



M. YAŞAR İŞCAN, SUSAN R. LOTH, E. HUNT SCHEUERMAN

AGE ASSESSMENT FROM THE STERNAL END OF THE RIB AND PUBIC SYMPHYSIS: A SYSTEMATIC COMPARISON

ABSTRACT: *It is known that the aging process in the human skeleton manifests itself at different rates in different sites. This is due, at least in part, to the effects of functional stress differentials between bones. To date, no study has compared the relative accuracy of adult age estimation techniques from two sites in the same individual. The purpose of this study is to compare the phase standards of age-related metamorphoses at the sternal end of the rib and pubic symphysis with each other, and with chronological age. A sample of both bones (N=80) were collected from each cadaver at autopsy. All were recent medical examiner's cases of documented age, sex, and race. The results indicate that twice as many ribs as symphyses of both sexes were assigned to the ideal chronological phase. Furthermore, while 92% of the male ribs were assessed to within one phase of ideal, this was true for only 51% of the symphyses. In conclusion, this study reveals that the rib is a better indicator of age than the pubic symphysis, mainly because it appears to show much less variation. This research also presents evidence that the authors' rib phase technique can provide a more consistently accurate estimation of age within a narrower range than methods available for the pubic symphysis.*

KEY WORDS: *Aging — Pubic symphysis — Rib aging — Comparison of aging techniques.*

INTRODUCTION

Since the 1920's the pubic symphysis has been one of the most popular sites for age estimation in the adult (Krogman and İşcan, 1986). Moreover, up until the past few years, it has also been considered the most accurate, especially since its only competition have been the notoriously unreliable cranial sutures. However, since 1979 when Suchey began testing this site, a number of problems ranging from great interobserver error to changes in the morphology of aging in the modern symphysis have been brought to light (İşcan and Loth, 1989).

The authors' introduction of the phase technique based on the sternal extremity of the rib for males in 1984 and females in 1985 has shown great promise of equaling or surpassing the pubis for age estimation in the adult

(İşcan et al., 1984, 1985). It offered a much greater effective range of assessment beginning in the teens and extending past the 70's. Tests by İşcan and Loth (1986a, 1986b) indicated good replicability and little interobserver error based on education and experience. From an anatomic standpoint, the rib is subjected to fewer direct stresses than the pelvic region. Thus, changes in the rib are more likely to accurately reflect aging. However, no systematic study has been carried out to compare age determination reliability from both sites in the same specimens.

Therefore the purpose of this paper is to compare the estimation of age at death from the rib and pubic symphysis of the same individuals. In this way it can be determined if both sites reflect age similarly, or if not, how they differ. Finally, it should also indicate if one site is a more consistently reliable age indicator.

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Table 1. Comparison of age estimation from the 4th rib and pubic symphysis of 80 White males and females.

	WHITE MALES (N=59)			WHITE FEMALES (N=21)		
	Total	+	-	Total	+	-
Correct	32			16		
±1	22	11	11	17	10	7
±2	5	4	1	10	3	7
±3				7	1	6
±4				3	1	2
±5				4	2	2
±7				2	1	1
Total correct						
to within 1 phase	54	(92%)		33	(56%)	
Total +	15	(25%)		17	(29%)	
Total -	12	(20%)		26	(44%)	

MATERIALS AND METHODS

In order to carry out this analysis, the sternal end of the right 4th rib and the right pubic bone cut at the rami were collected at autopsy from 80 White males and females. The sample ranged in age from 18 to 99 years. For all cases, precise documentation of age, sex, and race was obtained from death certificates. It should be emphasized that both bones were taken from the same individuals.

Each rib was assessed using the appropriate sex and race specific phase standards developed by the authors (İşcan et al., 1984, 1985) from the 4th rib. The pubic symphyses were phased using Angel's (1980) modification of Todd's (1920) phases. While the Suchey-Brooks casts for males were easy to use and accurately depicted the morphological formations observed in the bones, the extremely wide 95% confidence intervals, most of which range from 30 to 50 years per phase, were not at all comparable with the rib phases. Testing by Meindl and associates (1985) indicated that of existing methods, Todd's (1920) was most effective. Therefore, because the age ranges were closer to the 95% confidence intervals of the rib phases, the authors chose Angel's more generalized diagrammatic modifications of Todd's phases with the added 10+ phase, and used them for both sexes in this analysis. The ribs and pubic bones were examined separately so that the appearance of one would not influence judgment of the other.

