-related deposit types containing cremated human bone

Deposit type	*Definition*
Bustum	Pyre site that also functioned as a grave. The pyre burnt down into the under-pyre pit and the human remains are buried in situ. Where no secondary manipulation has occurred, the cremated remains are expected to lie in the correct anatomical position on a bed of charcoal. The effects of the burning have been observed to penetrate the soil by 2-5 cm. The average weight of bone retrieved from a cremated adult is between 1600-2000 g but may be as little as 1000 g.
Urned burial	Deposit of cremated bone within a container. May be surrounded by, on top of or overlain by redeposited pyre debris.
Un-urned burial	Concentrated deposit of bone, which may have been in an organic container, which may also include a secondary deposit of pyre debris within the backfill.
Un-urned burial or redeposited pyre debris	An apparently mixed deposit of cremated human bone and charcoal which may represent the remains of one or more cremated individuals.
Pyre site	Large quantity of charcoal with relatively small amount of burnt bone fragments situated on the ground surface or in under-pyre pits. The pits may also be T- or L-shaped to aid draught and are shallow (0.10-0.20 m deep). The soil beneath the pyre should show evidence of burning that may penetrate the soil by 2-5 cm.
Redeposited pyre debris	A mixture of fuel ash, fragments of cremated bone and pyre goods, and possibly burnt flint, burnt stone, burnt clay, fuel, ash and slag depending on the local environment. May contain a relatively large quantity of bone since a small deposit of bone may have been collected for burial. The deposit may be present in the backfill of the burial, over the cremation burial, within pre-existing features, uncontained in spreads and in deliberately excavated features.
Redeposited cremated remains	Small amounts of cremated bone situated or recovered from features, such as pits and ditches, and in the backfill of intercutting cremation burials.
Cremation-related deposit	Unknown deposit type including cremated human bone.

Table 5.55: Summary of cremated bone deposits (n=30)

Group	Contexts	Bone weight (g)	Depth of feature (m)	Primary colour	Secondary colour	Max. fragment size	Age and sex
Possible *busta*							
655	607	1641	0.43	White	Grey, black, blue	82 mm (tibia)	Adult male?
910	869*	1277.3	0.39	White	Blue, grey	65 mm (femur)	?Mature adult (36-45 y) female
1180	983	1566.7	0.13	White	Grey, blue	42 mm (rib)	Young adult (18-25 y) unsexed
1195	1121*	1308	0.68	White and light grey	Blue, brown, black	95 mm (tibia)	Young adult (18-25 y) unsexed
1215	1148*	1155.5	1.20	Blue	Grey, white	70 mm (ulna?)	Adult ?male
1806	1770, 1771*	1052.4	0.25	White	Grey, blue, black	70 mm (tibia)	Adult male
1845	1843, 1844	171.4	0.30	White	Grey, blue, black	33 mm (femur)	Infant
Redeposited cremated remains							
790	833	32.8		White	Grey, blue	60 mm (tibia)	?Unsexed adult
795	759	10.3		White	Light-grey	11 mm (cranium)	Unsexed adult
1671	1673	32.5		White	Grey, blue	30 mm (long bone)	?
1921	1924	3.1		White	Blue	23 mm (vertebra)	?
2064	857	100.3		Grey	White, blue, black	63 mm (femur)	?Adult
Un-urned burials							
895	843	1097.6	0.22	White	Grey, blue, black	50 mm (femur?)	Mature adult (36-45 y) ?male
915	872	1174.1	0.23	White	Blue, grey	77 mm (humerus)	Unsexed adult
945	888*	14.7	0.15	White	Light grey	15 mm (radius?)	?
1060	808*	1055.1	0.27	White/ light grey	Dark grey, blue	77 mm (femur)	1 adult ?female 1 adult ?male
1065	911*	47.3	0.14	Grey	White	42 mm (tibia)	Unsexed ?adult
1160	1107*	237.3	0.15	Grey	White	39 mm (tibia)	Unsexed ?adult
1320	1238	580.6	0.02	White	Grey, blue, brown, black	50 mm (femur)	Unsexed ?adult
1527	1526	95	0.05	White	Grey, blue	51 mm (radius)	Unsexed ?adult
1724	1661*	335.8	0.06	White	Grey	75 mm (tibia)	Adult ?female
1742	1728	465.8	0.09	Grey	White	87 mm (clavicle)	Mature adult (36-45 y) female
1786	1788	724.9	0.10	White	Light grey, blue, brown	70 mm (tibia)	Adult female
1798	1628*	405.7	0.12	White	Grey	42 mm (humerus?)	Unsexed adult
1904	1749, 1750*	351.7	0.24	White	Grey, blue	74 mm (femur)	?Young adult (18-25 y)
Urned burials							
510	457, 466, 468*	711.8	0.10	White	Light grey	47 mm (rib)	Adult ?male
845	766*	563.1	0.11	White/grey	Blue	67 mm (femur)	Unsexed adult
1055	1008	794.5	0.34	White	Blue, grey	92 mm (tibia)	Adult male
1255	1187*	51	0.16	White	Light grey, light brown	80 mm (rib)	Unsexed adult
2060	424, 425, 428	834.6	?	White	Grey, blue	78 mm (radius)	?Prime adult (26-35 y) male Unburnt infant (5 m-1 y)

Contexts marked with * have been truncated

cremated remains for burial by the mourners or funerary attendants, or more likely perhaps, be due to the truncation of burials by later activity - by subsequent graves and pits, and modern landscaping, foundation and service trenches of the school buildings. The group of cremation burials that appeared to be stratigraphically earlier than the main phase of burial activity at Lankhills comprised 1742, 1806, 1845, 1904 and possibly 1180.

A later group of cremated bone deposits appeared very late in the burial sequence. These included 655, 845, 1055, 1060, 1195, 1215 and 1255. Un-urned burial 1060 was cut by inhumation grave 790 and urned cremation grave 845. The redeposited cremated bone in inhumation grave group 790 (weighing only 32.8 g) thus probably derived from this disturbed cremation burial. Cremation burial 1215 was cut by cremation 1195.

The remaining six burials (895, 910, 915, 945, 1320 and 2060) were widely distributed across the excavation area. The un-urned, possibly boxed, burial 1320 survived to a depth of only 0.02 m while urned burial 2060 was recovered largely intact and its contents excavated in the laboratory. Cremation burial 895 cut burial 910, and hence may contain some redeposited bone from that context. Cremation deposit 945 survived to a depth of 0.15 m and contained only 14.7 g of cremated bone and some fragments of pottery. Grave depths and an indication of which were truncated appear in Table 5.55. Substantial amounts of bone were present in some relatively shallow features such as 1320 which contained 580.6 g of human bone. Un-urned burials can survive fully intact in graves only 0.06 m deep (J McKinley pers. comm.).

Demography

Minimum number of individuals

Urned burial 2060 contained the cremated remains of a prime adult male (26-35 years), alongside several unburnt cranial fragments and two deciduous molar crowns of an infant, aged five months to a year. The infant remains were recovered within the uppermost 60 mm of the urn fill. While the unburnt remains may be intrusive, and relating to one of the many disturbed infant burials on the site, it is equally likely that they were a deliberate inclusion. Un-urned burial 1060 contained two fragments of supra-orbital ridge, one female and one male. All other cremation burials appeared to contain the remains of only a single individual.

Age and sex distribution

Data on age and sex appear in Table 5.55. Possible *busta* 1180 and 1195 contained the remains of young adults (18-25 years) while 895, 910 and 1742 were considered to be mature adults (36-45 years). Un-urned burial 1904 was a probable young adult. An infant was identified within *bustum* 1845, while an unburnt infant was recovered from 2060 which also contained the remains of a prime adult (26-35 years). A total of 19 deposits could only be assigned to the adult category (more than 18 years). Three small deposits (945, 1671 and 1921) lacked diagnostic features that would allow an estimation of age to be made.

Owing to the good preservation and low fragmentation of the material in most deposits it was possible to identify the sex of almost half of the adults (42.3%): seven males or possible males and four possible females. This high proportion of sexed individuals reflected the good preservation and low fragmentation of most deposits. Some patterning of sex distribution was suggested by the different categories of cremation burial.

Three of the five urned burials contained the remains of a male (1055 and 2060) or possible male adult (510), while the sex of the others (845 and 1255) was unknown. In contrast, the sex of the individuals in un-urned burials was more mixed, with four possible females and two possible males being identified.

The individuals in the group of seven possible *busta* comprised one infant (1845), two young adults of unknown sex (1180 and 1195), one adult male (1806), two adult possible males (655 and 1215) and one mature adult possible female (910). In the past *bustum* burial has tended to be interpreted as a primarily military tradition introduced from the Northern Frontier zone, and associated with forts (eg Brougham, Cumbria (Cool 2004)) and Hadrian's Wall. More recent work on civilian cemeteries has also revealed *busta*, however, examples including Pepper Hill, Kent (Biddulph 2006), the Lea, Denham, Bucks (Cotswold Archaeology 2005), and the Eastern and Great Dover Street, Southwark, cemeteries of London (Barber and Bowsher 2000; MacKinder 2000). An older but poorly understood site is at Bray, Berks (Stanley 1972). These burials are not necessarily solely of adult males; for example at Pepper Hill the eight individuals from seven *busta* included two juveniles, three adult females, one adult male, one unsexed adult and one burial that could not be aged or sexed (Boston and Witkin 2006). At the Lea, Denham, at least one *bustum* contained a 5-10 year old child (Coleman *et al.* 2004; Cotswold Archaeology 2005). Thus, the inclusion of a possible female and an infant in the Lankhills *busta* assemblage is not unprecedented, although the latter is very young. Unfortunately, the human remains from the only possible *bustum* burial within Clarke's excavation could not be aged or sexed (Gowland 2002).

Non-metric traits

Three individuals showed non-metric variation: some of these traits are inherited while others are environmentally produced (Brothwell and Zakrzewski 2004, 28). A moderate to large mandibular torus was identified in deposit 895, while parietal bone fragments of deposits 1060 and 1215 displayed parietal foramina.

Skeletal pathology

Because of the partial nature of deposits, fragmentation and surface damage caused by burning, cremated bone tends to display much lower rates of pathological lesions than seen in unburnt bone. Nevertheless, a range of pathological lesions was identified in the Lankhills cremated assemblage, the most prevalent being degenerative joint disease (see Table 5.56). Detailed discussion of the pathologies is not included below, but may be found in the report on the unburnt skeletal material (above).

Degenerative joint disease was classified as spinal or non-spinal in location. Marginal lipping was observed on both spinal and non-spinal joints within deposits 845, 895, 915 and 1180.

Osteoarthritis was identified from clear contour deformation and osteophytosis of the head of a proximal hand phalanx from 1806. Macroporosity and osteophytosis of an atlas body fragment of deposit 845 indicated osteoarthritis in that joint, as did marginal osteophytes of the axis articular facet.

Cribra orbitalia was identified on fragments of the left and right orbits in deposit 1060. The lesions were severe (Grade 5 of Stuart-Macadam's (1991) scheme), suggesting marked or prolonged iron deficiency anaemia in childhood. This individual also showed endocranial lesions.

Pitting of the ectocranial surface of cranial vault fragments, and of the palate and zygomas of deposit 1215 was noted. Abnormal pitting of the maxilla was also observed in deposit 1180. The aetiology of these lesions is unclear but may include deficiency diseases (such as iron deficiency anaemia or scurvy) or localised infection of the overlying soft tissue.

Sixteen cranial vault fragments of adult 1060 showed considerable pitting or multiple small lytic lesions, many of which had penetrated the full thickness of the cranial vault. No bony proliferation was present. There appeared to be increased vascularity in the form of multiple indentations of small blood vessels in the endocranial surface. Although differential diagnosis is problematic, a neoplastic lesion is very tentatively suggested. This individual also displayed severe cribra orbitalia.

Periostitis was identified in three deposits (1180, 1320 and 1904). The surface of seven long bone shaft fragments (possibly humeral and ulnar) of deposit 1180 was overlaid by a mixture of grey porous and laminated bone, indicating active but fairly long-standing periostitis. This individual also displayed abnormal pitting on the maxilla. Together the lesions are very tentatively suggestive of active scurvy, but they may well not have been associated originally. The tibial shaft is the most common location of periostitis in most populations, the lack of overlying soft tissue on the shin making the bone more susceptible to trauma and infection.

Damage to muscle fibres and tendons may induce ossification at the point of insertion into bone, which has been interpreted as evidence of excessive mechanical stress of specific muscles or muscle groups. These manifest as small rugose ridges of bone, and are termed enthesophytes. These were observed in deposits 655, 845, 895, 915, 1055, 915, 1195, 1320 and 1806. The sites of enthesophyte formation all indicate strenuous muscle use of the lower limbs, particularly the thigh and knee joint.

