Chapter 7: Examination of methods used to estimate osteological age and sex

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AGE AT DEATH METHODS

Adults

The ages of 52 adults that were studied osteologically were known from the biographical data. This presented a rare opportunity to examine the performance of a number of the osteological ageing techniques described in Chapter 6. Osteological analysis was undertaken without knowing the identity or age of the skeleton beforehand. Osteological age was then compared with chronological age, in order to assess the accuracy and precision of the ageing methods used.

A maximum of six methods was used on skeletons aged over 28 years. Two additional methods (dental development and epiphyseal fusion) were used in adults aged younger than 28 years. The results of these two methods are discussed in the subadult ageing section below. The number of ageing methods used on each skeleton was limited by the bone preservation and completeness of the individual. Table 7.1 summarises the number of ageing methods employed on this assemblage.

The most commonly used adult ageing method was the auricular surface degeneration scoring system published by Lovejoy *et al* (1985), which was applied to 47 (90.38%) skeletons (Table 7.2). This high number reflects the good survival rate because of the relatively high bone density of the articular surface. The next most common ageing method involved observations relating to cranial suture obliteration, which was applied to 41 (78.84%) skeletons. Unlike many skeletons in less protected burial environments, the sternal end of 4th rib was often well preserved in the named sample from St George's, and was used to age 27 (51.92%) individuals. The Suchey-Brooks system was used on the pubic symphyses of 28 (53.85%) skeletons, and the Todd method on 26 (50%) individuals. Roden's (1997) dental attrition scoring was used to age 14 individuals (26.92%).

Some interesting observations were made when the results of these ageing methods were compared to the chronological ages of the individuals (known from the coffin plate inscriptions). The accuracy and precision of each ageing method is discussed individually below. The osteological age at death obtained by each method and the actual age of the individual is presented in Table 7.3

Auricular surface

When comparing the osteological age ranges provided by the auricular surface with the chronological age at death, 21 (44.68%) individuals were aged correctly; 18 (38.30%) were osteologically under-aged by an average of 13 years, and eight individuals (17.02%) were over-aged by an average of 5.5 years. All the young adults (n = 2), and a 22.22% (n = 2) of the prime adults were correctly aged. Five prime adults (62.5%) were over-aged, and one (11.11%) was under-aged. Of those individuals aged between 40 and 50 years, 60% (n = 3) were aged correctly and 40% (n = 2) were over-aged. Of the individuals aged over 50, 44.16% (n =

Table 7.1: Quantification of age assessment methods used per skeleton (N= 52)

Number of methods used	*6*	*5*	*4*	*3*	*2*	*1*	*Total*
Number of individuals	3	13	8	13	13	2	52
% of individuals	5.77%	25%	15.38%	25%	25%	3.85%	100%

Table 7.2 Quantification of ageing methods used (N= 52)

Auricular surface (n/N)	*Suture closure (n/N)*	*Sternal rib end (n/N)*	*Pubic symphysis (Suchey-Brooks) (n/N)*	*Pubic symphysis (Todd) (n/N)*	*Dental attrition (n/N)*
90.38% (47/52)	78.84% (41/52)	51.92% (27/52)	53.85% (28/52)	50% (26/52)	26.92% (14/52)

Table 7.3 Chronological age of adults compared with biological age (N = 52). All ages are given in years.

