How old is this pelvis? A comparison of age at death estimation using the auricular surface of the *ilium* and *os pubis*

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Introduction

The estimation of age at death from human bones is one of the most important questions for archaeologists, historians, physicians, forensic anthropologists and human paleontologists. Since the sixteenth century many attempts have been made to solve this problem using different parts of the skeleton, but until now the results are unsatisfactory.

This paper reviews, based on Santos (1995), the results of blind tests of two morphological techniques of age at death determination. The first one, a recently developed method, is based upon the metamorphosis of the auricular surface of the ilium (Lovejoy *et. al.* 1985). The other one concerns the age related changes of the pubic symphysis (France Casting 1986).

The sample

The material used in this study came from the Human Identified Skeletal Collection (HISC) from the "Museu de Antropologia" of the University of Coimbra. For each individual we have, among other things, information about sex, age at death, occupation, birth place, home place, year of birth (from 1824 to 1916), and death (up to the 1940s).

Of the 505 individuals comprising this collection, we have selected, randomly, 231 pelvises of individuals with ages at death varying from 16 to 95 years (Table 1). Due to *post mortem* changes and pelvis ankylosis it was impossible to examine an equal number of individuals in each age category. The *os pubis* sample is more fragile than the auricular surface, so the sample was reduced to 203 pairs of bones.

Table 1 Age at death distribution of the sample under study (N=number of individuals).

Stage	Age (years)	Males N	%	Females N	%	Total N	%
0	16-19	7	3,0	9	3,9	16	7,0
1	20-24	8	3,5	5	2,2	13	5,6
2	25-29	8	3,5	7	3,0	15	6,5
3	30-34	10	4,3	8	3,5	18	7,8
4	35-39	7	3,0	8	3,5	15	6,5
5	40-44	10	4,3	8	3,5	18	7,8
6	45-49	10	4,3	10	4,3	20	8,7
7	50-59	18	7,8	20	8,7	38	16,5
8	≥60	34	14,7	44	19,1	78	33,8

Methods

During this study on the HISC, the inominate bones were isolated from the rest of the skeleton and the observation was done without knowledge of the real age, stated on the obituary records. Each method was applied separately without reference to the other.

Test 1: The auricular surface of the ilium

The first method to be tested was the chronological metamorphosis of the auricular surface of the *ilium*. This region presents a high frequency of preservation both in archaeological and forensic materials.

Since 1930 the morphology of this region has been thought to be related to organism senescence. However it was only in 1983 that Meindl and co-workers started studying this area as an age at death indicator. In 1985, Lovejoy and collaborators developed a new method in which they defined eight metamorphic stages.

During this test using HISC, each pair of bones from the same individual was compared with the original description of Lovejoy *et al.* (1985). In cases where none of the stages corresponded exactly to the morphology found in the individual, comparison was made with the Bedford *et al.* (1991) age-graduated slides. Some difficulties arose because the authors do not provide explicit instructions for classifying ambiguous specimens (those that cannot, with certainty, be assigned to one age category). As Saunders *et al.* (1992) have pointed out, the recommendation of seriation of all specimens to permit interpolation within age categories is impracticable, given the complexities of observations required, especially in large samples.

Test 2: Pubic symphysis changes

Among the many approaches for age estimation based on *os pubis*, I have chosen the Brooks-Suchey (1990) description since it is based on a large identified sample. Furthermore, in order to help the observation, two sets of casts (France Casting 1986), one of each sex, are available.

Results

The results of this study were not very encouraging for the application of either method. With auricular surface only 17,7% (38/215) of the individuals were correctly classified (Table 2). Nevertheless, Kendall's coefficient shows a significant value (X^2=42,762, p<0,001) due mainly to the large size of the sample. Thus, I tried to find out if misclassification occurred mainly on some stages or sexes (Table 3) but there was no significant difference between any stage or sex (X^2 = 4,213, degree of freedom = 7, p= 0,755).

Table 2 Number of individuals misclassified within each age category.

Stage	Total	N	Males	N	Females	N
1	12	13	8	8	4	5
2	10	15	6	8	4	7
3	12	18	8	10	4	8
4	13	15	6	7	7	8
5	15	18	7	10	8	8
6	15	20	8	10	7	10
7	32	38	16	18	16	20
8	68	78	30	34	38	44

To allow comparisons with other tests the following parameters were calculated:

inaccuracy = |real age - estimated age / N|;

bias= real age - estimated age / N.

The results (Table 3) revealed that the estimated age deviates from real age in all the stages, which agrees with Saunders *et al.* (1992) results. The worst results occurred in the individuals older than 45 years, for whom there was an age under estimation. After the fourth decade bias becomes negative (Lovejoy *et al.*, 1985).

