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6 *T. Waldron*

The relative survival of the human skeleton: implications for palaeopathology

'Still one thing is left – the bone' Edith Sitwell, *Lullaby*

In the study of health and disease in the past, human and animal bones are amongst the most important pieces of evidence on which deductions can be based. The human skeleton is the closest most of us will ever come to the forms of our ancestors, but it is obvious that the quality of the information which the human or animal bone specialist can derive from his material depends to a considerable degree on the quality of the assemblage on which he has to work. Animal bone specialists have studied the factors which affect bone survival in some detail but, so far, those interested in human bones have not. Brain (1976), in his classic studies amongst the Kuiseb River Hottentots in Namibia showed that the bones which survived best were those which were unchewable. The economy of the Hottentots amongst whom he worked was built around their goat herds and the bones of the animals they slaughtered were extensively modified by their methods of butchery and processing. After the carcase had been boiled and the meat removed, the skull was smashed to remove the brain and the long bones were broken open to remove the marrow. After this the bones were passed to the dogs. Brain found that the horns survived this treatment best and then the mandible; next in frequency were found the distal humerus and tibia and the proximal radius and ulna. As a general rule, Brain suggested that the survival of the limb bones was related firstly to the state of epiphyseal fusion at the time of slaughter and secondly to the density of the bone. Epiphyses which were cartilaginous at the time of slaughter were readily eaten by the dogs; the fully ossified ends of the bones and the dense shafts of the long bones were resistant to chewing and so survived well. Thus, Brain concluded, survival is not haphazard, but is determined by inherent qualities of the parts.

Brain's work has been followed up and amplified most notably by Binford who has written at great length on the subject (see, for example, Binford & Bertram, 1977; Binford, 1981). Andrews and Cook (1985) have also recently discussed the factors which affect the survival of animal bones

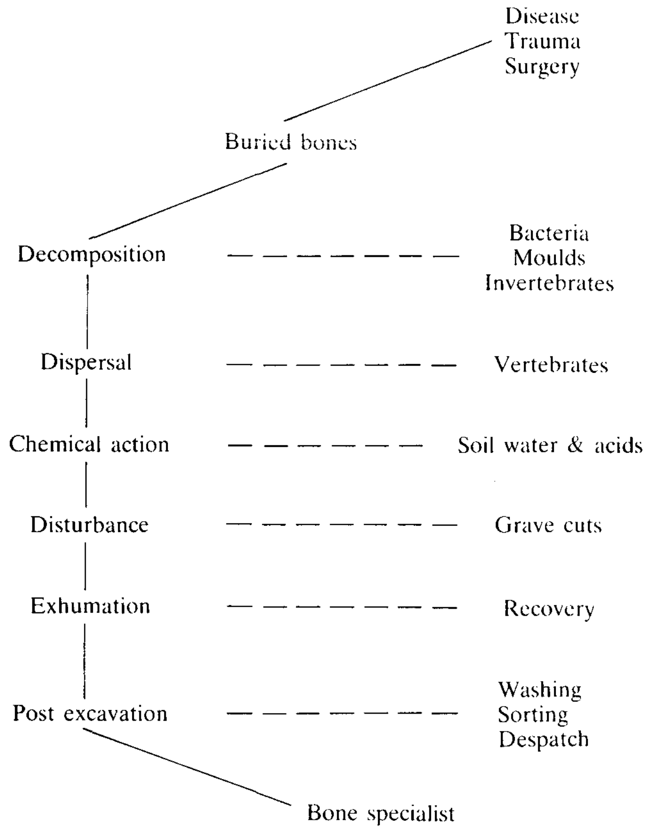


Fig. 6.1 Some factors affecting bone survival. Solid lines indicate processes and dashed lines some of the mechanisms involved.

and they have prepared a useful flowdiagram to illustrate some of their points.

6.1 Factors affecting bone survival

The factors which influence the survival of human bones differ in some important respects from those affecting animal bones, largely because humans are invariably subject to some burial (or disposal) ritual. Many of these factors are discussed at greater length in Chapters 5 and 10, but some which seem most important to me, and which bear upon palaeopathology are shown in Fig. 6.1.