Skeleton Number	*Chronological age at death*	*Auricular surface age*	*Cranial suture closure age*	*Dental attrition age*	*Pubic symphysis age (Suchey and Brooks)*	*Pubic symphysis age (Todd)*	*Sternal rib end age*
1041	83	>60	35-56		34-86	>50years	43-55
1052	56	50-55		25-31	23-57	40-45	54-64
1055	85	50-55	45-55		27-66	45-49	
1057	57	40-50	43-46		27-86	45-49	34-42
1059	23	20-25					24-32
1068	71	50-59	35-60				
1077	58	50-59	>40	36	27-86	45-49	
1527	70	50-55	>50				
1564	81	>60	>40		27-66	45-49	65-78
2006	57	40-44	45-52	31-36	25-83	>45	43-71
2008	27	31-44	45-53	24-25	21-53	27-35	34-46
2020	38	30-34	39	30-31			
3002	77	54	40-49	42			
3022	57	>60	40-50				43-58
3085	77	45-50	45-51	45			
3090	63	45-55	40-52	38-44	27-66		54-64
4002	86	50-55	45-55				
4003	78		35-57				70-82
4007	80	>60	22-40		21-46	30-39	
4011	64	>60	34-57		27-66	45-49	65-78
4013	43	45-50			27-66	40-45	34-42
4017	75	50-54	>40				
4019	44	40-44	35-52				
4024	28	40-49	45-58				33-46
4035	41	40-44	32-51				
4036	55	45-49	35-57				
4047	49	55-60	45-51				
4049	57	50-55	40-50		27-66	45-49	
4065	81	54-63			42-87		59-71
4069	82	>60	41-52		27-66	>50	26-32
4070	56	50-54	43-52				34-54
4073	68	50-54	>50		27-66	45-49	
4074	65	40-44	30-45				24-32
4075	69	>60	35-58	42-51	34-86	>50	43-55
5007	36	35-39		25	21-57	27-35	26-32
5012	53		45-52	31-38	27-66	45-49	
5039	84	>60			34-86	>50	65-78
5041	67	>63					38-52
5043	52	40-44	45-56		27-66	30-35	32-46
5056	86		40-52		34-86	>50	
5070	62	45-50	43-53		27-66	45-49	55-64
5071	55	45-60	34-58				
6048	39	45-55	40-52		23-57	40-45	43-55
6071	27	30-34			19-40	22-24	
6085	21	20-25					
6110	26				21-53	22-26	
6121	35	30-35	40-50	25-30			
7006	33	35-39			26-70	30-39	
7016	78	>55	>50				
7043	62		>50	30			54-64
7045	60	50-59	40-50	24-30			33-46
7081	41	35-44	35-45		26-70	35-39	33-46

14) were correctly aged and 54.84% (n = 17) were under-aged.

It therefore appears that the method worked well for young adults, but greater inaccuracy was noted in the prime, mature and ageing adult categories. The general tendency was to over-age prime and mature adults and to under-age individuals older than 50 years.

Cranial suture closure

Ageing by cranial suture closure was undertaken on 41 individuals. The accuracy of this method was poor, however, and only 15 (36.58%) individuals were correctly aged. Twenty-one (51.22%) skeletons were under-aged by an average of 17.52 years, and five (12.19%) individuals were over-aged by a mean of 10.4 years. All skeletons that were under-aged were in the 50+ age category. Those that were under-aged were all prime adults.

This method is based on the assumption that the cranial sutures fuse in a predictable sequence from about age 30 to 50 years. The poor correlation between osteological and chronological age indicates considerable individual variation in the timing of suture closure.

Dental attrition

None of the 14 individuals were correctly aged by this method, on average being under-aged by 19 years. The prime adults were under-aged by 6.25 years and the individuals in the 50+ category by an average of 26.78 years. This clearly shows that the method became more inaccurate with increasing age. It is therefore clear that this method cannot be used for this type of post-medieval population, but further research is required to establish its usefulness in skeletal assemblages composed of working class individuals.

Pubic symphysis

Ageing methods based on degeneration of the pubic symphysis developed by Brooks and Suchey (1990) and Todd (1921a and 1921b) were incorporated and contrasted. The Suchey-Brooks method correctly aged 23 of the 28 skeletons examined (82.14%). Five (17.86%) individuals were under-aged by an average of 17.2 years. All individuals that were under-aged were in the 50+ years age category. The lack of precision of the Suchey-Brooks system (evidenced in large age ranges using a 95% confidence interval) does however limit its usefulness.

The Todd method was applied to 26 individuals, of whom 10 (38.46%) were correctly aged. The method under-aged 14 (53.84%) individuals by a mean of 14.64 years. Two individuals (7.69%) were over-aged by an average of seven years.