Despite the authors' suggestion that this method is more effective for older ages, it concentrates the estimated age in an interval between 30 and 54 years old, which results in individuals of real ages older than 60 having their age underestimated. Similar results were found by Murray and Murray (1991).

Table 3 Results of inacurrancy (inac) and bias for each stage (M=male, F=female).

Stage	Total	Inac	Bias	M	Inac	Bias	F	Inac	Bias
1	13	1,3	1,3	8	1,5	1,5	5	1,0	1,0
2	15	1,8	1,8	8	2,3	2,3	7	1,3	1,3
3	18	1,2	0,9	10	1,5	1,1	8	0,9	0,6
4	15	1,4	0,1	7	1,4	-0,3	8	1,4	0,4
5	18	1,3	-0,6	10	1,1	-0,5	8	1,5	0,8
6	20	1,3	-1,2	10	1,1	-0,9	10	1,4	-1,4
7	38	1,7	-1,6	18	1,9	-1,8	20	1,6	-1,4
8	78	1,9	-1,9	34	1,9	-1,8	44	1,6	-1,6
Total	215	1,614	0,833						

Subsequently, I tried to find out the mean stage value within each stage of real age (Table 4). Besides the increase of the mean stage value in the sample, the results are very unsatisfactory since, for example, stage 2 classified individuals with real age from 25 to 44 years old.

Table 4 Results of statistical analysis in the HISC (N=number of individuals; sd=standard desviation; m=minimum; M=maximum; M=males; F=females).

Stage	N	mean	sd	m-M	M	mean	sd	m-M	F	mean	sd	m-M
1	13	2,3	0,8	1-4	8	2.5	0.8	2-4	5	2.0	0,7	1-3
2	15	3,8	1,6	2-6	8	4,3	1,8	2-6	7	3,3	1,4	2-5
3	18	3,9	1,5	2-7	10	4,1	1,6	2-7	8	3,6	1,3	2-6
4	15	4,1	1,7	2-7	7	3,7	1,7	2-6	8	4,4	1,7	3-7
5	18	4,4	1,4	2-7	10	4,5	1,4	2-6	8	4,3	1,5	3-7
6	20	4,9	1,1	3-7	10	5,1	1,0	4-7	10	4,6	1,2	3-6
7	38	5,4	1,4	3-8	18	5,2	1,4	3-8	20	5,7	1,3	3-8
8	78	6,1	1,4	3-8	34	5,8	1,5	3-8	44	6,4	1,3	3-8

Concerning the Suchey-Brooks system, the Kendall's coefficient reveals significant differences in both sexes ($X^2 = 68{,}21$ to females and $X^2 = 88{,}00$ to males, degree of freedom = 1, p = 0,000) since 85,4% (88/103) of the individuals from the male sample and 76% (76/100) from the female one were misclassified.

Statistical analysis was applied to each phase by sex. The poor results (highest standard deviation) in the female sample are probably due to pregnancy which increases variability in *os pubis.* In females, phase IV had a broad range, larger than phase V and VI altogether, which means that all individuals included in phase V and VI can be assigned to phase IV (Figs. 1 and 2; Tables 5 and 6). In the male sample, mean age increases from phase I to VI, and there was no individual classified to phase II. As an example a woman with an age at death between 32 and 87 years old can be assigned to phase III to VI. A similar situation can occur with a man of about 30 years who can be included in phase III to V. Only phase I is relatively individualized in both sexes.

These methods fail mainly in older individuals. In agreement with Saunders *et al.* (1992) I think that 40 years should be the cut off age for this method. The broad age range for each phase associated with these systems is probably the main cause of error.

Discussion

This study has tested two techniques of age estimation based on inominate bones. From the above we can conclude that neither of them should be used in isolation as an age indicator, either in archaeological or in forensic cases.

For application of the auricular surface method, the observation of Bedford slides helps very much. Nevertheless I think it can be improved since after the fifth decade of life, there are only two photos, both representing degenerative cases which are not very frequent in this age category. Another problem concerns asymmetry found in right and left bones from the same individual: if the two bones were found separately, they could be placed in different stages.

Figure 1 Graphic representation of minimum, mean and maximum age within each phase in the HISC male sample.