The ante-mortem processes which affect the state of the bones and which

are of the greatest interest to the palaeopathologist are, of course, the relatively few diseases which leave their stigmata on the skeleton. Other ante-mortem factors of importance include trauma, both accidental and deliberate, and surgery. The state of the bones which come to the palaeopathologist's attention, however, is predominantly determined by the operation of post-mortem factors. The changes which follow upon decomposition are detailed in Chapter 7 although it should be remembered that these are not of great importance in relation to bone survival, particularly when compared with the chemical reactions which take place between the bone mineral and the surrounding medium in which the skeleton is buried. Acid conditions may seriously affect the bones, leading on the one hand to an alteration in the elemental composition of the bones and on the other, to the complete dissolution of part, or the whole, of the skeleton. The effects which the physical conditions of the soil may have on bone buried in it are by no means always predictable as Ruffer pointed out almost three-quarters of a century ago: 'The skeleton of a female. . . lying on a bed of dry sand was so fragile that some bones were broken when their removal was attempted; on the other hand, bones lying in liquid mud were sometimes very hard, whereas others, in the same grave, broke as soon as handled' (Rietti & Ruffer, 1912).

Scattering of the remains and damage by scavengers is not a major cause of disturbance unless the body is exposed and this is one of the most important differences between the fate of animal and human bones. What is of considerable importance in terms of the theme of this book, however, is the damage which follows when a burial site is disturbed. Limbs may be lopped off and scattered by the undertaker's spade, skulls crushed by the navvy's pick, and bodies built into new structures on an old site. During excavation bones may be damaged, missed or lost, as indeed they may at any stage on their journey from site to washroom to bone specialist and back to the museum.

6.2 A study of human bone survival

I have conducted a preliminary study of relative bone survival using data from the Romano-British site at West Tenter Street in London. This cemetery (which was dug by the Department of Greater London Archaeology of the Museum of London under the direction of Robert Whytehead) dates from the second to the fourth centuries. There were 112 discrete burials, a small number of cremations and a great deal of disarticulated bone (Waldron, unpublished data). Of the 112 burials, 88 were from adults, and an 'expected' number was calculated for each bone from an adult skeleton.

For example, if survival and recovery had both been complete, there would have been 176 of each limb bone, 616 cervical, 1056 thoracic and 440 lumbar vertebrae, and so on. During the examination of the skeletons, the condition of each bone was coded as follows: '1' if complete, '2' if incomplete but more than half the epiphysis was present, '3' if only half the epiphysis was present, and '4' if only a fragment was present. By definition, no useful information either anthropological or palaeopathological could be derived from a bone coded '4'. Coding was carried out separately for the proximal and distal ends of the bones as appropriate, and bones which were coded 1–3 were counted as 'present' and the observed number of bones in the entire assemblage was computed and expressed as a proportion of the expected number; the results are shown in Table 6.1 and in Figs 6.2 to 6.5.

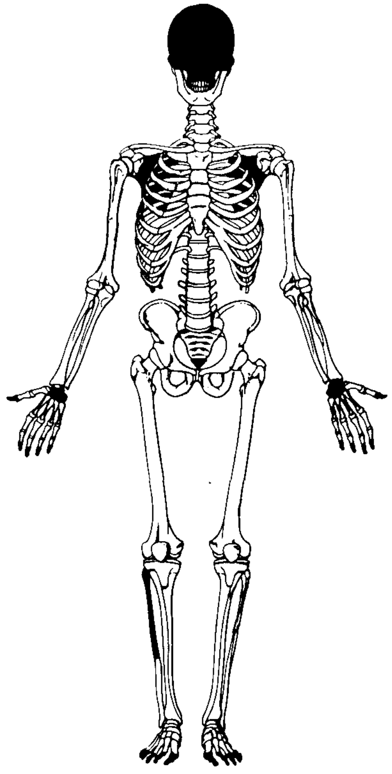
Table 6.1. Proportion of bones recovered from 88 adults at a Romano-British site in London.