Sternal rib ends

Ageing from degenerative changes to the sternal rib end is a method that is not commonly available to osteoarchaeologists, due to the poor survival of this fragile element, but at St George's preservation of this element was fairly good. The method specifies that the fourth rib is used, but in this study a rib from the mid-chest region (not necessarily the fourth rib) was chosen. This was necessary due to the fragmentation of rib shafts that made specific identification of the fourth rib problematic. The advantage with this method is that individuals that may be osteologically aged up to 78 years. Theoretically, this enables ageing of older individuals beyond the 50-60 years limit of other ageing methods.

Of the 27 skeletons aged using this method, 10 (37.04%) were aged correctly; thirteen (48.15%) were over-aged by an average of 13.61 years, and four (14.81%) were under-aged by an average of 5.5 years.

Statistical analysis

Statistical analysis was undertaken to examine the correlation between known age at death and osteological age at death, as described above. Two types of analysis were performed: multiple linear regression and curve fitting on the scattergrams of the individual age indicators. The results of these analyses are detailed and discussed in Appendix 2 and summarised here.

Multiple linear regression

This analysis examined the correlation between known age at death and all age indicators combined. The incompleteness of data meant that only a combination of four of the six ageing methods could be used on a total of 13 skeletons. The methods incorporated were those that relate to the pubic symphysis (Brooks and Suchey 1990), the sternal rib end, cranial suture closure and the auricular surface. For the 13 individuals, the results showed a high degree of correlation between known age at death and osteological age ($R=0.836$; $P=0.031$), with the auricular surface making the greatest contribution to this result (Appendix 2). The results also showed systematic under estimation of the ages of older adults, a result that is consistent with those reported by Molleson and Cox (1993, 171) who tested osteological ageing methods against known age at death in a sample from Spitalfields. However, unlike Spitalfields, the present sample showed no systematic over estimation of the age of young adults. This difference may be because the auricular surface ageing method was not employed in Molleson and Cox's study.

Regression of the individual age indicators

This analysis examined the correlation between each individual age indicator with known age at death. All six ageing methods were examined for all

52 individuals using different numbers and combinations of individuals, depending on the availability of data (see Table 7.3). Lines of best fit were computed using graphs as visual summaries. Results showed that the auricular surface has the highest correlation with known age at death (coefficient of correlation=0.454; N=47), followed by dental attrition (coefficient of correlation=0.418; N=15), then the pubic symphysis (Suchey-Brooks: coefficient of correlation=0.175; N=28; Todd: coefficient of correlation=0.378; N=26), with the sternal rib end in fourth place (coefficient of correlation=0.191; N=28). Virtually no correlation with age was shown by the results for cranial suture closure (coefficient of correlation=0.002; N=41).

Discussion of ageing methods

All ageing methods contain a degree of error due to variability in ageing processes between individuals, which is dependent on a complex interplay of genetic and activity related factors (Mays and Cox 2000). It is therefore impossible to assign an age with 100% accuracy. Moreover, inter-observer error in age estimation also may also be responsible for discrepancies in ageing, particularly among less experienced osteologists. However, by using multiple methods and broad age categories it was hoped that a high degree of accuracy was obtained (ibid.).

Overall, all ageing methods, except dental attrition, were found to be very accurate when applied to adults younger than 30 years of age. This trend was also reflected when statistical analyses were performed. Poorer correlation between osteological and chronological age was found in the 30 and 50 years age categories, with some methods under-ageing, and others over-ageing individuals by as much as 10-15 years. This variability is illustrated in three individuals (skeletons 2008, 7045 and 7081) that were chosen at random (Figs 7.1-7.3).

Overall, ageing methods tend to under-age skeletons by approximately 15 years. This trend is particularly apparent in the ageing population of St George's, as under-ageing became more pronounced with increasing age. It also highlighted the paucity of osteological ageing methods for skeletons older than 40 years. These findings are also supported by statistical curve fitting.