Table 5.56: Dental and skeletal pathology in the cremated human bone (n=30)

Group	*Deposit type*	*Age and sex*	*Pathology*
655	?*bustum*	Adult ?male	Possible gross caries on upper molar. Osteophytosis on 1 LV. Enthesophytes on tibial tuberosity
845	Urned burial	Unsexed adult	OA (macropitting and osteophytosis) on 1 CV body, osteophytosis on facet of atlas, rim of radial head, unidentified articular surface fragment and on at least 2 TV and 1 LV bodies, considerable enthesophytes on linea aspera of femur
895	Un-urned burial	Mature adult ?male	Osteophytosis on part of glenoid fossa and on at least 1 TV (or LV) body fragment, moderate enthesophytes on patella and syndesmophytes on two vertebral spinous processes
915	Un-urned burial	Unsexed adult	2 lower premolars lost ante-mortem. Osteophytosis on acetabulum, moderate enthesophytes on iliac crest and linea aspera and considerable on ischial tuberosity and patellae
1055	Urned burial	Adult male	Slight enthesophytes on patella
1060	Un-urned burial	1 adult male 1 adult female	Gross caries on one upper molar. Endocranial lesions and severe cribra orbitalia
1180	?*bustum*	Young adult, unsexed	Fragment of maxilla with abnormal pitting, slight osteophytosis on neck facet of left rib. At least 7 shaft fragments of possible humerus and ulna with periosteal new bone formation
1195	?*bustum*	Young adult, unsexed	1 tooth lost ante-mortem. Osteophytosis on superior CV body; enthesophytes on calcaneous and patella
1215	?*bustum*	Adult ?male	Ectocranial pitting and pitting on palate and zygomatic bones
1320	Un-urned burial	Unsexed adult?	Tibial periostitis. Slight enthesophytes on linea aspera
1742	Un-urned burial	Adult (30-50 y) female	1 tooth lost ante-mortem (upper premolar or molar).
1806	?*bustum*	Adult male	OA on head of proximal hand phalanx; moderate enthesophytes on patella and some portions of linea aspera
1904	Un-urned burial	Probable young adult, unsexed	Active periostitis
2060	Urned cremation	Prime adult (26-35 y) male Infant	1 lower molar lost ante-mortem. Slight ectocranial pitting on left parietal fragment), slight osteophytosis on fovea capitis of femur, syndesmophytes on 2 spinous process of vertebrae

OA = osteoarthritis

Dental pathology

Dental pathology is difficult to recognise in cremated bone due to the tendency of teeth to shatter during the cremation process. Dental disease may, however, be reflected in alveolar bone. Two conditions recognised in the latter were ante-mortem tooth loss and apical abscesses (probably the result of down-tracking infection from the tooth or gums). A large maxillary fragment in deposit 655 had a smooth-walled lesion typical of an apical abscess, as did a maxillary fragment in deposit 1060. In both deposits a molar was affected. Ante-mortem tooth loss was indicated by remodelled tooth sockets in alveolar bone fragments of deposits 910 (a right upper first molar), 915 (two pre-molars), 1195 (location not recognised), 1742 (upper pre-molar or molar), and 2060 (lower molar).

Pyre technology and ritual

The thoroughness of cremation of the corpse on a pyre is very dependent on high temperatures being sustained for at least 7-8 hours (McKinley 1994b). This often requires tending the pyre and adding fuel during the conflagration. By the end of this period, soft tissue should be burnt away, and most of the skeleton oxidised, although experimental work has revealed that the pelvis may continue burning in the hot pyre debris for several hours after the pyre has collapsed (ibid., 67). Thus, effective cremation requires sufficient fuel and a technology of pyre construction that allows the free flow of oxygen through the structure (McKinley 1989; 2000b).

In 23 of the Lankhills cremation deposits, the predominant or primary bone colour was white, (fully oxidated or calcined bone). The primary bone colour was grey in five cases and blue in one (possible *bustum* 1215). All deposits contained bone that had undergone more or less thorough burning, with all predominantly white deposits containing grey and/or blue bone, and some grey deposits containing white bone. Bone from un-urned burials 1320 and 1786, and urned deposit 1255 showed the most variation in colour, containing predominantly calcined bone but also light grey, charred and unburnt bone. Overall, however, the impression was of effective cremation in most cases. There did not appear to be any correlation between efficacy of cremation and burial type, suggesting that effective pyre technology and sufficient pyre fuel were widely available.

In the Lankhills assemblage, all the cremation deposits showed evidence of burning of green bone (Ubelaker 1989; Buikstra and Ubelaker 1994).

Weight of bone for burial

Investigations in modern crematoria have found that the bone weight of cremated adults ranges from approximately 1000-2400 g, with an average of 1650 g (McKinley 2000a, 269). Predictably, individuals of smaller and more gracile build (such as many females and children) will often have a lower bone weight; poorer bone survival of the articular surfaces and spongy bone has been observed in modern older individuals with osteoporosis (McKinley 2000b, 404). Thus, the infant remains in possible *bustum* 1845 weighed only 171.4 g, in contrast with the remains of the adult male in possible *bustum* 655, which weighed 1641 g. Greater mean bone weight was observed in the seven males or possible male burials (1041.1 g) compared with the four possible female burials (701 g) in the assemblage. These data include all three categories of burial, along with both disturbed and undisturbed burials.

In an archaeological context, the weight of bone recovered may be very influenced by the extent of mechanical truncation of deposits and through bone destruction (particularly of trabecular or spongy bone) in the burial environment (eg by chemical leaching). Many cremated bone deposits at Lankhills are known to have suffered truncation. As cremated bone preservation appeared to be very good, however, it is not anticipated that chemical leaching contributed significantly to loss of bone weight.

Grave depths and bone weight are presented in Table 5.55. If the redeposited cremated remains are excluded, there are only 11 completely undisturbed cremation deposits, three *busta* (655, 1180 and 1845), six un-urned (895, 915, 1320, 1527, 1742, 1786) and two urned cremation burials (1055, 2060) with a weight range of 95-1641 g. Unsurprisingly the most substantial deposits are from the adult *bustum* burials (excluding the infant in 1845), bone weights falling within the ranges expected of complete skeletons (McKinley 1994a). *Bustum* burial did not usually include the funeral phase involving the collection of cremated bone from the burnt out pyre - a process that almost always results in the exclusion of some of the cremated skeleton, whether deliberate or inadvertent. The *in situ* undisturbed anatomical position of the skeletons within four possible *bustum* burial pits or graves at Lankhills was confirmed by the presence of appropriate skeletal elements in samples taken from the head, torso, leg and foot ends of the grave (burials 655, 1180, 1806 and 1845).

Of the remaining burials, undisturbed urned deposits had a higher mean weight than their un-urned counterparts (591 g and 506 g respectively) although the numbers are small. Cremated bone deposits placed within a cinerary urn are less susceptible to damage by overlying soil weight, and dispersion by bioturbation and other taphonomic processes. In addition, most urns from Lankhills were lifted intact and excavated in the more controlled conditions of the laboratory, thus facilitating complete bone recovery. McKinley (2004a, 297) suggests that social status may influence the care with which bone was collected from the pyre, with higher bone weights in higher status burials. She does comment, however, that while this appears to hold true for primary barrow burials in the British Bronze Age, such a clear relationship has not been observed in other periods. This trend is evidenced elsewhere during the early to middle Roman periods in Britain, at Pepper Hill, Kent (Boston and Witkin 2006), Brougham, Cumbria (McKinley 2004a), the Eastern Cemetery, London (McKinley 2000a, 250), and Westhampnett, West Sussex (McKinley 1997, 250).

Overall, bone weights suggest that collection of the entire burnt skeleton from the burnt out pyre was not carried out thoroughly, either because total collection of remains for burial was not regarded as necessary by mourners, or, if professional funerary operators were employed at Lankhills, because considerations of time and profit may have reduced the care with which bone was collected.

Fragmentation

Fragment size represents the measurements taken by the osteologist during analysis and does not necessarily represent fragment size at the time of deposition. Factors that affect fragmentation include both components of the cremation rites, such as the cremation, collection, deliberate crushing and burial of the human remains, bone preservation in the burial environment and the much later process of archaeological excavation and post-excavation processing (McKinley 1994a, 340).

The Lankhills cremated bone demonstrates a low level of fragmentation, probably reflecting both burial practices and good bone preservation within the burial environment. The maximum fragment size in the group of possible *busta* ranged between 33 mm and 95 mm, while the urned burials had a range of 47-92 mm. The large sizes probably reflect lack of post-cremation manipulation of the burnt bone in the former, and the protective effects of the urn in the latter. Maximum fragment size in the un-urned burial group was generally lower (between 15 mm and 87 mm) but higher than in the redeposited cremated remains (11-63 mm). These differences probably reflect damage from soil pressure on the unenclosed remains, and in the latter case, greater fragmentation associated with disturbance and redeposition.

Similarly, where the proportion of bone fragments in the >10 mm, 10-5 mm and <5 mm fractions were compared, the redeposited cremated remains showed the lowest average proportion of large fragments (35.8%), compared to the un-urned burials (45.6%), possible *busta* (52.9%) and urned burials (69.3%). The last two also contained very little bone in the <5 mm category (6.1% and 7.6 % respectively). The largest fragment size in the urned burials reflected the protection offered by the urn, whereas all other deposits were subject to the destructive effects of soil pressures. The differences in fragmentation between these three groups probably reflected the differing extents of manipulation in the post-cremation period, for example variation in collection procedures.

Representation of skeletal elements

There appeared to have been no deliberate selection or exclusion of specific elements or body parts within the cremation deposits, with the exception of undisturbed urned cremation burial 1255, where only the cranium and torso appear to have been represented. The deposit weighed only 51 g.

Pyre goods

Burnt animal bone was recovered from within 13 cremated human bone deposits (43.3%), although in most cases this comprised very small quantities amounting to between 1.9 g and 14 g (see Worley below). A cremated dog's tooth was recovered from possible *bustum* 1215, but this may have constituted a keepsake or decoration (eg part of a pendant) rather than being a pyre offering *per se*. The complete cremated skeleton of a dog aged at least 18 months at death was present in *bustum* 1845.

Pottery vessels were contained within deposit 1060, 1195, 1215. A copper alloy belt buckle and plate, belt plate and an unidentified object were recovered from possible *bustum* 1180. A bone spindle whorl and a coin were recovered from possible *bustum* deposit 1195. A glass fragment was found in possible *bustum* 655. The latter also contained a crossbow brooch, a copper alloy strip, a sheet fragment and an unidentified iron object.

Melted metal and glass are commonly recovered from cremated bone deposits, sometimes melting onto the bone. Such pyre goods include dress items (such as jewellery and clothes fastenings) worn by the deceased on the funerary pyre (Cool 2004, 438-9) or constituted the remains of offerings or objects used in the funerary display (eg unguent bottles or metalwork from biers). The presence of metalwork may also be suggested from staining of the bone (brown-red with iron, and green with copper alloys). In the Lankhills assemblage, green staining was noted on an ilial fragment from possible *bustum* burial 1195, tentatively suggesting the location of a copper alloy object near the hips (possibly part of a belt or an object suspended therefrom). An iron pin adhering to two fragments of clavicle in urned burial 845 may be an *in situ* cloak pin. Hobnails were found within 16 cremation deposits (510, 655, 895, 915, 945, 1060, 1160, 1180, 1195, 1215, 1527, 1724, 1786, 1798, 1806 and 1845). Distinguishing between burnt and unburnt iron is problematic, although the presence of hobnails within these deposits suggests that shoes had been placed on the pyre rather than in the grave, as is common in late Roman inhumation burials.

Discussion

Cremation involves a multi-stage mortuary rite: the laying out and display of the body on a bier and/or the pyre, the cremation on a pyre, the collection of bone following the burning, and the burial of selected human remains within a pit or grave (Pearce 1998, 105). The relative importance of the cremation and the burial stages appears to vary across time periods, and also between social groups (*ibid.*). Within the early Roman period, military sites in the north and west of Britain seem to emphasise the pyre as a location for display much more than in the south-east of England (*ibid*.; Philpott 1991, 220-1). It is highly likely that the act of cremation was still an important visual component of funerary ritual by the late Roman period. The number and range of pyre goods recovered from the Lankhills cremation burials is a reflection of changing fashions in personal adornment and therefore accompanying artefacts. The most richly furnished pyres appear to have been the possible *busta*, suggesting that for this group at least, the spectacle of cremation was an important part of the funerary process.

In Romano-British cremation rites offerings of food and drink, often contained within or upon pottery vessels, were placed on the pyre (Pearce 1998, 105). Lindsay (1998, 70) comments on the widely held Roman belief that beings in the nether-world required nourishment from the survivors in this world for their well-being. In offering food and drink during and after the main funerary rites, it was hoped that the deceased would be transformed into a benevolent, rather than a disruptive ancestor, capable of conferring prosperity and fertility on the living rather than ill luck (ibid., 72). Funerary feasting may also be a source of animal and plant remains within cremated deposits.

The 30 cremation deposits recovered in the OA excavations at Lankhills form an uncommon and relatively large assemblage of late Roman cremation burials. Together with the seven deposits recovered in Clarke's excavations this represents one of the largest late Roman assemblages in Britain. Most commonly, 3rd- to 4th-century cremation burials have been recovered as singletons in among the more ubiquitous inhumation burials. Slightly larger assemblages are known from sites such as Boscombe Down, Wilts (McKinley in Wessex Archaeology 2008) and Barrow Hills, Radley, Oxon (Chambers and Boyle 2007, 58-64). The much larger cemetery at Brougham is exclusively of 3rd-century date (Cool 2004).

At a time when the normative burial rite was inhumation, the presence of a small but significant cremated bone assemblage at Lankhills is interesting, and begs the question as to whether these represent a particular ethnic, social or religious group. The presence of possible *busta*, a burial type often associated with military installations and native rites along the northern Rhine, raises the question of possible ethnic associations with these regions, but the continental evidence, like that relating to most burials of this type in Britain, suggests an emphasis on the early Roman period.

CARBON AND NITROGEN STABLE ISOTOPE ANALYSES *by Colleen Cummings and Robert Hedges*

Introduction

This section presents the results from analyses of carbon and nitrogen stable isotopes performed on a selection of the individuals buried at the Lankhills cemetery site. Because the carbon and nitrogen stable isotope ratios are distinct in different food groups, and these distinctions are passed on in the consumer's bodily tissues, this type of analysis can be used to understand ancient dietary practices. When isotopes from the diet are incorporated into bodily tissue, a change typically occurs in the ratio of one isotope to another, commonly referred to as fractionation. Nitrogen isotopes primarily provide information about position in the food chain, as each step up the food chain (trophic level) entails a fractionation of 3-5‰ from diet to consumer (Hedges and Reynard 2007). Thus, in general, more enriched nitrogen isotopes indicate greater consumption of animal protein or the consumption of animals which themselves are higher on the food chain.