Skeletal elements			Number recovered	% of expected
Skull				
Frontal	left		36	40.9
	right		38	43.2
Parietal	left		29	33.0
	right		29	33.0
Occipital	left		35	39.8
	right		38	43.2
Occipital condyle				
	left		41	46.6
	right		43	48.9
Petrous temporal				
	left		59	67.0
	right		53	60.2
Mastoid	left		52	59.1
	right		50	56.8
Zygoma	left		42	47.7
	right		41	46.6
Maxilla	left		46	52.3
	right		50	56.8
Whole skull			15	17.0
Mandible				
Head	left		46	52.3
	right		44	50.0
Ramus	left		53	60.2
	right		51	58.0
Body	left		57	64.8
	right		56	63.6
Post-cranial skeleton				
Vertebrae				
	cervical		318	51.6
	thoracic		1056	58.0
	lumbar		440	58.4
	first sacral		52	59.1
	second scaral		41	46.6
	third sacral		35	39.8
	fourth sacral		30	34.1
	fifth sacral		26	29.5
	coccyx		1	1.1
Clavicle	left proximal		37	42.1
	left distal		38	43.2
	right proximal		40	45.5
	right distal		42	47.7
Scapula				
	body	left	10	11.4
		right	16	18.4
	glenoid	left	44	50.0
		right	49	55.7
	acromion	left	33	37.5
		right	40	45.5
	coracoid	left	29	33.0
		right	33	37.5
Sternum	manubrium		21	23.9
	body		20	22.7
Humerus	left proximal		41	46.6
	left distal		49	55.7
	right proximal		47	53.4
	right distal		51	58.0
Radius	left proximal		51	58.0
	left distal		44	50.0
	right proximal		44	50.0
	right distal		45	51.1
Ulna	left proximal		55	62.5
	left distal		36	40.9
	right proximal		54	61.4
	right distal		36	40.9
Femur	left proximal		55	62.5
	left distal		46	52.3
	right proximal		48	54.6
	right distal		44	50.0
Tibia	left proximal		39	44.3
	left distal		43	48.9
	right proximal		42	47.7
	right distal		44	50.0
Fibula	left proximal		18	20.5
	left distal		27	30.7
	right proximal		16	18.2
	right distal		30	34.1
Patella	left		22	25.0
	right		25	28.4
Calcaneum	left		42	47.7
	right		40	45.5
Talus	left		39	44.3
	right		45	51.1
Carpals	left		127	18.0
	right		110	15.6
Metacarpals	left	1	43	48.9
		2	49	55.7

Table 6.1. (Continued)

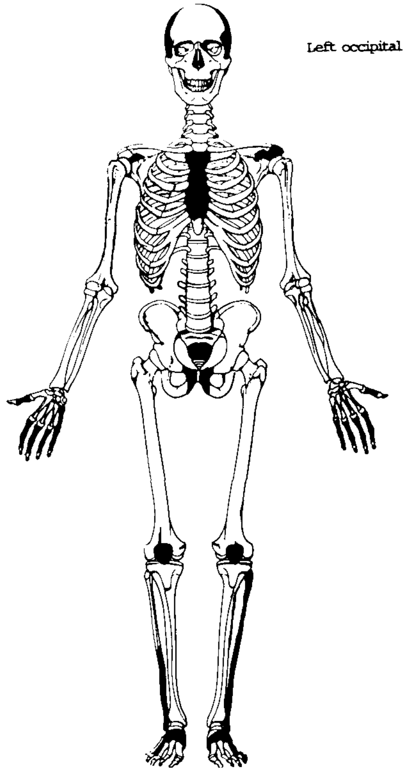
Skeletal elements			Number recovered	% of expected
		3	56	63.6
		4	46	52.3
		5	40	45.5
	right	1	38	43.3
		2	47	53.4
		3	45	51.1
		4	43	48.9
		5	35	39.8
Phalanges	left	1	164	37.3
		2	80	22.7
		3	37	8.4
	right	1	158	35.9
		2	80	22.7
		3	25	5.7
Tarsals[a]	left		130	29.6
	right		137	31.1
Metatarsals	left	1	37	42.1
		2	36	40.9
		3	40	45.5
		4	35	39.8
		5	38	43.2
	right	1	40	45.5
		2	40	45.5
		3	41	46.6
		4	33	37.5
		5	37	42.1
Phalanges[b]	left	1	50	11.4
		2	11	3.1
		3	6	1.4
	right	1	55	12.5
		2	11	3.1
		3	5	1.4
Pelvis				
Acetabulum	left		54	61.4
	right		53	60.2
Pubic symphysis				
	left		27	30.7
	right		24	27.3
Ischial tuberosity				
	left		52	59.1
	right		47	53.4
Sciatic notch	left		62	70.5
	right		54	61.5
Auricular surface				
	left		56	63.6
	right		49	55.7

[a] Excluding talus and calcaneum
[b] Phalanges of foot (to distinguish from phalanges of hand)



<20%

Fig. 6.2 Parts of the skeleton (shown in black) for which observed numbers are less than 20% of expected.