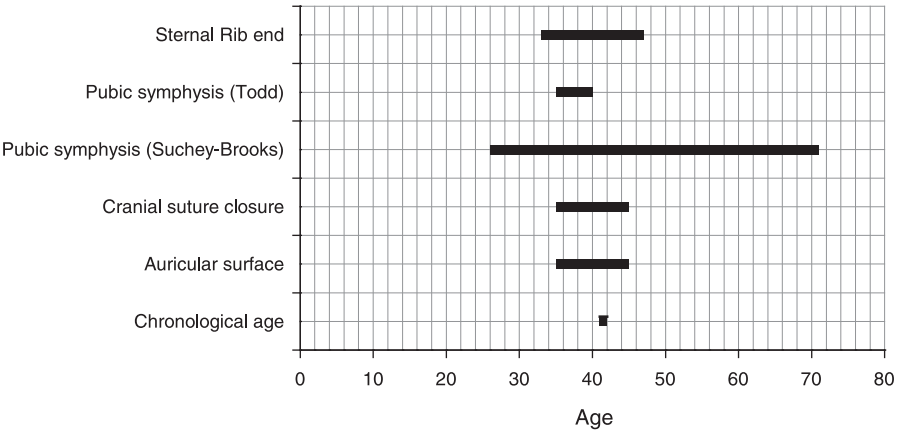

Fig. 7.1 Skeleton 7081: comparison of age determinations using different ageing methods

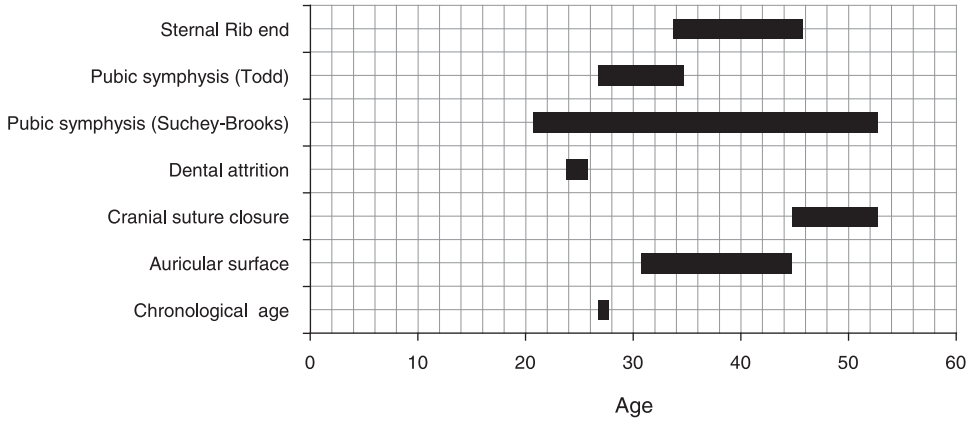

Fig. 7.2 Skeleton 2008: comparison of age determinations using different ageing methods

To conclude, more ages estimated with the Suchey-Brooks system correlated with known age at death than those using other indicators did (Fig. 7.4). However, statistical analysis indicated that the auricular surface was the most accurate method. Further, although the wide age ranges in each phase ensure a high accuracy, they render the Suchey Brookes method all but meaningless. The sternal rib end method appears useful for ageing older adults as this is the only method with age categories that continued into the ninth decade of life. The indicator with the lowest percentage of accuracy was dental attrition (Figure 4.5), but multiple linear regression and regression analysis showed cranial suture closure to be the least reliable method.

Subadults

The chronological ages of four subadults were known from coffin plate inscriptions. These individuals were aged osteologically using a maximum of three methods (Table 4.11). Due to the small sample size, this section will only contain a general discussion of the results since any attempt to quantify accuracy of these methods is meaningless.

Discussion of ageing methods

Observations on dental development were employed to age three subadults. The results were correlated with chronological age (Table 7.4).