Although carbon isotopes also fractionate by about 1‰ from diet to consumer, carbon isotopes also provide different types of information on diet depending on the local climate. In areas where C4 plants (usually tropical grasses such as maize, millet, or sugarcane) are present, carbon isotopes can distinguish between these and C3 plants (almost all other grains, fruits and vegetables) due to the different photosynthetic pathways in these two types of plants. This type of analysis is commonly performed in New World Archaeology to trace the introduction of maize into new areas (Larsen 1997, 270-280). In temperate climates where C4 plants are not present (such as England), carbon isotopes are primarily used to distinguish between terrestrial and marine food sources (eg Arneborg *et al*. 1999; Barrett *et al*. 2001). Marine environments are enriched in carbon by approximately 8‰ compared to terrestrial food webs due to differences between seawater carbonate and atmospheric CO2 (Chisholm *et al*. 1982; Richards and Hedges 1999). In addition, plants and animals from river and lake environments tend to be depleted in carbon compared to completely terrestrial animals (Fry 1991). Thus, enrichment or depletion in the carbon isotopes of humans beyond the standard expected 1‰ enrichment over terrestrial animals can indicate the presence of fish, freshwater or marine, in the diet.

The focus of this study has been the analysis of bone collagen from a selection of the animal and human remains at Lankhills. There is a general consensus that bone collagen primarily represents only the protein portion of the diet, other than in exceptional circumstances (Ambrose and Norr 1993; Tieszen and Fagre 1993). It is important to remember therefore, that the results presented here are concerned with relative proportions of dietary protein from different foods, not the total diet. Animal remains are tested in order to build a picture of the local foodweb, and then human remains are related to these results in order to determine the types of foods they were eating.

Materials

The initial sampling strategy for carbon and nitrogen isotope analysis was to sample approximately 200 humans and 100 animals. However, the skeletal preservation at the cemetery was variable leading to difficulties in sampling, particularly as rib and torso bones were especially deteriorated. Only rib fragments were sampled from humans, to prevent undue damage to the skeletal collection. For the animal sample, small sections of bones easily identifiable to species were used. Further, as the animal bone remains at the cemetery did not provide many sheep/goat or pig bones, further animal bone samples were taken from the Staple Gardens site in Winchester (site AY93 in Table 5.59), about 700 metres south of Lankhills and contemporaneous with the main phase of burial at Lankhills (3rd to 4th century AD). In total, the number of samples taken from the Lankhills cemetery group for carbon and nitrogen stable isotope analysis was 124 humans and 35 animals from the Lankhills site and 26 animals from the Staple Gardens site. Care was taken while sampling to avoid areas of bone with markings on them, or which had been glued or treated with a conserving agent in any way, as these procedures have been shown to alter isotope ratios (Moore *et al*. 1989).

Collagen extraction and isotope analysis

The samples were cleaned by shotblasting the bones to remove any dirt or markings. Following this, an amount of bone weighting 0.5 to 1 gramme was broken into smaller fragments. The bone collagen was extracted by first demineralising the bones in 0.5M hydrochloric acid at less than 10º C for approximately one week. The bones were then rinsed with deionised milliQ water and placed in sealed tubes with pH3 water at 75º for 48 hours to gelatinise the collagen. The supernatant of this was filtered off and freeze-dried to obtain the collagen. An amount of 2.0-3.5 mg of this extracted collagen was then weighed out and placed into 6 mm tin capsules; this was done in duplicate for each sample. This method, a modification of the Longin (1971) method, follows standard procedures at the University of Oxford for archaeological bone samples (Richards and Hedges 1999), which have been shown to be comparable to other methods of collagen preparation in stable isotopes studies (Jørkov *et al*. 2007).

Table 5.57: Summary of carbon and nitrogen isotope analyses

	N	*$\delta^{13}C$ Mean*	*$\delta^{13}C$ Std. Dev.*	*$\delta^{15}N$ Mean*	*$\delta^{15}N$ Std. Dev.*
Humans – total	125	-19.2	0.4	8.9	1.0
Humans – adult males	51	-19.0	0.5	9.0	1.0
Humans – adult females	45	-19.2	0.4	8.6	0.7
Cows	14	-21.8	0.4	5.3	1.1
Sheep/Goats	14	-21.6	0.2	4.6	1.5
Pigs	12	-21.2	0.4	5.9	1.3
Domestic Fowl	5	-19.9	0.4	7.2	0.5
Ducks	3	-25.6	0.6	9.2	2.1
Equids	7	-22.1	0.3	4.5	0.7
Dogs	3	-19.9	0.0	7.7	0.3

The carbon and nitrogen isotope ratios of the samples were analysed using a Carlo Erba carbon and nitrogen elemental analyser coupled to a Europa Geo 20/20 mass spectrometer set to operate in a continuous-flow mode. All measurements were made relative to nylon and alanine laboratory standards.

Only data which conform to the standard procedures for determining valid collagen preservation (van Klinken 1999) are included in this analysis, thus any with C:N ratios outside the accepted range were excluded. In this respect, only one sample taken was rejected because its C:N ratio lay outside the accepted range; this was a cow bone from context 1713. All other samples yielded acceptable collagen and were processed as described above. The range of machine variation between multiple mass spectrometer runs of the same sample was 0 to 1.26‰, with an average of 0.14. Summary results are presented in Table 5.57 and the full data are given in Tables 5.58 and 5.59.

Animals

As the primary function of stable isotope analysis in archaeology is to build a picture of the local foodweb at a site and situate humans in relation to that foodweb, it is logical to begin by addressing the common agricultural animals first, and later comparing the humans to these results.

Herbivorous animals (such as cows and sheep/goats) tend to be quite similar to each other in their carbon and nitrogen values and there is no reason to expect a substantial divergence in their data patterns unless the management strategies relating to these animals were quite different. Indeed, at Winchester, there is no substantial difference in carbon values between cows and sheep/goats, and while cows have slightly more elevated nitrogen isotope values than sheep/goats, this difference is

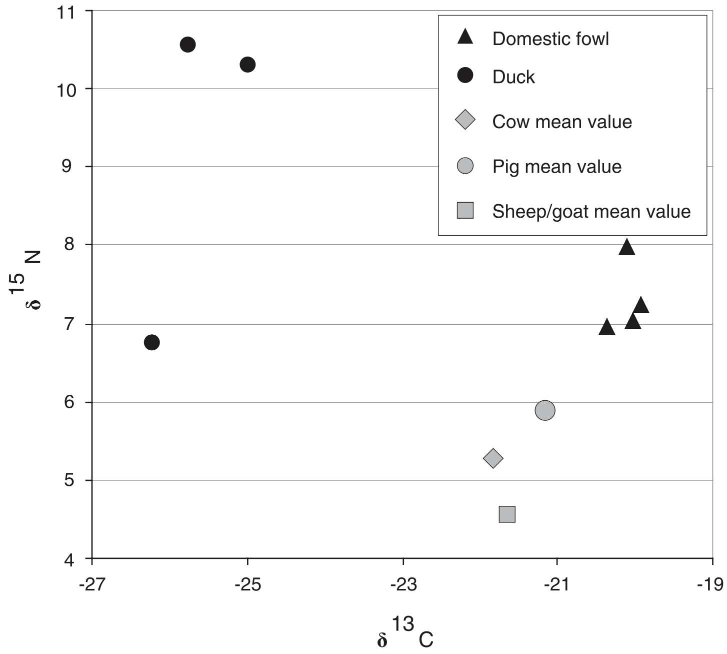

Fig. 5.61 Carbon and nitrogen isotope values for duck and domestic fowl against mean values for principal animal species

not statistically significant. The large range of δ15N values is consistent with other British sites where there is evidence for similarly wide nitrogen value ranges among herbivores (eg Jay and Richards 2006; Müldner and Richards 2007b).

As omnivorous animals, pigs have the potential to exhibit considerable differences in isotopic ratios compared to herbivores. In turn, if pork consumption among humans is prevalent, this can drastically affect human isotope values. The pig values from Winchester are very slightly enriched in carbon compared to the herbivores, and enriched in nitrogen by approximately 1‰. Both of these differences are statistically significant (δ13C t = -3.461, df = 38, p = 0.001 and δ15N t = -2.115, df = 38, p = 0.041). This is consistent with what would be expected if a pig were being fed a mixture of animal and vegetable protein.

The omnivorous nature of pigs at Winchester is important to note, as it breaks with the recommendations of the standard Roman agricultural writers. In these works, pigs are described as having a primarily herbivorous diet – mixed amounts of grains, legumes, vegetables, fruits, refuse from wine making, etc. (Columella *Agri*. 7.9.8-9, Origen *Med. Comp*. 1.49, Varro *Agri*. 2.4, Vergil *Geor*. 2.520), as well as occasional references to allowing pigs to forage on their own in wooded areas (Columella *Agri*. 7.9.6). Indeed, this vegetarian diet of pigs in the Roman world is supported by isotopic analysis of pigs at sites from elsewhere in the Roman world where pigs are isotopically indistinguishable from cows or sheep/goats (Dupras 1999, 259; Prowse *et al*. 2004). Herbivorous pigs are also found in the Iron Age, Anglo-Saxon and medieval periods in Britain (Privat and O'Connell 2002; Müldner and Richards 2005; Jay and Richards 2006). This stands in contrast to the data from Winchester and elsewhere in Roman Britain (Cummings 2008) where pigs clearly have a omnivorous diet. The data therefore suggest that the methods of raising pigs at Winchester (and other sites in Roman Britain) were distinctly different from those in other areas of the empire as well as in contiguous time periods.

Perhaps more surprisingly than the pigs, domestic fowl are also enriched in carbon and nitrogen compared to other animals, including pigs. As with pigs, domestic fowl in Roman Britain are more common on urban sites than on rural (Maltby 1997), and may have shared a similar diet of kitchen scraps comprising mixed animal and vegetable sources. In addition, free-range fowl have access to animal protein in the form of insects and other small animals. Indeed enriched nitrogen levels in chickens have been found at other sites, suggesting that this trend is widespread (eg Dupras 1999, 259; Müldner and Richards 2005; 2007b). Further animal protein consumption for poultry may have come from the processes of fattening the birds prior to consumption. This was a well-attested process for all types of birds in the Roman world (Columella *Agri*. 8.7.1, 8.10; Cato *Agri*. 89; Pliny *NH* 10.25; Varro *Agri*. 3.6, 3.9.19-21), and bread soaked in milk was one food often used in the fattening process. If milk was a common food for domestic fowl, then the carbon and nitrogen isotope enrichment of these birds is understandable.

The animal bone assemblage at Winchester also provided the possibility to test a few duck bones, which yielded interesting results (Fig. 5.61).

As is evident from the graph, the duck values are substantially depleted in carbon compared to the rest of the animals, and particularly the domestic fowl. In addition, two of them are considerably enriched in nitrogen compared to other animals at the site. If these ducks came from a riverine environment close to the city, anthropogenic factors (eg sewage) could be affecting the nitrogen isotopes (McClelland *et al*. 1997; Schlacher *et al*. 2005). The depleted carbon values are consistent with the range of values characteristic of freshwater environments (Fry 1991).

Humans general

Although there is considerable spread in the human data, on average the humans are enriched by 4‰ in nitrogen and 2.5‰ in carbon compared to the herbivores. These values are considerably higher than one might expect from typical agriculture-based societies. If one were working with a strictly linear model considering herbivorous animals and plants as the only two food sources (eg Schwarcz 1991; Little and Little 1997) the data would appear to indicate that most of the people buried at Lankhills had 100% of their dietary protein from animal products. Of course, this is highly unlikely (Hedges and Reynard 2007) and the likelihood that there were multiple items in the diet with different isotopic values (pigs, fowl, marine and freshwater fish) greatly complicates the linear model approach. The individuals at the site who have the most enriched nitrogen values are enriched by more than one full trophic level above the herbivores, thus the incorporation of other, enriched nitrogen foods is necessary to account for their isotope values. Indeed, even those individuals most depleted in nitrogen are enriched by roughly 2‰ compared to the herbivores, still indicating substantial animal protein consumption. Even though crops can become slightly enriched in nitrogen through practices such as manuring (Bogaard *et al*. 2007), enrichment of this magnitude is significant as it indicates that everyone buried at Lankhills had some access to animal protein. It has often been assumed (largely based on textual evidence) that the vast majority of people living in the time of the Roman Empire had extremely limited access to animal based foods (White 1976; Foxhall and Forbes 1982; Garnsey 1998; 1999; Donahue 2004). However this certainly does not appear to be the case for the Lankhills population (or other groups in Roman Britain, see Cummings 2008), supporting the growing body of zooarchaeological evidence for greater consumption of meat in the Roman world than is generally allowed (King 1999; Grant 2004; MacKinnon 2004).

In relation to carbon, those individuals with a carbon value of around -20‰ can be seen as a normal carbon trophic level enrichment of around 1‰ over the carbon values of the animals, and therefore consistent with a terrestrial based diet. The individuals in the -18 to -19‰ range are enriched by 2‰ or more compared to the carbon values of both pigs and herbivores. This shift in carbon, as well as the enriched nitrogen values of most of the population, again suggests the importance of other food items in the diet besides (or in addition to) the protein gained from terrestrial herbivores. In particular, the slight enrichment in carbon suggests a small, but consistent, incorporation of marine fish or shellfish into the diet of some of the people interred in the cemetery.