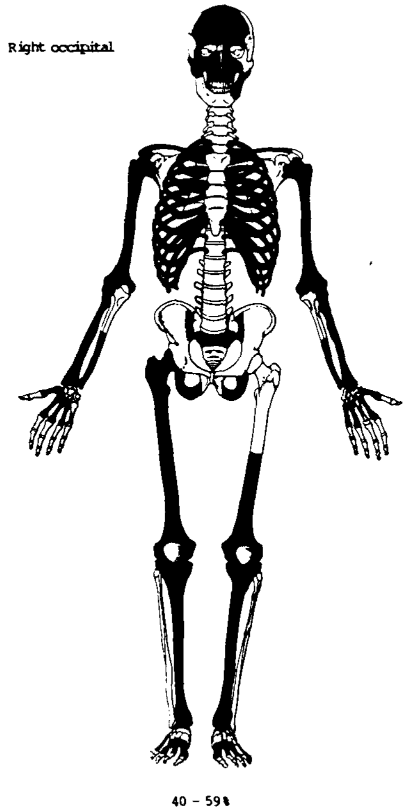


20 - 39%

Fig. 6.3 Parts of the skeleton (shown in black or named) for which observed numbers are between 20 and 39% of expected.

At this site there is a reasonably consistent relationship between size and survival and also some evidence that anatomical position may influence survival. The bones which are least well represented are the phalanges of the hands and the feet, the carpals, and the coccyx; for all of these bones the observed numbers were less than 20% of the expected. The body of the scapula also survived extremely poorly, probably because it is thin and extremely vulnerable to damage. The small tarsal bones are also much under-represented (less than 40% of expected), but the talus and calcaneum are found more frequently, and the metacarpals and metatarsals also appear to be relatively resistant to the various processes of destruction.

There is an interesting under-representation of bones which occupy an



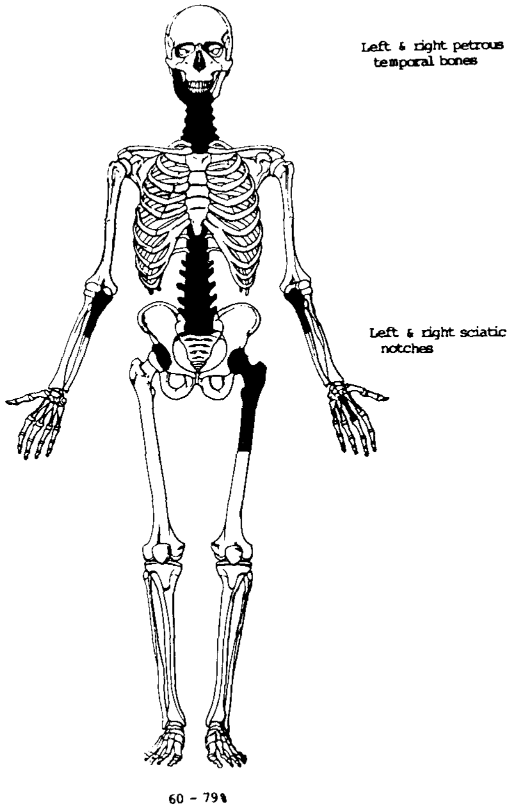


Fig. 6.4 Parts of the skeleton (shown in black or named) for which observed numbers are between 40 and 59 % of expected.

Fig. 6.5 Parts of the skeleton (shown in black or named) for which observed numbers are between 60 and 79 % of expected.

anterior position in the body, i.e. the sternum, coracoid and acromion processes of the scapula, pubis and patella. None is present in numbers greater than 40 % of that expected. The loss of the pubis is particularly unfortunate since this bone may be extremely useful for ageing the skeleton.

The bones which appear to be most resistant to the processes of destruction and have survived best at this site are dense, relatively heavy bones such as the petrous temporal bone and mastoid in the skull, the right hemimandible, the acetabulum and the sciatic notch of the pelvis, parts of some of the long bones such as the proximal end of the ulna, and (curiously) the left middle metacarpal. In some respects the pattern of survival of the human bones at this site is similar to that of the animal

bones described by Brain (1976). Thus, dense, heavy bones are well represented whereas small or fragile bones are not. How far this pattern can be taken as typical of what might be found elsewhere is unclear, however. Given that soil conditions vary so much from one site to another, it would be surprising if the results were, in fact, typical.

6.2.1 *The implications of relative bone survival for the palaeopathologist*

Were it to be the case that the relatively poor survival of some bones reported here is general, this would have important consequences for both anthropology and palaeopathology. The anthropological consequences are not the prime concern of this chapter; suffice it to say that reliable ageing and sexing of the skeleton can be achieved only if the important diagnostic elements, such as the skull, pelvis and pubis survive well.