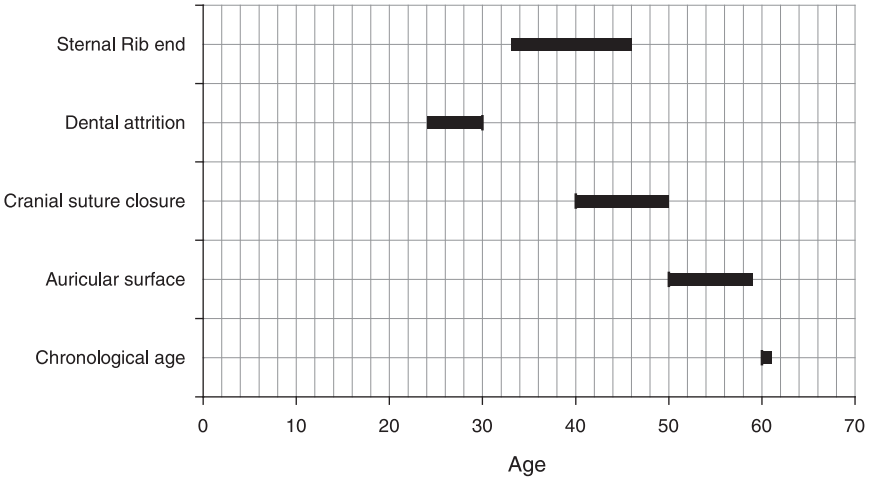

Fig. 7.3 Skeleton 7045: comparison of age determinations using different ageing methods

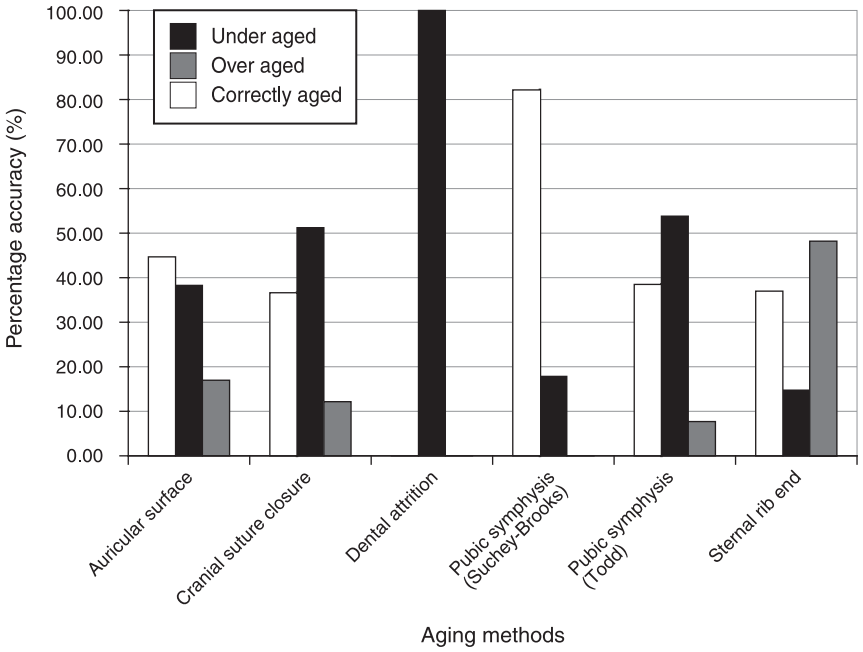

Fig. 7.4 Bar graph showing percentage accuracy in ageing methods (N=52)

Table 7.4 Chronological age of subadults compared with biological age

Skeleton Number	*Age at Death (years)*	*Age at Death (months)*	*Age at Death (days)*	*Dental development*	*Epiphyseal fusion*	*Long bone length*
3041			17	0 – 5 months		40 – 40 weeks
3064	6			6 – 8 years	4 – 6 years	5 – 5 years
4039		19			0 – 1 years	1 – 1.1 years
5049	15			12 – 16 years	16 – 17 years	

Ageing by epiphyseal fusion provided a more random result, with two of the three children under-aged, and one over-aged by a year. Similar results were obtained using diaphyseal long bone measurements, in which two of the three were under-aged.