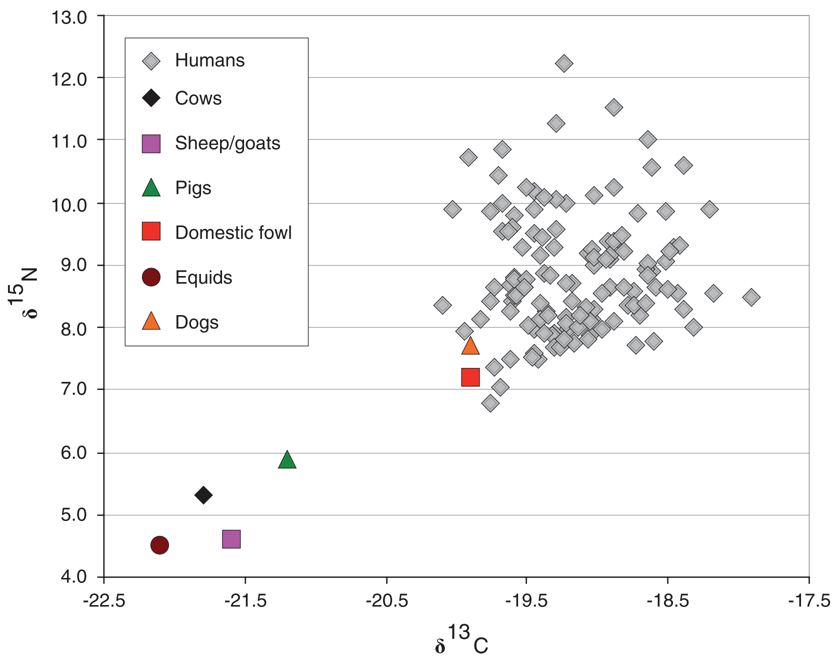

Fig. 5.62 Carbon and nitrogen isotope values for humans and mean animal values

Age and sex

Among the adults at the site, no differences were found between individuals of different age groups. Adult males and females have very similar values, though men do show a slight enrichment over females in both carbon (0.02‰) and nitrogen (0.04‰). While this difference in nitrogen values is statistically significant (t = 2.371 df = 94, p = 0.020), the actual difference is quite small, indeed within the range of standard machine error. Therefore, the enrichment of men over women is unlikely to reflect any substantial difference in actual dietary practices between the two sexes.

With respect to subadults, enough infants were sampled to address the question of infant feeding and weaning processes. The isotopic values for the infants and children are plotted in Fig. 5.62, along with the mean adult value at the site.

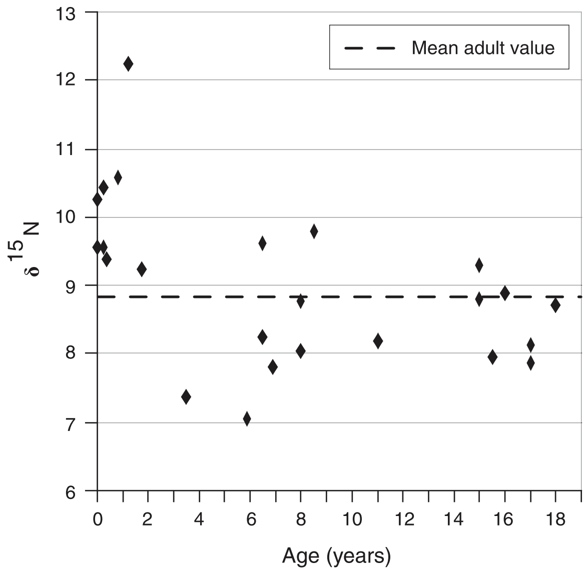

Fig. 5.63 Infant feeding and weaning

It is immediately apparent that among the infants under two years of age, while they are all enriched in nitrogen values compared to the adult mean, only one shows the full trophic level enrichment (~3-5‰) that is generally expected for exclusively breast-fed infants (Fogel *et al*. 1989; Schurr 1999; Fuller *et al*. 2006). It is possible, particularly in the case of the perinatal infants, that the bone had not yet sufficiently remodelled to show any signs of breast-feeding, but for those that are more than a few months old this is unlikely due to the extremely quick rate of bone tissue turnover in very young infants. It is perhaps more likely that these infants were *not* exclusively breastfed, which in turn could have led to malnourishment, and possibly contributed to their early death. It is also worth noting that at least three of the infants under the age of two (grave numbers 231, 1317, 1725) show evidence of health problems including growth retardation, porotic hyperostosis, and possibly scurvy. Unfortunately, therefore, the evidence for the practices of breast-feeding is ambiguous and the lack of children between the ages of two and four makes it difficult to estimate the timing of weaning. Further isotope analysis of dental tissue of older adults (eg using the methodology of Fuller *et al*. (2003) or Humphrey *et al*. (2008)) might be a useful way of getting around the osteological paradox (ie assuming that the population of non-survivors accurately reflects the practices of those who lived, see Wood *et al*. 1992), by directly measuring the infant feeding practices of those who survived to adulthood.

Stature

It is not unreasonable to suggest that those individuals who received the highest quality food items would have had greater success in achieving their full height potential. Therefore, the possibility of correlations between adult stature and stable

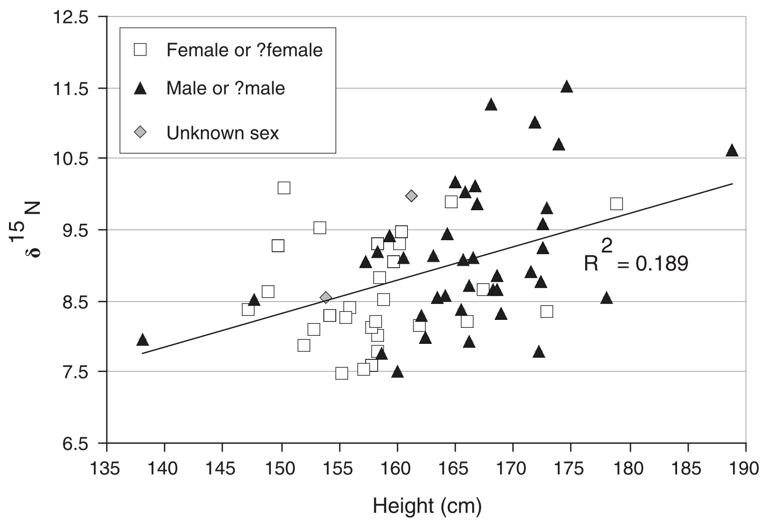

Fig. 5.64 Stature, sex and nitrogen correlation

isotope ratios was explored. A correlation was indeed found between stature and nitrogen for the total population at Winchester ($R2 = 0.189$, Pearson correlation = 0.434, $p = <0.000$):

Because stature is affected by sex, men and women were also tested separately to see if stature correlated with nitrogen in these two subgroups. The correlation held for men when tested on their own ($R2 = 0.198$, Pearson correlation = 0.445, $p = 0.005$), but not for women. This correlation for the men remains statistically significant even when the outliers (men taller than 1.85 m and shorter than 1.50 m) are excluded, thus they have been left in the calculation.

This correlation between stature and nitrogen isotope ratios among the males could be used to suggest better nutrition (specifically higher animal/fish protein content of diet) during growth resulting in taller individuals. However, the skeletal element sampled for isotopic testing was rib bone, which is generally thought to have a relatively quick turnover rate of approximately two years. Thus, except where individuals are quite young, it is unlikely that the isotopic values gained from the rib bones can provide much information on nutritional status during the growing period. Only if the taller individuals not only had a different diet during childhood but also continued to have this same nitrogen isotope enriching diet throughout their adulthood would this type of result be detectable. This may, indeed, be the case at Winchester.

DISH

Three individuals (in Graves 263, 855 (not sampled) and 1310) at Lankhills were afflicted with diffuse idiopathic skeletal hyperostosis (DISH), a relatively rare skeletal condition that causes certain tissues with the body to ossify. The most visually spectacular of these, and often considered the most diagnostic criterion in identifying the condition, is the ossification of the anterior longitudinal ligament in the spine (Ortner 2003, 558-560). This links the individual vertebrae within the spine with a long band of ossified tissue, which is often described as similar in appearance to dripped candle-wax. Bony spurs also occasionally occur elsewhere in the body, where other connective tissues have ossified, particularly at joint margins or muscle insertion points. The aetiology of this condition is elusive, but it has been linked to adult onset diabetes and obesity (Littlejohn 1985; Kiss *et al*. 2002), and in palaeopathological studies, has been used to suggest higher status groups within certain populations (Waldron 1985; Rogers and Waldron 2001; Jankauskas 2003; Müldner and Richards 2007a). Because of the link between this condition and diabetes and obesity, it is interesting to examine whether these two people had a different diet from the other individuals at the site.

Although the individuals with DISH are not completely separate from the rest of the group, they are enriched in both carbon and nitrogen compared to the majority of the population. It is difficult to

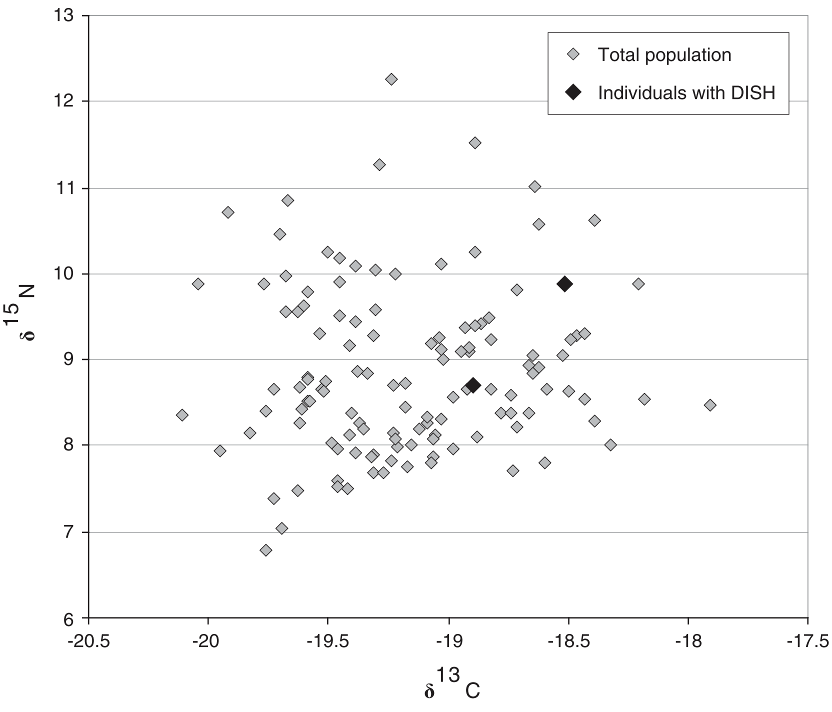

Fig. 5.65 Carbon and nitrogen isotope values for individuals with DISH

base an argument on only two data points, but this could indicate that these people consumed a higher proportion of animal protein, perhaps particularly marine fish, than other people. It has been suggested elsewhere that elevated carbon and nitrogen isotopes are indicative of increased social status, due to the high value placed on marine fish in the Roman (Richards *et al*. 1998; Cummings 2008) and medieval (Müldner and Richards 2007a) worlds. It is possible therefore, that these individuals' condition was indeed related to their dietary practices during life.

Burial position

In addition to biological characteristics of the skeletons, the variation in burial practices at Lankhills provides rich ground for exploring potential differences among individuals buried in particular ways or with distinctive items. For instance, those who were buried prone are depleted in carbon compared to those buried supine (there are only two crouched burials at this site, and they are not significantly different from the rest). This depletion is statistically significant ($t = 2.042$, $df = 113$, $p = 0.044$) (Figure 5.66).