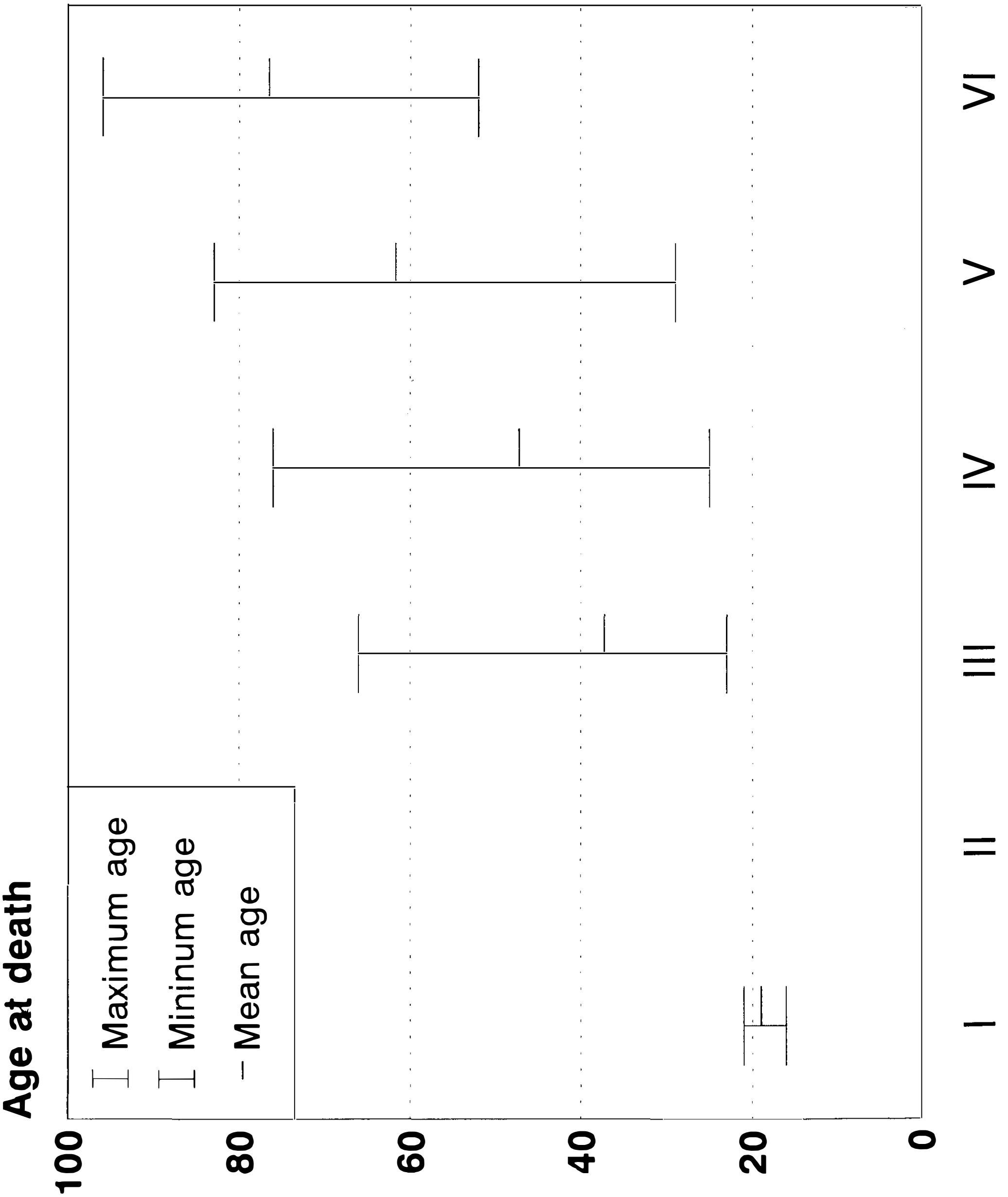

Figure 2 Graphic representation of minimum, mean and maximum age within each phase in the HISC female sample.