Following morphological phase assessment, each rib and pubis was assigned an "ideal phase" number based on its chronological age at death. The ideal rib phase is that closest to the mean of the 95% confidence interval within which the age of the bone falls. For the pubic symphysis, the ideal phase was chosen based upon which of Angel's phase ranges bone age fell. The actual and ideal phases were then compared for the two bones to ascertain their relative accuracy and direction of error.

RESULTS

A comparison of age estimation by phase assignment between the rib and the pubic symphysis

appears in Table 1. A tally of exact phase placement revealed that twice as many ribs as symphyses were "correct" because the authors' assessment matched the ideal phase. A nearly equal number of both bones were off by + or - one phase. However, when specimens missed by more than one phase were examined, it was found that the rib was off by two phases in only a few specimens and there were no cases in which error exceeded two. This is quite a contrast to the pubis where distance from ideal ranged from two to seven phases in

Table 2. Comparison of the direction of phase estimation by decade for the rib (R) and pubis (P) in males (N=59) and females (N=21) (c correct, + overaged, - underaged).

	18-29	30-39	40-49	50-59	60-69	70-X	Total
Males							
Rc, Pc	3		1	1		2	7
Rc, P-		2		2	3	6	12
Rc, P+	6	3	2	1			12
R-, Pc		1				2	4
R+, Pc		3	1	1			5
R+, P+	3		2				5
R-, P-	1	1	2	1	3		8
R+, P-	1			4			5
R-, P+	1						1
Total	15	10	8	10	6	10	59
Females							
Rc, Pc	1		1			3	5
Rc, P-				1		4	5
Rc, P+	1				1		2
R-, Pc	1						1
R+, Pc	1						1
R+, P+	1						1
R-, P-				2	1	1	4
R+, P-		1			1		2
R-, P+							0
Total	5	1	1	3	3	8	21

about half of the sample. Overall, in males, 92% of ribs and 56% of pubes were judged to lie within one phase of ideal. In females, those figures were somewhat higher with 95% for ribs and 76% for the pubic symphysis.

Table 2 shows the relative direction of estimate by decade without regard to the number of phases over or underestimated. The most significant finding here lies in rows pinpointing where the rib is correctly phased and the symphysis is not. In males, for example, half of the cases in each row are over 70 years of age, where the pubis underestimated relative to the rib, and under 30 where it overaged. The few instances where the pubis was correct and the rib was off, lie in the 30 to 50 year range. In the much smaller female sample, there is a similar distribution in the 70 and over group in which the rib was correct and the pubis underaged in four out of five cases.

Table 3. Summary of relative phase estimation (N=50 males, N=21 females).

	Males		Females	
	N	%	N	%
Both correct	7	12	5	24
Total Rc P ±	24	41	7	33
Total Pc R ±	9	15	2	10
Both off in same dir.	13	22	5	24
Both off in opposite dir.	6	10	2	10

A summary of correlation of phase estimation in both sites appears in Table 3 where 12% of males and 24% of females were phased exactly from both sites in the same individual (e. g. Figure 1). It also becomes evident that in 41% of males and 33% of females the rib was correct where pubic symphysis was not (e. g. Figure 2). Yet the reverse held true in only 15% of males



Figure 1. The rib and pubic symphysis of a 58 year-old White male in which phase assignments from both sites were accurate.

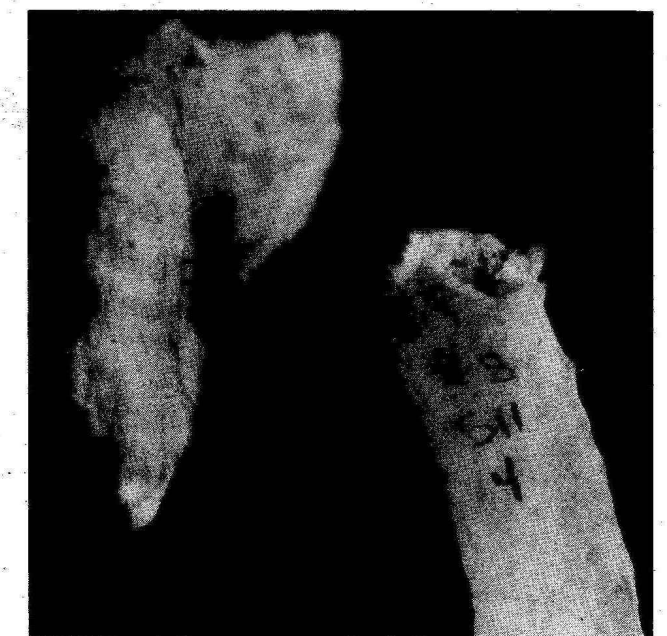


Figure 2. Specimens from a 55 year-old White male precisely aged by the rib, but underaged four phases (over 20 years) by the pubic symphysis.