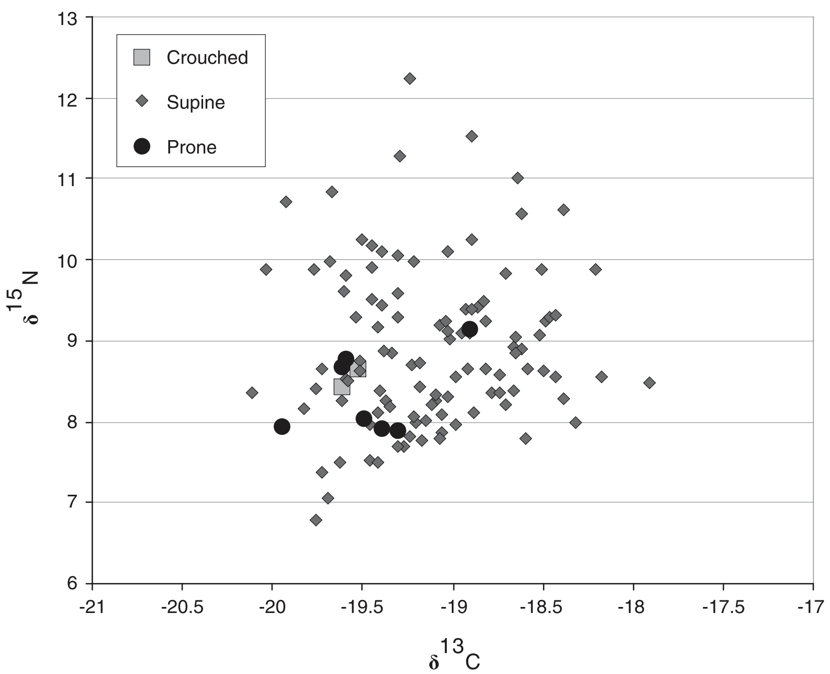

Fig. 5.66 Carbon and nitrogen isotope values in relation to body position

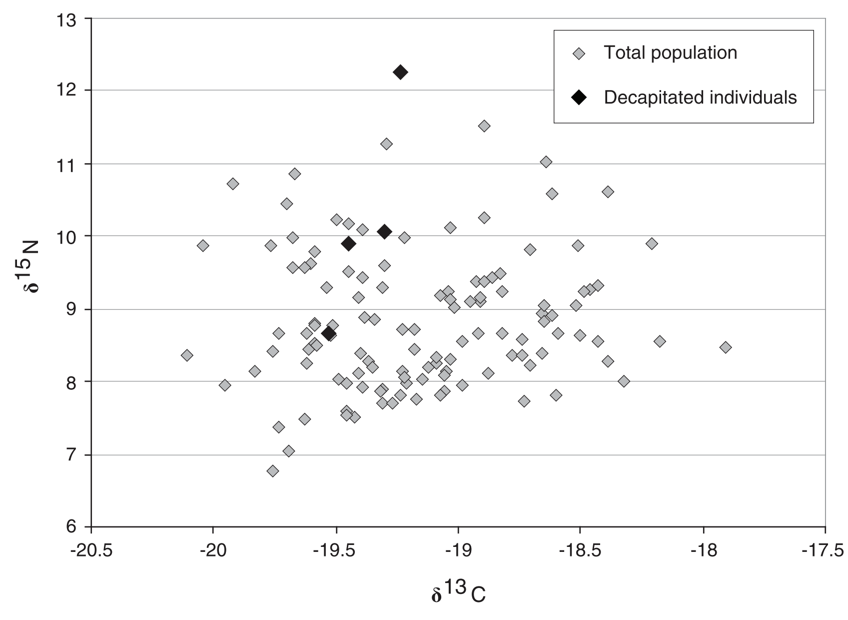

Fig. 5.67 Carbon and nitrogen isotope values of decapitated individuals

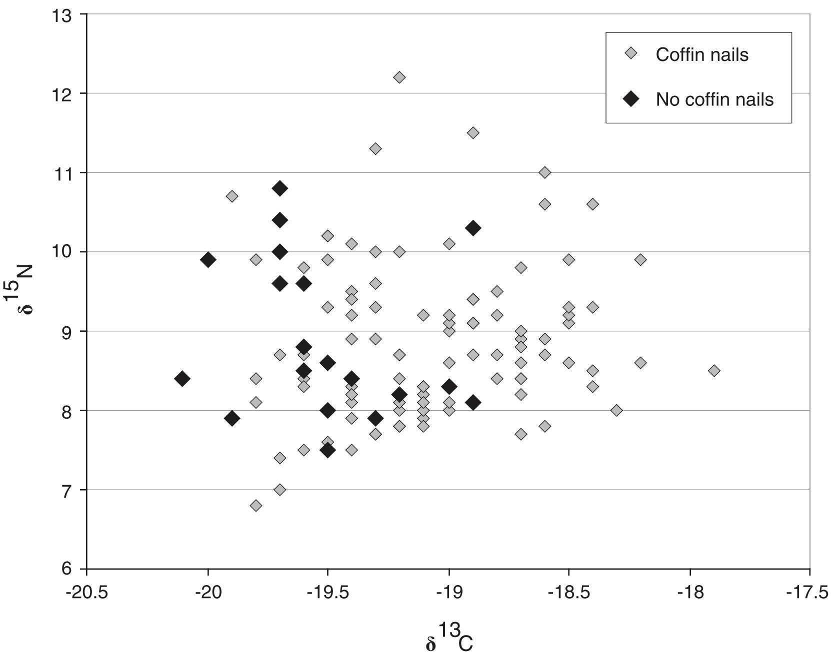

Fig. 5.68 Carbon and nitrogen isotope values in relation to coffin provision

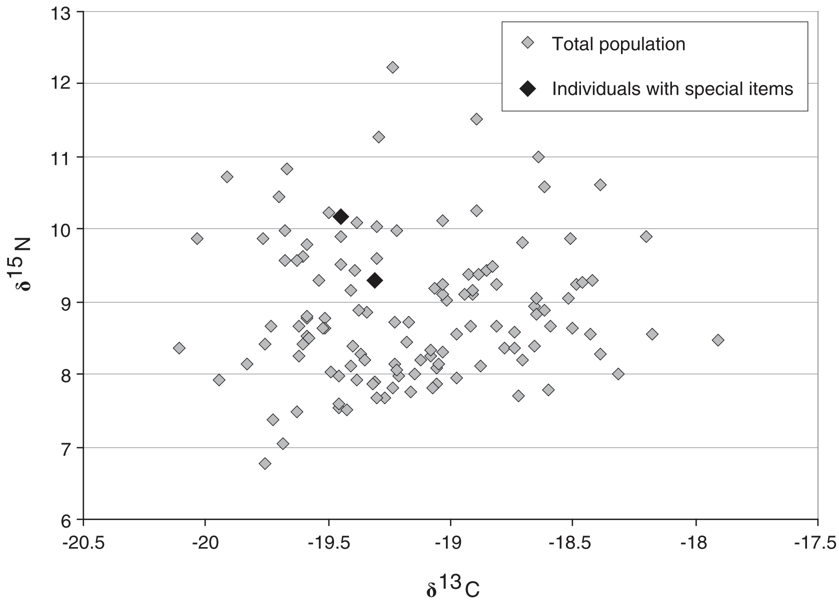

Fig. 5.69 Carbon and nitrogen isotope values for individuals with unusual grave goods

Decapitation

As with prone burials, decapitated individuals are depleted in carbon compared to the majority of the population, but here the nitrogen values are more variable (Figure 5.67).

The point that is the most enriched in δ15N is that of a baby aged 1 to 1.4 years (grave 110), so this point was excluded from any statistical testing, on the basis that his or her elevated nitrogen value is likely due to breastfeeding. The three remaining points are significantly different from the majority of the population in their δ13C values (t = 3.568, df = 3.804, p = 0.025).

Though the cultural significance of the practice of decapitation is unclear (Boylston *et al.* 2000), the stable isotope data indicate that the people who were decapitated or buried prone did not have dietary practices that were completely different from the broader population. However, it does appear that these individuals did not have access to foods that would result in isotopic values particularly enriched in carbon (ie marine fish). The results here are comparable to Cirencester where decapitated individuals are similarly depleted in carbon compared to the majority of the population, though here they are also significantly enriched in nitrogen, a result not found in the Lankhills sample (Cummings 2008).

Coffins

Among the burials at Lankhills, those buried in nailed coffins are significantly enriched in δ13C values compared to those for whom there is no evidence for coffins (p = 0.000), though there is considerable overlap between the two groups (Figure 5.68).

It is, of course, always possible that those burials without coffin nails did indeed have coffins but of a wood-jointed construction and the isotope difference between the two groups is spurious. However, if the burials without coffin nails do indeed indicate an absence of coffins, it is possible that a class difference existed within the Lankhills group, reflected both in dietary practices during life and burial custom at death.

Grave goods

As at the previous Lankhills excavation, there were several burials that contained crossbow brooches and other distinctive items (buckles, strap-ends, spurs etc.), which some have argued are indicative of a special class of foreigners who were buried within this particular cemetery in Britain (Clarke 1975; 1979, 377-403; Baldwin 1985; Evans *et al*. 2006a). Unfortunately, skeletal preservation at Lankhills was variable, and only two of the five individuals with these distinctive brooches had rib fragments suitable for sampling (Graves 745 and 1925). These two are presented in Figure 5.69, in relation to the rest of the group.

These two individuals did not have isotopic values distinct from the rest of the group however, suggesting that their possible cultural differences did not extend to dietary practices. If these two individuals are representative of the crossbow brooch burials in general, and these people are in fact immigrants to the area, then the stable isotope analysis raises two possibilities. The first possibility is that upon moving to the area they adapted to local dietary customs, but choose to maintain traditional burial rites. Secondly, it is also possible that they maintained traditional dietary practices as well as burial rites, but that the original diet is not distinguishable from a Romano-British diet through the use of stable isotopes.

Conclusions

Overall, the stable isotope results from the Lankhills cemetery suggest that this group of people had ready access to multiple sources of animal protein, including, for some people at least, small amounts of marine fish. Although stable isotope analysis cannot determine whether people were meeting their basic minimal health requirements in a quantifiable way, this evidence for access to animal protein would seem to indicate that the people buried in the Lankhills cemetery were generally well fed and likely had overall adequate nutrition. The possible exception to this may be certain young infants, but the evidence is ambiguous, and certainly the osteological paradox (Wood *et al*. 1992) should prevent us from using this to infer general practice towards the majority of infants who lived into adulthood.

These isotopic results may provide some evidence of a status differentiation within the site. This is particularly evident in carbon isotopes where the individuals buried in coffins show more enriched values. Likewise, the prone and decapitated burials, depleted in carbon, may be evidence of lower socio-economic status, though the meaning of decapitation in Roman Britain is ambiguous (Philpott 1991; Boylston *et al*. 2000). It is generally acknowledged that marine fish was accorded particular status as a luxury item within the Roman world (Wilkins 1993; Purcell 1995; Locker 2007) and the variation in carbon isotopes at Lankhills may reflect varying access to marine fish among different segments of the community.

Table 5.58: Carbon and nitrogen isotope data, humans

Laboratory ID Number	*Original Context #*	*Age*	*Sex*	*δ13C*	*δ15N*
LH001	8	0-6 mos	?	-19.7	9.6
LH002	25	45+	M	-18.2	9.9
LH003	74	12-19yrs	?	-19.5	8.0
LH004	95	30-40	M?	-19.7	10.0
LH005	108	25-35	M	-19.2	8.0
LH006	271	18-25	F	-18.9	9.4
LH007	284	45+	F?	-19.4	8.3
LH008	451	45+	M	-17.9	8.5
LH009	661	45+	F	-19.3	7.9
LH010	683	45+	M	-19.4	8.4
LH011	712	15 yrs	?	-19.3	9.3
LH012	919	35-45	F	-19.6	8.7
LH013	1026	8 yrs	?	-19.5	8.0
LH014	1197	30-40	F?	-19.4	9.2
LH015	1247	45+	M	-19.7	10.8
LH016	1258	45+	F	-19.2	8.2
LH017	1281	25-35	F	-19.9	7.9
LH018	1284	45+	M	-19.3	7.9
LH019	1517	50+	M	-19.5	8.6
LH020	1532	35-45	M	-19.2	8.1
LH021	1557	25-35	F	-20.0	9.9
LH022	1565	3-4 yrs	?	-19.7	7.4
LH023	1640	50+	M	-18.4	10.6
LH024	1870	14-16 yrs	?	-19.6	8.8
LH025	1882	45+	M	-19.0	8.1
LH026	12	30-40	M	-18.6	8.7
LH027	20	16-18	F	-19.1	7.9

(continued overleaf)

Table 5.58 (continued): Carbon and nitrogen isotope data, humans

Laboratory ID Number	Original Context #	Age	Sex	δ13C	δ15N
LH028	55	40+	?M	-18.9	9.4
LH029	61	30-40	F	-19.1	8.0
LH030	113	8-9	?	-19.6	9.8
LH031	118	1-1.4 yrs	?	-19.2	12.2
LH032	119	20-30	F	-19.4	9.5
LH033	212	50+	?F	-20.1	8.4
LH034	281	30-40	F	-18.5	9.9
LH035	404	0-5 mos	?	-19.7	10.4
LH036	488	25-40	?	-19.2	10.0
LH037	507	16-18	F	-19.4	8.1
LH038	559	30-40	F	-18.6	7.8
LH039	611	6-7	?	-19.6	9.6
LH040	612	25-45	?M	-19.2	7.8
LH041	686	25-35	F	-19.3	7.7
LH042	829	6-7	?	-19.1	8.3
LH043	926	15-17	?	-18.6	8.9
LH044	932	40-50	M	-19.1	7.8
LH045	939	60+	M	-19.4	7.9
LH046	1094	30-50	?	-19.8	6.8
LH047	1119	40+	M	-18.7	9.8
LH048	1134	30-40	F	-18.9	8.1
LH049	1232	35-45	M	-19.7	8.7
LH050	1244	10-12	?	-19.4	8.2
LH051	1271	40+	M	-18.9	8.7
LH052	1304	30-40	?F	-19.4	8.9
LH053	1697	40-55	M	-18.6	11.0
LH054	1926	30-40	?M	-19.5	10.2
LH055	84	25-35	F	-19.0	9.0
LH056	134	25-35	M	-19.3	8.9
LH057	476	30-40	F	-18.5	9.1
LH058	522	35-45	M	-18.7	8.9
LH059	593	18-25	M	-18.8	8.4
LH060	614	12	?	-19.6	8.4
LH061	623	40-60	??M	-19.6	8.5
LH062	636	35-55	?M	-18.7	8.6
LH063	667	16-20	F	-19.2	8.7
LH064	717	40+	M	-19.0	10.1
LH065	741	17-20	M	-19.4	7.5
LH066	806	40-45	F	-19.0	8.3
LH067	861	35-45	M	-19.6	8.8
LH068	879	40-50	? M	-19.1	9.2
LH069	938	35-45	M	-19.4	9.4
LH070	1022	35-45	M	-18.9	9.1
LH071	1082	40+	F	-19.1	8.1
LH072	1084	30-35	F	-19.5	9.9
LH073	1103	25-35	F	-18.5	9.3
LH074	1114	25-30	F	-19.6	8.5
LH075	1173	50+	F	-19.5	9.3
LH076	1191	18-24	? M	-19.1	8.3
LH077	1209	35-45	M	-18.7	9.0
LH078	1223	45-50	?M	-18.3	8.0
LH079	1227	30-45	F	-18.4	9.3
LH080	1277	40-44	M	-18.9	9.1
LH081	1289	35-45	M	-19.3	10.0
LH082	1341	30-50	F	-19.5	7.6
LH083	1361	30-50	F	-18.7	8.8