From the palaeopathological point of view, the important issues which follow from differential survival relate to the apparent prevalence of pathological changes in the skeleton and their appropriate classification. The likelihood of finding pathological changes in the skeleton is directly related to the number of bones which survive. Where survival is poor, there will be a tendency to underestimate the frequency of disease within a population and this may lead to errors when making comparisons from one study to another.

When classifying the pathological changes in a skeleton into their most probable cause (or causes), it is often of great help to be able accurately to establish their distribution. This is nowhere more critical than when attempting to classify the arthropathies (Rogers *et al*, 1986). The classification of changes in the joints into their 'most probable cause' can seldom, if ever, be made from a consideration of isolated elements of the skeleton. For the arthropathies, which are probably the most common of the pathological changes seen in bones, it is as important to be able to determine which joints are normal as it is to determine those which are pathological, and in this assessment the state of the small joints of the hands and feet is crucial. At the site studied here, the phalanges of both the hands and feet are greatly under-represented, severely limiting the ability to classify the changes which may be seen in other joints such as those in the vertebrae which survived well. The loss of the phalanges can also have important repercussions for the diagnosis of other conditions; it might be critical for assessing the earliest changes in leprosy, for example.

It is not possible to be certain about the processes which are causally related to the loss of bones, although it seems likely that the most significant was the disturbance which took place during the time that the cemetery was in use. Many of the graves had been cut into by others causing damage to the pre-existing skeleton; this is a common occurrence at all cemetery sites. The great under-representation of the small bones of the hands and the feet, however, may also be due in part to a failure of recovery. The carpal bones can easily be mistaken for small pebbles by an excavator unfamiliar with human anatomy and the phalanges may be missed, especially in a sticky clay soil. Recovery of these bones would almost certainly be enhanced by ensuring that all those who dig human skeletons have a knowledge of basic anatomy so that, for example, they would know that they ought to find eight small bones at the ends of the radius and ulna. The yield of phalanges might well be improved by sieving the soil from the areas in which the hands and feet would be expected to lie.

6.3 Conclusions

The study which I have reported here has shown that, at one site at least, human bone survival (and/or recovery) is less than ideal from the palaeopathological point of view. Bones have a very limited capacity for expressing disease – they can either lose bone or form bone – and virtually no change in a single bone is pathognomonic of a disease. The correct interpretation of changes seen in the skeleton, therefore, depends a great deal on being able to determine their pattern. This is obviously not possible when the skeleton if fragmentary. Unfortunately nothing can be done to protect the skeleton before it is excavated, but during recovery every effort should be made to ensure that everything that is there to be lifted is lifted. Where there are constraints of time or money at a site it may be possible to discuss the strategy of recovery with the bone specialist at the time, bearing in mind the questions which it is hoped may be answered from the study of the bones. As a general rule, however, care should be given in proportion to the completeness of the skeleton since the quality of the information to be derived from it will also be so related.

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7 *A. K. Mant*

Knowledge acquired from post-War exhumations

7.1 Factors influencing decomposition

7.1.1 *Introduction*

In Great Britain exhumations for medico-legal and other purposes other than the removal of bodies from one cemetery to another are of rare occurrence. It is not surprising, therefore, that information concerning decomposition which can only be obtained from exhumations during the post-mortem interval is sparsely covered in text books of forensic medicine.

The large numbers of exhumations for medico-legal purposes (Mant, 1950) which were carried out in Europe after the Second World War provided a unique opportunity for a study of the changes which occur in a cadaver following interment under different conditions. It was not surprising that some of the old traditional teaching was found to be misleading. For example, it was considered that as completely contrary conditions were required for saponification or adipocere formation and mummification these two forms of late decomposition did not occur together, whereas in fact the changes of saponification, mummification and putrefaction may all be seen on the same cadaver.

The material upon which this chapter is based was derived from over 150 exhumations (Mant 1950, 1953) carried out in Germany after the Second World War. These cadavers were buried under widely different conditions but the dates of death and interment were usually known. In some cases bodies were buried immediately after death, in contrast to the usual post-mortem interval of several days. Thus, it was possible to study the effect of immediate burial upon subsequent post-mortem changes.

During the period when these exhumations were carried out there were no laboratory facilities available for carrying out chemical analyses upon the tissues present on the exhumed bodies. Only the gross changes were recorded. These changes, however, provided a wealth of information concerning many of the various factors which influence the rate and type of

Death, decay and reconstruction

Approaches to archaeology and forensic science

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