The methods used to age the subadults provided impressive results with a high level of accuracy and narrow age ranges. Dental development was more accurate than skeletal development. There was a greater tendency to under-age than over-age subadults. Saunders and Hoppa (1993), using the known aged assemblage from St Thomas' church, Belleville, Ontario, found little or no discrepancy between modern growth curves for long bones and this 19th-century Canadian population. They concluded that most subadults in archaeological populations died of acute illness, and hence, did not suffer retarded skeletal development before death. This was not the case with the two children from St George's, who did display delayed epiphyseal fusion and stunting before death. This argues for a more chronic pattern of ill health, possibly due to a single specific chronic disease or disorder (e.g. tuberculosis), or from a repeated onslaught of different environmental stressors from which the children never recovered. No such pattern was observed in the adolescent (5049), where dental and epiphyseal fusion ages broadly concurred.

Sexing methods

All subadults and any adult individual with an unknown real and/or osteological sex were omitted from the analysis. The sex of 65 adults recorded osteologically was known from coffin plate inscriptions, and 68 adults could be sexed osteologically. Of the former, 36 (55.39%) were male and 29 (44.62%) were female. Of the latter, 36 (52.94%) were male, 30 (44.12%) were female and the sex of two (2.94%) could not be determined. Only one individual (a female) had been sexed incorrectly- an accuracy of 98.46%.

It was clear that some features of the cranium and pelvis were more representative of the documented sex of the individuals than others, and that the pelvis was markedly more reliable in determining sex than the cranium (Table 7.5). Sex estimation from pelvic morphology was found to be the most

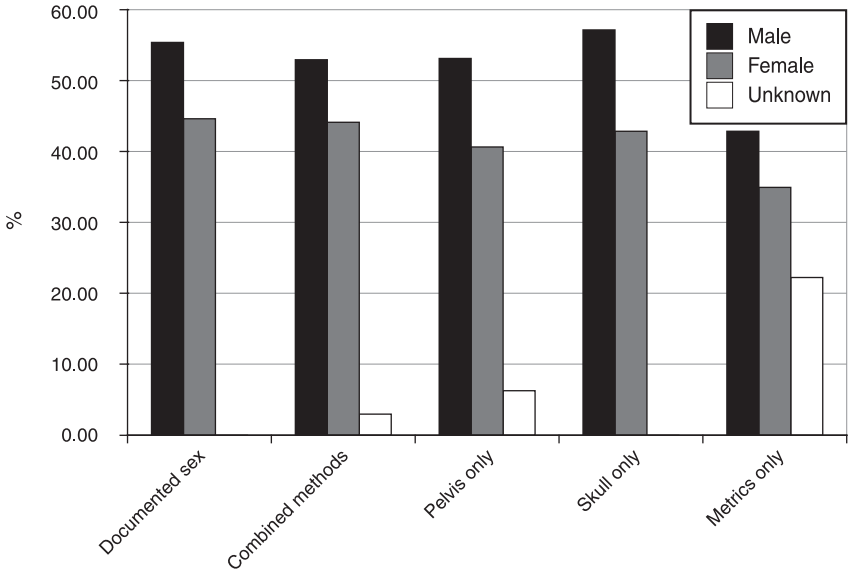

Fig. 7.5 Percentages of adult males and females estimated using different methodologies (N = 63)

accurate method (Fig. 7.5). This was not unexpected (see discussion in methodology section above). Sex estimation from pelvic morphology also produced the lowest intermediate values, as well as probable males and females.

Considerably more males were diagnosed from skull morphology alone. In addition, a high proportion of probable males and females was also estimated using these features. During the analysis it was noted that many female crania displayed several masculine traits, particularly those in the older age categories.

By contrast, skeletons sexed from metrics resulted in a preponderance of females. There was also a large number whose sex could not be determined (Table 7.5 and Fig. 4.6). Of all the methods employed, this one was the least reliable.

Table 7.5 Sex determination per method used (N=63)

Sex	*Pelvic sex (n/N)*	*Cranial sex (n/N)*	*Metric sex (n/N)*
Female?	4.69% (3/64)	20.63% (13/63)	6.35% (4/63)
Female	35.94%	22.22%	28.57%
Male?	3.12% (2/64)	7.94% (5/63)	14.29% (9/63)
Male	50.0% (32/64)	49.21% (31/63)	28.57% (18/63)
Indeterminate	6.25% (4/64)	0.0% (0/63)	22.22% (14/63)