Table 5.58 (continued): Carbon and nitrogen isotope data, humans

Laboratory ID Number	Original Context #	Age	Sex	δ13C	δ15N
LH084	1416	20-25	F	-19.6	7.5
LH085	1481			-19.0	9.2
LH086	1512	20-30	F	-19.4	10.1
LH087	1552	20-40	F	-19.5	10.2
LH088	1598	40+	? F	-19.6	8.3
LH089	1934	adult	?	-19.2	8.4
LH090	221	.58-1.08	?	-18.6	10.6
LH091	232	40+	?M	-19.3	7.7
LH092	240	25-35	F	-19.8	8.1
LH093	280	1.5-2y	?	-18.8	9.2
LH094	477	7.5-8.5	?	-19.5	8.8
LH095	489	25-35	?M	-19.2	8.7
LH096	554	40-45	M	-18.4	8.5
LH097	566	45-50	M	-19.9	10.7
LH098	579	20-30	M	-18.5	9.2
LH099	616	40-45	M	-18.2	8.6
LH100	702	40-50	M	-19.0	9.1
LH101	726	adult	?	-18.5	8.6
LH102	767	5.25-6.5	?	-19.7	7.0
LH103	852	40-50	?	-19.0	8.6
LH104	908	40-45	F	-19.1	8.2
LH105	914	35-45	M	-18.4	8.3
LH106	917	35-45	F	-19.8	8.4
LH107	967	25-35	F	-18.8	8.7
LH108	971	40-45	M	-19.8	9.9
LH109	1061	6.25-7.5	?	-19.2	7.8
LH110	1137	30-40	F	-18.7	8.2
LH111	1156	40-50	F	-19.5	8.6
LH112	1167	25-30	M	-18.9	11.5
LH113	1219	50+	M	-19.0	8.0
LH114	1393	40-50	M	-19.3	11.3
LH115	1498	40-44	M	-18.9	9.1
LH116	1637	40-45	F	-18.7	8.4
LH117	1722	38w-0	?	-19.6	9.6
LH118	1723	3m-5m	?	-18.9	9.4
LH119	429	60+	F	-18.7	7.7
LH120	435	40-50	F	-19.5	7.5
LH121	1314	38w- 0	?	-18.9	10.3
LH122	866	50+	F	-18.7	8.4
LH123	1621	35-39	F	-18.8	9.5
LH124	1802	30-35	?M	-19.3	9.6

Table 5.59: Carbon and nitrogen isotope data, animals

Laboratory ID Number	Original Context #	Species	δ13C	δ15N
LH125	115	Pig	-20.7	6.9
LH126	1689	Pig	-21.3	6.7
LH127	4	Sheep/Goat	-22.1	6.0
LH128	4	Sheep/Goat	-22.0	5.7
LH129	235	Sheep/Goat	-21.3	2.8
LH130	4	Sheep/Goat	-21.9	5.9

Table 5.59 (continued): Carbon and nitrogen isotope data, animals

Laboratory ID Number	*Original Context #*	*Species*	*δ13C*	*δ15 N*
LH131	152	Fowl	-19.9	7.3
LH132	1	Fowl	-17.6	7.6
LH133	853	Fowl	-20.1	8.0
LH134	1159	Duck	-25.0	10.3
LH135	738	Fowl	-20.5	10.3
LH136	1149	Dog	-19.9	7.5
LH137	1306	Dog	-20.0	7.7
LH138	779	Dog	-19.9	8.0
LH140	132	Cow	-21.1	4.5
LH141	749	Cow	-21.9	5.2
LH142	115	Cow	-21.4	5.9
LH143	1212	Cow	-21.9	5.2
LH144	671	Cow	-22.7	4.7
LH145	913	Cow	-21.6	7.2
LH146	964	Cow	-22.4	4.8
LH147	1138	Cow	-21.6	5.2
LH148	1113	Cow	-21.8	7.8
LH149	603	Cow	-22.0	5.0
LH150	1117	Cow	-22.4	5.0
LH151	603	Equid	-21.9	5.7
LH152	1624	Equid	-22.1	4.2
LH153	1543	Equid	-21.5	5.3
LH154	214	Equid	-22.5	3.5
LH155	1698	Equid	-22.1	4.4
LH156	1629	Equid	-21.9	4.1
LH157	799	Equid	-22.4	4.5
LH158	100	Bird	-19.4	6.6
LH159	1159	Duck	-25.8	10.6
LH160	AY93 2290	Duck	-26.2	6.8
LH161	AY93 2344	Fowl	-20.0	7.0
LH162	AY93 9543	Fowl	-20.4	7.0
LH163	AY93 2000	Cow	-21.9	5.1
LH164	AY93 4743	Cow	-21.5	5.1
LH165	AY93 9543	Cow	-21.6	3.3
LH166	AY93 1248	Pig	-20.8	5.8
LH167	AY93 1393	Pig	-20.9	5.0
LH168	AY93 2000	Pig	-21.0	5.0
LH169	AY93 2344	Pig	-21.8	8.2
LH170	AY93 2510	Pig	-21.8	6.8
LH171	AY93 3744	Pig	-21.6	7.4
LH172	AY93 4743	Pig	-21.5	5.6
LH173	AY93 7574	Pig	-20.5	4.2
LH174	AY93 9543	Pig	-21.5	4.5
LH175	AY93 9711	Pig	-20.9	4.6
LH176	AY93 1248	Sheep/Goat	-21.9	6.2
LH177	AY93 1260	Sheep/Goat	-21.7	5.1
LH178	AY93 1393	Sheep/Goat	-22.0	2.2
LH179	AY93 2000	Sheep/Goat	-21.2	4.0
LH180	AY93 2344	Sheep/Goat	-21.6	3.9
LH181	AY93 2510	Sheep/Goat	-20.6	3.4
LH182	AY93 4688	Sheep/Goat	-22.2	2.6
LH183	AY93 4742	Sheep/Goat	-21.8	5.5
LH184	AY93 4743	Sheep/Goat	-20.6	3.5
LH185	AY93 4762	Sheep/Goat	-22.0	6.9

OXYGEN AND STRONTIUM ISOTOPE ANALYSIS *by C Chenery, J A Evans, A Lamb, G Müldner and H Eckardt*

Introduction

In this report we present strontium ($^{87}Sr/^{86}Sr$) and oxygen ($\delta^{18}O$) isotope data for tooth enamel sampled from 40 individuals buried in the late Roman cemetery at Lankhills School, Winchester. The aim is to define 'local' or 'immigrant' origin through isotope analysis, and to compare archaeological assessment of 'ethnic' origin to isotopic signatures. Forty tooth samples were provided by Oxford Archaeology and analysed at the NERC Isotope Geoscience Laboratory at the British Geological Survey (NIGL/BGS). Twenty samples were analysed as part of a larger University of Reading AHRC-funded project "Diaspora Communities in Roman Britain" and twenty samples were analysed by NIGL as a commercial project commissioned by Oxford Archaeology (Evans and Lamb 2008; report in the project archive). A detailed discussion of the results and their implications for the study of funerary archaeology, and a comparison with an earlier study (Evans *et al.* 2006a) has recently been published in the *Journal of Archaeological Science* (Eckardt *et al*. 2009).

Isotopic context

Strontium and oxygen form two independent isotopic systems, reflecting local geology and climate respectively. Oxygen and strontium isotopes are fixed in enamel biogenic phosphate at the time of tooth formation (Hillson 1996a; Price *et al.* 2002; Hoppe *et al.* 2003). As strontium and oxygen isotopes behave independently of one another, they provide two parameters for investigating an individual's place of origin and migration patterns (Evans *et al*. 2006a; 2006b).

Oxygen isotopes of phosphate in tooth enamel ($\delta^{18}O_p$) are derived primarily from ingested fluids and indirectly reflect the isotopic value of available meteoric/ground/drinking water (Levinson *et al.* 1987; Daux *et al.* 2008). Oxygen (and other light stable isotopes, H, C and N) are subject to several stages of metabolic fractionation, from drinking water to body fluids and again from body fluids to phosphates. This fractionation is understood and predictable, thus allowing the calculation of drinking water values ($\delta^{18}O_{dw}$) to assist in determining an individual's place of origin (Longinelli 1984; Levinson *et al.* 1987). Breast feeding affects isotopic signatures, complicating the interpretation of some individuals; these issues are discussed in more detail in Eckardt *et al*. (2009).

Strontium isotopes are derived from both solid and liquid food and directly relate to the geology of the area where the food was produced (Montgomery 2000; Bentley and Knipper 2005; Evans *et al.* 2006b). Strontium isotopes, unlike oxygen, are not fractionated by metabolic functions;

therefore breastfeeding is unlikely to affect the $^{87}Sr/^{86}Sr$ signal in early forming teeth.

Geological context

Winchester lies within 40 km of the south coast of England, at the western end of the South Downs, approximately 8 km north of the Hampshire Basin. The local geology (within 30 km of Winchester) is dominated by Cretaceous chalk with one third of the area covered by Oligocene and Eocene sediments (clays, sands and gravels) to the south and along the coast. To the east, at the western margin of the Weald, about 25 km from Winchester, is a small area of lower Cretaceous, Upper Greensand and Gault clay (Figure 5.70). Strontium isotope values for the area within 30 km of Winchester are expected to range from 0.7072 to 0.7092 (Evans *et al.* 2006a). For comparison, strontium isotope values recently reported for mineral waters from England and Wales were 0.70587 to 0.72065 (Montgomery *et al.* 2006).

Meteorological context

Drinking water is ultimately derived from meteoric water and the oxygen isotope value depends on the source of the rain or snow (evaporation from the Atlantic Ocean for most of Europe), the distance from the coast, latitude, altitude and local temperature of precipitation and humidity (see Darling and Talbot 2003; Darling *et al.* 2003; Darling 2004).

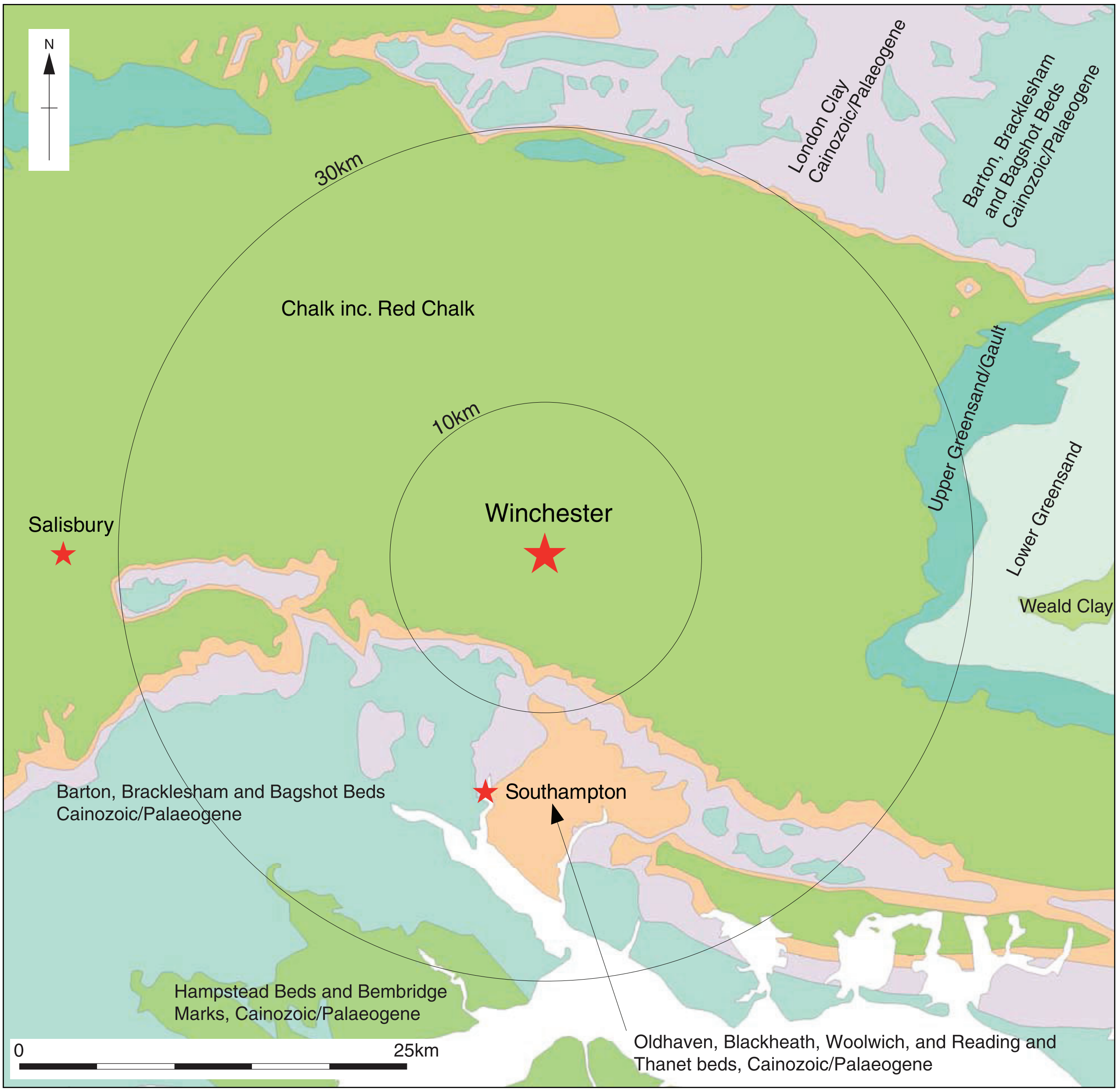

Fig. 5.70 Geology of the Winchester area

The $\delta^{18}O$ of modern UK groundwater varies systematically, from higher values on the west coasts to lower ones in the east. They range between ~ -9‰ to -4.5‰, although values > ~-6.0 are largely confined to extreme western Britain, that is modern Devon and Cornwall, western Wales and the Scottish Isles (Darling and Talbot 2003; Darling *et al.* 2003). Modern drinking waters from the Winchester area gave $\delta^{18}O$ from -7.0‰ to -5.8‰ (-6.6±0.7‰, 2σ, n=14, Darling and Talbot 2003; Darling *et al.* 2003; Darling pers. Comm.).