Figure 3. A 69 year-old White male in which both bones appeared two phases younger than ideal.

and 10% of females. The percentage of cases where both sites were off was practically the same for both sexes. However, it is significant to note that both sites are nearly 2.5 times more likely to err in the same direction as in opposite directions (e. g. Figure 3).

DISCUSSION

The results of this study show significant discrepancies between age estimation from the rib and the pubic symphysis. The figures obtained clearly favor the rib for consistent accuracy. For both sexes combined, the overall percentage of estimates within one phase of ideal is about 93% for the rib compared with only 61 for the pubis. This contrast was greatest below the age of 30 and over 60 in males. The rib was nearly perfect while the pubis had an average error of +3 phases in the younger group and -3 phases in the older bones. The rib showed most deviations in the 38 to 48 year range in males, where it was only slightly better than the symphysis.

It was somewhat surprising that females fared slightly better than males in the rib and considerably better in the pubic symphysis, but this can probably be attributed to the sample distribution. The female sample was much smaller and nearly half were over age of 70. Only about one sixth of the larger male group was in that category.

When the direction of error was analysed regardless of the size of the phase deviation, it became apparent that error is more than twice as likely to be in the same, rather than opposite directions, where both bones do not resemble their ideal phase. Technically, these cases may not be wrong per se, but may merely indicate that systemically, physiological age does not correspond with chronological age in these individuals.

There are a number of factors that must be considered when assessing the impact of the results. First, characteristics of the techniques themselves may be important. Initially we assumed that the added pubic phases in Angel's modification of Todd were primarily responsible for the large deviation in the error of estimation. However, this was not the case because the vast majority of deviations greater than two phases occurred in pubic phases 1 through 4 which correspond to within two years of the first 4 rib phases and again in 10 and 10+ pubic phases which cover the same range as rib phases 7 and 8. Although rib phases 5 and 6 roughly correspond to pubic phases 6 through 9, the pubis showed by far the least deviation in the range.

Another methodological concern that Suchey (1979) demonstrated is the considerable interobserver error associated with pubic symphyseal methods. Admittedly, two of the authors (MYI and SRL) are more experienced with the rib than the pubis, yet tests by İscan and Loth (1986a, 1986b) have revealed that relative experience or education has a negligible effect on the successful application of the rib phase technique. Furthermore, the rib phases themselves are based on modern samples, and thus, are more likely to adequately reflect current rib morphology. A number of studies have criticized and attempted to improve upon Todd's original phases in order to account for temporal changes, but while the recent (unpublished) Suchey-Brooks modifications accurately reflect symphyseal morphology, they do not approach the narrow 95% confidence interval ranging from less than 1.5 to about 5 years obtained for the rib.

Apart from technical factors, differences in anatomic structure and function almost certainly play a role in the results obtained in this study. The pelvis is directly involved in weight bearing, locomotion, and

child bearing. Thus, there is a great deal of functional stress imposed on the pubic symphysis and much of it is highly variable between the sexes and even from one individual to the next. The sternal extremity of the rib, on the other hand, is directly affected only by breathing - an activity with little variation among healthy individuals. This structure is, of course, involved with upper body and extremity motion, but only indirectly.

In conclusion, the results of this preliminary investigation indicate that the rib is a better indicator of age than the pubic symphysis, mainly because it appears to show much less morphological variation at any given age. This assessment also yields strong evidence that the authors' rib phase technique can provide a more consistently accurate estimation of age within a narrower range than methods available for the pubic symphysis.

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M. Yasar İscan, Susan R. Loth
Department of Anthropology
Florida Atlantic University
Boca Raton, FL 33431
USA

E. Hunt Scheuerman
District 9 Medical Examiner's Office
Orlando, FL 32806
USA