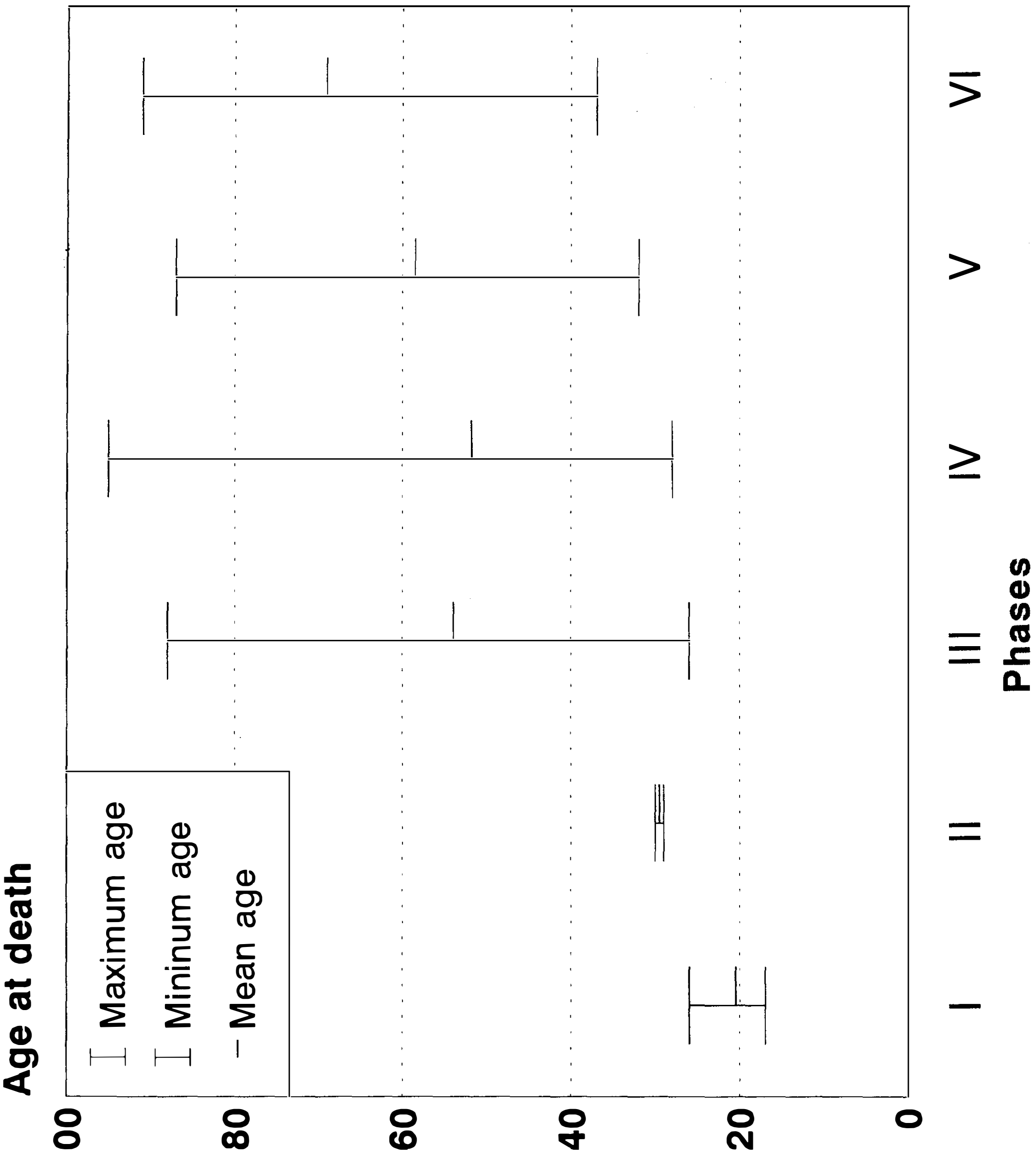

Table 5 Statistical analysis: comparison between the results found in HISC and Brooks and Suchey in the female sample.

Phase	N	HISC			Suchey-Brooks		
		m-M	mean	sd	m-M	mean	sd
I	15	17-26	20,53	3,00	15-24	19,4	2,6
II	2	29-30	29,50	0,71	19-40	25,0	4,9
III	12	26-88	53,92	18,17	21-53	30,7	8,1
IV	27	28-95	51,82	16,90	26-70	38,2	10,9
V	30	32-87	58,53	16,72	25-83	48,1	14,6
VI	14	37-91	69,14	20,70	42-87	60,0	12,4

Table 6 Statistical analysis: comparison between the results found in HISC and Brooks and Suchey in the male sample.

Phase	N	HISC			Suchey-Brooks		
		m-M	mean	sd	m-M	mean	sd
I	10	16-21	19,00	2,00	15-23	18,5	2,1
II	0				19-34	23,4	3,6
III	8	23-66	37,25	14,10	21-46	28,7	6,5
IV	50	25-76	47,16	13,42	23-57	35,2	9,4
V	25	29-83	61,72	12,82	27-66	45,6	10,4
VI	10	52-96	76,50	12,51	34-86	61,2	12,2

For application of pubic symphysis, the casts were very useful but the choice of two extreme morphologies for each phase is a possible source of error. A third cast, representative of middle appearance, is desired. This method concentrates age at death by the age of fifty years (Pfeiffer 1985). As found with the auricular surface, the pubic symphysis may also be asymmetric.

My findings suggest that the search for techniques of age estimation is far from being concluded. Both tests presented here reveal that caution should be exercised in applying these methodologies. As Maples (1989) said: "Age estimation is ultimately an art, not a precise science. Many areas of scientific data must be evaluated, but the final best estimate results from a subjective weighting of the results of all the techniques that were employed".

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