Materials and methods

Sample selection

Tooth samples from 40 individuals from the cemetery were supplied by Oxford Archaeology (see Tables 5.60 and 5.61). The samples represent a broad cross section of age, sex, burial style and grave goods represented in the recent excavations. They included individuals assessed in terms of the criteria used by Clarke (1979, 377) to identify intrusive elements in the Lankhills population (although

Table 5.60: Summary of skeletons selected for strontium and oxygen isotope analysis

Sample No	*Grave*	*Skeleton*	*Tooth*	*Age (yrs)*	*Sex*	*Origin based on field evidence*	*Position*	*Coffin*	*Grave goods/[other characteristics]*
Ay21-0012	10	12	LP2	45+	Male	Local	S	Y	Shoes unworn
Ay21-0084	82	84	RM2	Adult	Female	Others	S	Y	2 pots [step grave]
Ay21-0118	110	118	dI1	10m-2	Infant	Pannonian?	SD	Y	Beads & bracelets unworn
Ay21-0119	99	119	LM2	26-35	Female	Pannonian?	S	Y	Pot
Ay21-0212	210	212	LP2	60+	?Female	Local	S	N	Shoes
Ay21-0271	272	271	LM2	26-35	Female	Local	S	Y	Pot, shoes unworn
Ay21-0281	263	281	RM2	45+	Male	Local	S	Y	Coin [DISH]
Ay21-0435	530	435	LM2	45+	Female	Local	S	N	Bone ?pendant
Ay21-0489	550	489	LM2	45+	?Male	Local	S	Y	-
Ay21-0566	610	566	RM2	26-35	Male	Others	S	Y	-
Ay21-0661	665	661	LP1	36-45	Female	Others	S	N	Shoes
Ay21-0683	790	683	LM3	45+	Male	Local	S	N	Coin, shoes
Ay21-0776	805	776	RM2	Adult	Male?	Others	S	Y	-
Ay21-0806	850	806	LP2	60+	Female	Local	S	N	-
Ay21-0812	855	812	RM2	45+	Male?	Others	S	Y	Shoes ?unworn
Ay21-0861	905	861	LM3	60+	Male	Others	P	N	Shoes
Ay21-0861	905	861	LP2	Ditto	Ditto	Ditto			
Ay21-0862	930	862	M2	36-45	Male	Pannonian?	S	Y	Knife, ?buckle, shoes ?unworn
Ay21-0874	920	874	RM2	6-12	Child	Local	S	Y	Beads, bracelets, ?ring, shoes, all unworn
Ay21-0926	985	926	L?M2	13-17	?Female	Local	S	Y	Beads, bracelets, rings, pin, all unworn
Ay21-0932	965	932	LM2	18-25	Male	Local	S	Y	2 pots, shoes unworn
Ay21-1026	1070	1026	RM1	Child	Child	Pannonian?	P	N	Bracelets, ring
Ay21-1084	1150	1084	LM2	26-35	Female	Others	SD	Y	Coin
Ay21-1091	1135	1091	RM2	18-25	Female	Others	S	Y	-
Ay21-1094	1140	1094	LP2	Adult	Female	Local	S	Y	Shoes
Ay21-1114	1170	1114	RM2	26-35	Female	Local	S	Y	-
Ay21-1119	1175	1119	RM2	45+	Male	Local	S	Y	Coin, knife, buckle
Ay21-1133	1355	1133	M1	Child	Child	Pannonian?	S	Y	Comb, buckle, shoes ?unworn
Ay21-1134	1190	1134	LP2	36-45	Female	Local	S	N	-
Ay21-1197	1270	1197	LRP2	60+	Female	Local	S	Y	Comb, shoes unworn
Ay21-1207	1280	1207	M2	Adult	?Female	Local	S	Y	Comb
Ay21-1227	1349	1227	LM2	36-45	Female	Others	S	Y	Pot, shoes unworn
Ay21-1244	1360	1244	LM2	13-17	?Female	Local	S	Y	Beads, bracelets, shoes, all unworn
Ay21-1271	1310	1271	RM2	45+	Male	Pannonian?	S	Y	Knife [DISH]
Ay21-1277	1345	1277	RM2	36-45	Male	Others	P	Y	-
Ay21-1289	1329	1289	LM2	36-45	Male	Others	S	Y	Shoes
Ay21-1517	1515	1517	RP2	60+	Male	Others	CD	N	-
Ay21-1697	1805	1697	RM2	36-45	Male	Local	S	Y	3 coins, knife
Ay21-1761	1760	1761	RM3	Child	Child	Pannonian?	S	N	Coin, knife, ring, buckle, glass vessel, pot
Ay21-1870	1866	1870	LM2	6-12	Child	Pannonian?	S	N	Pot, finger rings, bracelets
Ay21-1894	1895	1894	LP2	18-25	Male	Local	S	Y	-

Abbreviations for position: S = supine; P = prone; C = crouched; D = decapitated there were substantial reservations about the validity of this interpretative framework, and in fact few burial assemblages which matched these criteria closely).

Tooth sampling

Sampling was restricted to later-forming teeth wherever possible (permanent M2, M3 or P3, mineralised between ~3 and ~13 years of age; see Smith 1991). Additional ^{18}O-enrichment must nevertheless be taken into account for individuals where only early forming teeth are available, namely Ay21-118 (deciduous incisor), Ay21-1026 and 1133 (permanent first molars) and possibly Ay21-661 (1st premolar) (Smith 1991; Hillson 1996a).

Isotope analysis

Tooth sample preparation

Each tooth was cut in half using a flexible diamond edged rotary dental saw. The half selected for analysis was cleaned ultrasonically for five minutes in high purity water and rinsed twice to remove loosely adhered material. A tungsten carbide dental burr was used to abrade off the enamel surface to a depth of >100 microns. Secondary dentine was removed and discarded and the enamel and primary dentine were separated. The dentine was reserved for future carbon, nitrogen and background strontium analyses and the enamel was prepared for oxygen and strontium analysis as described below.

Oxygen isotope analysis

Biogenic phosphate was converted to silver phosphate using the method of O'Neil *et al*. (1994), which is briefly summarised here. The core enamel samples were crushed to a fine powder and cleaned in hydrogen peroxide for 24 hours to remove organic material. The peroxide was evaporated to dryness and the sample dissolved in 2M HNO3. The sample solutions were transferred to clean polypropylene test tubes and each sample was treated with 2M KOH followed by 2M HF to remove Ca from the solution by precipitation. The following day, the samples were centrifuged and the solution was added to beakers containing silver amine solution. The silver phosphate was precipitated, filtered, rinsed and dried.

Analytical O isotope determinations were by Continuous Flow Isotope Ratio Mass Spectrometry (CFIRMS) using the method of Venneman *et al*. (2002). The instrumentation comprises a TC/EA (thermo chemical elemental analyser) coupled to a Delta-Plus XL isotope ratio mass spectrometer via a ConFlo III interface, all by Thermo Finnigan.

Reported isotope ratios are expressed using the delta (δ) notation in parts per thousand (permil: ‰) relative to a standard:

$$\delta(‰) = ((\mathrm{Rsample}/\mathrm{Rstandard}) - 1) \times 1000$$

The reference material NBS120C, calibrated against certified reference material NBS127 (assuming $\delta^{18}O$ of NBS127 = +20.3‰ versus SMOW, has an expected value of 21.70‰ (Chenery *et al.* 2010). Each sample was analysed in triplicate. The mean internal mass spectrometry reproducibility for these sets of analyses is ± 0.11‰ (1σ, n=13 over 3 analysis runs). The mean batch reproducibility was 0.13‰ (1σ, n=12 over 3 precipitation batches). Drinking water values are calculated using Levinson's equation (Levinson *et al.* 1987)

$$\delta^{18}O_{\mathrm{Drinking\ Water}} = (\delta^{18}O_{\mathrm{Phosphate\ Oxygen}} - 19.40)/0.46,$$

after applying a method bias of -1.4‰ to the measured $\delta^{18}O_p$ value (see Appendix to Chenery *et al.* 2010).

Strontium isotope analysis

In a clean laboratory, the enamel samples were washed in acetone and cleaned twice, ultrasonically, in high purity water to remove dust and impurities. They were dried and weighed into pre-cleaned Teflon beakers. Each sample was mixed with ^{84}Sr tracer solution and then dissolved in Teflon distilled 16M HN03. The sample was then converted to Chloride and taken up in 2.5M HCl. Strontium was separated and collected using conventional, Dowex® resin ion exchange methods.

The Sr isotope composition and concentrations were determined by Thermal Ionisation Mass spectroscopy (TIMS) using a Thermo Finningan Triton multi-collector mass spectrometer. Samples were run at *c* 5V using single Re filaments loaded using TaF following the method of Birck (1986). The international standard for $^{87}Sr/^{86}Sr$, NBS987, gave a typical value of 0.710275±0.000006 (1s, n=12). All strontium ratios have been corrected to a value for the standard of 0.710250. Strontium procedural blanks provided a negligible contribution.

Results

Oxygen and strontium isotope analyses of dental enamel on the 40 Lankhills individuals are presented in Table 5.61 and Figure 5.71. Drinking water values were calculated using Levinson *et al*.'s (1987) equation, after applying a method bias correction of -1.4‰ to the measured $\delta^{18}O_p$ value, as we have found that $\delta^{18}O_{dw}$ computed this way most closely match local freshwater values for different areas in the UK (see Chenery *et al*. 2010).

Our interpretation of 'non-local' places of origin relies on published data, isotope maps and isotope data bases. Where these do not exist, locations are suggested based on interpolation of geological and hydrological maps. It should be understood that

Table 5.61: Oxygen and strontium isotope results
(All $\delta^{18}O$ is presented in ‰ v SMOW and $\delta^{18}O_{dw}$ has been calculated using the Levinson et al. 1987, equation)

Sample No.	Tooth	Sex	$\delta^{18}O_p$	2δ	$\delta^{18}O_{dw}$	2δ	Sr ppm	Sr8786
Ay21-0012	P2	M	18.2	0.0	-5.7	0.4	103	0.7082
Ay21-0084	M2	F	18.8	0.2	-4.3	0.4	79	0.7086
Ay21-0118	dI1	n.d.	19.1	0.1	-3.7	0.2	77	0.7088
Ay21-0119	M2	F	19.5	0.2	-2.8	0.4	100	0.7087
Ay21-0212	P2	F	18.3	0.2	-5.4	0.4	66	0.7087
Ay21-0271	M2	F	19.4	0.2	-3.0	0.5	139	0.7102
Ay21-0281	M2	M	16.8	0.1	-8.6	0.3	92	0.7115
Ay21-0435	M2	F	17.5	0.2	-7.1	0.4	53	0.7089
Ay21-0489	M2	M	17.8	0.2	-6.6	0.5	72	0.7112
Ay21-0566	M2	M	18.8	0.3	-4.4	0.6	169	0.7095
Ay21-0661	P1	F	18.1	0.1	-5.9	0.3	54	0.7085
Ay21-0683	M3	M	18.9	0.1	-4.2	0.2	132	0.7094
Ay21-0776	M2	M	17.8	0.2	-6.5	0.3	86	0.7096
Ay21-0806	P2	F	19.3	0.0	-3.2	0.0	88	0.7087
Ay21-0812	M2	M	19.0	0.0	-3.8	0.1	128	0.7087
Ay21-0861	P2	M	18.2	0.0	-5.7	0.1	ND	0.7098
Ay21-0862	M2	M	17.8	0.1	-6.6	0.3	118	0.7082
Ay21-0874	M2	n.d.	18.0	0.3	-6.0	0.6	81	0.7088
Ay21-0926	M2?	F?	18.3	0.3	-5.5	0.5	104	0.7086
Ay21-0932	M2	M	17.9	0.2	-6.4	0.4	67	0.7084
Ay21-1026	M1	n.d.	17.9	0.2	-6.2	0.5	78	0.7085
Ay21-1084	M2	F	18.2	0.3	-5.7	0.6	105	0.7092
Ay21-1091	M2	F	18.1	0.2	-5.9	0.4	105	0.7091
Ay21-1094	P2	F	17.0	0.1	-8.2	0.3	42	0.7083
Ay21-1114	M2	F	19.0	0.3	-4.0	0.6	121	0.7089
Ay21-1119	M2	M	15.8	0.3	-10.9	0.7	87	0.7094
Ay21-1133	M1	F	18.5	0.4	-5.1	0.8	52	0.7092
Ay21-1134	P2	F	18.0	0.2	-6.1	0.5	65	0.7086
Ay21-1197	P2	F	17.8	0.2	-6.6	0.4	59	0.7110
Ay21-1207	M2	F	17.9	0.2	-6.2	0.5	108	0.7089
Ay21-1227	M2	F	18.3	0.2	-5.4	0.4	73	0.7083
Ay21-1244	M2	F?	18.4	0.1	-5.1	0.1	61	0.7086
Ay21-1271	M2	M	17.7	0.2	-6.7	0.5	67	0.7083
Ay21-1277	M2	M	18.2	0.3	-5.6	0.6	87	0.7115
Ay21-1289	M2	M	18.1	0.1	-5.8	0.3	58	0.7087
Ay21-1517	P2	M	18.7	0.2	-4.6	0.4	81	0.7090
Ay21-1697	M2	M	18.8	0.1	-4.3	0.1	95	0.7090
Ay21-1761	M3	n.d.	18.3	0.2	-5.5	0.4	80	0.7086
Ay21-1870	M2	n.d.	17.6	0.2	-6.9	0.4	79	0.7087
Ay21-1894	P2	M	18.1	0.1	-6.0	0.3	46	0.7118

these are suggestions, based on currently available data, not secure attributions. They do not rule out origin in other areas where similar combinations of climates and geology exist.

The $\delta^{18}O_p$ signatures for the individuals in this study give a broad range of values, from 15.8‰ to 19.5‰ (mean 18.2±1.4‰, 2σ) with corresponding drinking water values between -10.9‰ and -2.8‰ (mean -5.7±3.1‰, 2σ). Of these, one individual (Ay21-1119) is a clear statistical outlier, with an unusually low $\delta^{18}O_p$ (15.8‰, $\delta^{18}O_{dw}$ = -10.9‰) which falls further than 3σ from the mean.

Strontium isotope ratios for the 40 individuals range from 0.7082 to 0.7118 (mean 0.7092±0.0019, 2σ).

Defining 'local' individuals

In order to use isotope analysis for reconstructing mobility, the range of values consistent with a local upbringing needs to be defined. Typical strontium isotope values for the Cretaceous chalk, Oligocene and Eocene sediments around Winchester are expected to fall between 0.7072 and 0.7092 (Evans *et al.* 2006a; Trickett 2008). Twenty-nine individuals have $^{87}Sr/^{86}Sr$ within this range. Unfortunately, these types of values are not overly specific as they can also be expected for other Mesozoic limestones, Palaeogene sediments and young or low radiogenic igneous terrains (Montgomery *et al.* 2006, 2007; Thirlwall 1988; Beckensale *et al.* 1981).

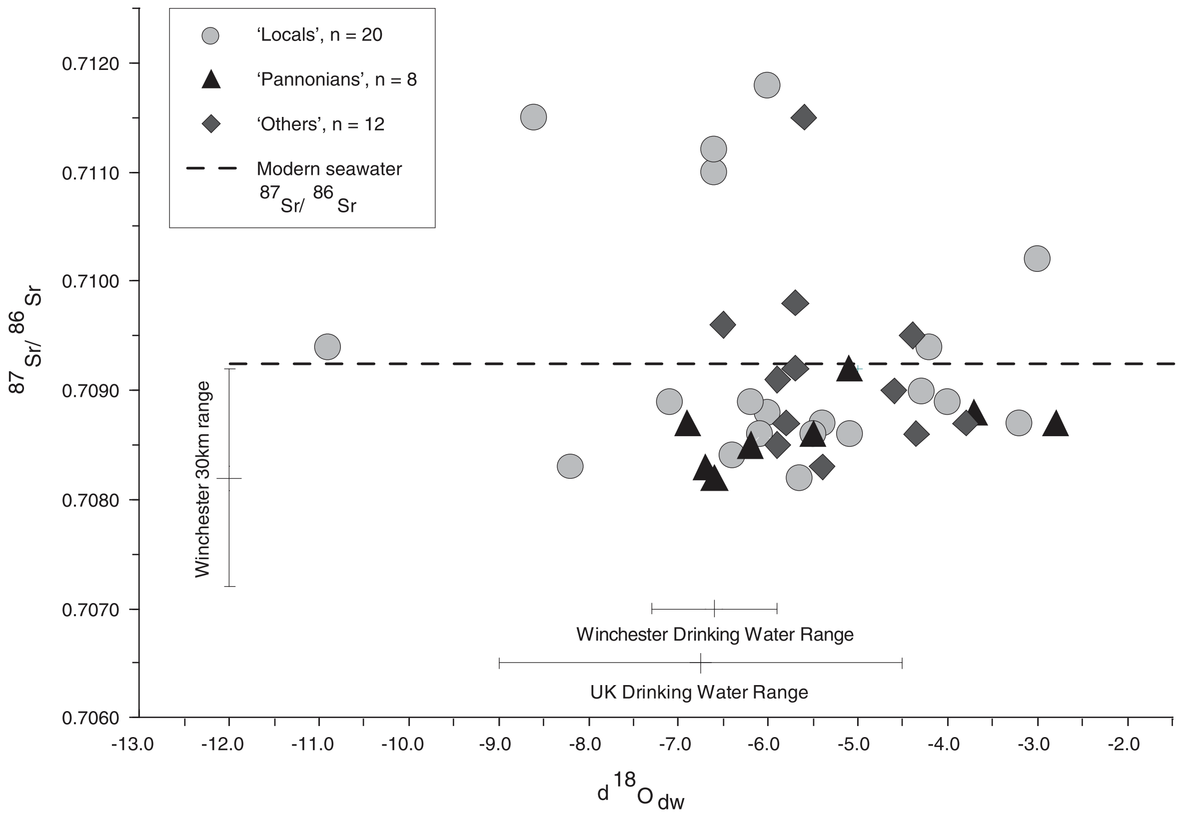

Fig. 5.71 Oxygen and strontium isotope ratios for Lankhills humans

Constraining the 'local' range further with the aid of oxygen isotopes is not straightforward, mainly because there are still few empirical data to allow estimation of the degree of oxygen isotope variation in a sedentary population with the same drinking water source. Observed values for modern British freshwaters are between ~-9 ‰ to ~-4.5‰, although values >~-5 ‰ are isolated to the extreme west of the UK, the western tip of Cornwall, western Wales and the Scottish Isles (Darling *et al.* 2003), some of these being areas outside immediate Roman control. At the present time, we do not want to attempt to subdivide the oxygen isotope data further than this proposed British range. The oxygen isotope composition of drinking water in the Winchester area (~-7.3 to ~-5.9‰; Darling pers. comm.) is nevertheless useful as it allows making relative statements with regards to the human data: individuals with oxygen isotope signatures <-6.6‰ are, if not from the Winchester area itself, more likely to have come from the east of the country (or compatible 'cooler' regions on the European continent), while individuals with higher values are more consistent with 'warmer' areas in western Britain or areas with a comparable climate abroad. In this context it is worth emphasizing that oxygen isotope compositions encountered in British freshwaters are of course not exclusive to the British Isles. They are also found in many areas of western (Iberian peninsula, France, the Low Countries, Northwest Germany and Denmark) and southern Europe (Italy, Greece) as well as the Mediterranean (Turkey, the Levant and even parts of Northern Africa) (IAEA/WISER 2008; Lecolle 1985; Bentley and Knipper 2005; Lykoudis and Argiriou 2007; Daux *et al.* 2008).

Individuals with 'local' $^{87}Sr/^{86}Sr$ and $\delta^{18}O_p$ in the British range

Twenty-one individuals have $^{87}Sr/^{86}Sr$ between 0.7080 and 0.7092 and oxygen isotope signatures consistent with an upbringing in Britain. As discussed above, this combination of strontium and oxygen isotope ratios may be compatible with various places in the UK and abroad; however, it is likely that at least the majority of these individuals are indeed of local origin. The apparent clustering of data-points in this region suggests the same (Figure 5.71). Of these 21 individuals, 10 (Ay21-0012, 0212, 0435, 0874, 0926, 0932, 1094, 1134, 1207, 1244) are characterised as 'local/Romano-British' in terms of their burial rites and grave furnishings, six (Ay21-0862, 1026, 1133, 1271, 1761, 1870) are suggested 'Pannonians' (in Clarke's terminology) and a further five (Ay21-0661, 1084, 1091, 1227, 1289) are classed as 'other/unusual' in terms of their mortuary treatment.

Individuals with 'non-local' $^{87}Sr/^{86}Sr$ and $\delta^{18}O_{dw}$ in the British range

Seven individuals have $^{87}Sr/^{86}Sr$ outside the Winchester range (ie >0.7092) but $\delta^{18}O_{dw}$ which are consistent with a childhood in Britain or a similar climatic zone. Of these, the signatures of two individuals (Ay21-0776, 0861), both classed as 'other' burials on the basis of the field evidence, are only slightly more radiogenic than local values (0.7096 to 0.7098). They are comparable with biosphere data obtained from vegetation on Mesozoic, non limestone, terrains, bottled waters from Carboniferous limestone aquifers, and Mesozoic mudstones, sand, and clay geologies (Chenery *et al.* 2010; Montgomery *et al.* 2006; Beckensale *et al.* 1981). Areas compatible with these values are, for example, the Mesozoic terrains around Bath, Bristol, and Gloucester (Chenery *et al.* 2010). Alternatively, the data may also fit origins on older rocks, but in coastal areas where marine strontium has a significant impact on local biosphere values (Montgomery *et al*. 2003; Montgomery *et al.* 2007).

Five individuals (Ay21-281, 489, 1197, 1277 and 1894), four of them classed as 'local' on the basis of their burial rites, and the fifth as 'other', have higher $^{87}Sr/^{86}Sr$ values (0.7112-0.7118), which are more typical of bottled waters from Palaeozoic (especially Carboniferous and Devonian) sand- and mudstone terrains, as may be found in various areas of western (eg Wales, the Malverns, parts of Devon or Cornwall) and northern Britain (eg Cumbria, parts of Scotland) (Montgomery *et al.* 2006; Thirlwall 1988; Beckensale *et al.* 1981). One of them (Ay21-281) has a markedly lower oxygen isotope signature than the others (-8.6‰) which is at the very edge of the UK range (Figure 5.71), and which makes an origin in western Britain very unlikely. Instead, given the extent of Roman occupation in Britain, the isotopic profile of this individual perhaps rather suggests origins elsewhere in Europe. Areas with compatible drinking water compositions and geology can be found, for example, in certain regions of Belgium (Ardennes) or Western Germany (Rheinisches Schiefergebirge), which are dominated by Palaeozoic terrains (Lecolle 1985, Asch 2005).

Individuals with $\delta^{18}O_{dw}$ suggesting non-British origins

Eleven individuals have oxygen isotope ratios outside the estimated UK range. (Non-adult Ay21-118 is excluded here as the raised $\delta^{18}O_{dw}$ values are probably due to the breastfeeding effect). Ten individuals (archaeologically classified as five 'locals', one suggested 'Pannonian' and four 'others') have higher values, suggesting origins in warmer/more coastal climates. These extend from -4.6‰, which is still compatible with extreme western Britain, to -2.8‰, which is only just within two standard deviations from the population mean. Within the confines of the Roman Empire, oxygen isotope values like these are consistent with parts of the Iberian peninsula, and the Mediterranean, on the southern European and North African side (IAEA/WISER 2008; Longinelli and Selmo 2003; Lykoudis and Argiriou 2007). $^{87}Sr/^{86}Sr$ of nine of the 10 individuals are between 0.7086 and 0.7095 and therefore close to the value of modern seawater (0.7092). They are compatible with a range of Mesozoic and younger terrains (see Chenery *et al.* 2010; Montgomery *et al.* 2006; Beckensale *et al.* 1981), but would also be consistent generally with areas in proximity to the coast (Montgomery *et al.* 2007; Müldner *et al.* in press). One individual (Ay21-271) has a higher strontium isotope signature (0.7102), suggesting an origin on different, older/more radiogenic terrains or further away from the coast.

Ay21-1119, an older adult (45+) male who appeared 'local' by his mode of burial, is the only statistical outlier in the sample. His $\delta^{18}O_{dw}$ (-10.9‰) is more than 3σ from the population mean, indicating a childhood in a significantly cooler and/or more continental climate than Britain. Combined with the $^{87}Sr/^{86}Sr$ (0.7094) which is not easily compatible with the geology of major western European mountain ranges (and therefore areas of significant altitude which could also explain the low $\delta^{18}O$: Asch 2005; Müller *et al*. 2003), an origin in central Europe is the most likely interpretation.

Discussion

The combined isotope results suggest that 21 individuals may be from Winchester and surrounding areas, with a further eight probably from other parts of the UK (Tables 5.64 and 5.65 and Figure 5.71). The remaining 11 individuals are defined as incomers, with 10 coming from warmer and one from colder areas. Many of the individuals defined as incomers isotopically cluster around the edges of the UK range, and we have outlined above how difficult it is to pinpoint specific areas of origin. It is also clear that the relationship between isotopical origin and burial rites is more complex than previously assumed. Only one individual (Ay21-1119) had isotope values compatible with those expected for 'Pannonian' origin (see above). However, this adult male was described as 'local' in terms of the characteristics of his burial.

Two of the three individuals with the warmest oxygen isotope signature were also classed archaeologically as 'local', while the third was tentatively considered 'Pannonian' based on the artefactual evidence (see Figure 5.71). The $\delta^{18}O_{dw}$ of the latter, a female (Ay21-119), is certainly too high to be consistent with an origin either in Britain or Pannonia. The two others, interestingly also both female (Ay21-0806; Ay21-0271), also fall outside the UK range, again contradicting the archaeological criteria.

There is no statistical relationship between isotopically defined origin and sex in our sample, but it should be noted that the three individuals with the highest $\delta^{18}O_{dw}$, which are by current estimates certainly too 'warm' for the UK, were all female.

Six non-adults were sampled, and the technical difficulties regarding selection of teeth and a possible 'breastfeeding effect' have been discussed above. Although five of these were classed as possibly 'Pannonian' archaeologically, isotope analysis indicates that at least four of them (Ay21-1026, 1133, 1716 and 1870) were probably raised in the Winchester area (and certainly not in Central Europe; see Figure 5.71). Although the remaining individual (Ay21-0118) has slightly higher oxygen isotope signatures than the others, the sample was taken from an early forming tooth and the results are likely due to the 'breastfeeding effect'. On isotopic grounds, there is therefore no reason to suggest that the child was not local. Ay21-0118 in particular is a very unusual burial in that the infant (10 months to 2 years) was decapitated. The sixth child (Ay21-0874) was classed as 'local' on archaeological grounds and has an isotope signature consistent with a local Winchester origin.

There is no clear patterning with regard to unusual burial rites such as prone burial and decapitation. Of the two remaining decapitated individuals (in addition to Ay-21-0118 discussed above), Ay21-1084, an adult female, has a local isotopic signature, while the $\delta^{18}O_{dw}$ of Ay21-1517 (-4.6‰), an older male, is strictly still just inside the UK range and therefore inconclusive. All three prone burials (two males Ay21-0861 and Ay21-1277 and a child Ay21-1026) could be from the UK, though interestingly, neither of the adults is from Winchester (Table 5.61).

In conclusion, the results of this study suggest that up to a quarter of sampled Lankhills individuals were incomers and spent their early childhood outside the Winchester area, with a significant proportion likely to have started life outside Britain. These individuals may have originated from as far afield as the Hungarian Basin and the Southern Mediterranean.