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Pubic Bone Age Estimation in Adult Women*

ABSTRACT: In recent years, numerous physical anthropologists have pointed out the need for regional standards for estimating age in various world populations. While investigating aging methods for East European populations, dramatic changes were noted in the pubic symphyseal morphology and structure of older adult female individuals. These changes were not captured in the typically used pubic symphysis aging methods. This paper defines and tests the need for a new phase, phase VII, that follows the Suchey-Brooks phase VI. In addition, Suchey-Brooks phases V and VI are redefined. Phase definitions, decision-making rules, and comparison graphics for the new method are presented. Balkan (n = 85) and Eastern Tennessee (n = 104) samples, totaling 189 individuals, were used in the analysis. Pearson correlation coefficients between four observers and a control seriation were strong, indicating ease of replicability between investigators. No statistically significant intra-observer error was detected. Summary statistics show that individuals in phase V were on average in the early 50s, while individuals in phase VI were in their mid 50s to mid 60s, and individuals in phase VII were in their mid 70s. Since linear regression models tend to under-age the elderly and over-age the young, transition analysis, using an unrestricted cumulative probit model, was undertaken to evaluate the phases and to produce point estimates for the ages-at-transition for the Balkan sample. The highest posterior density region point estimates with their associated upper and lower bounds can be used for predicting age for unknown forensic cases related to the Balkan sample. Further, the mean ages and standard deviations for phases V–VII for the Tennessee sample are presented for use in American forensic cases.

KEYWORDS: forensic science, forensic anthropology, aging, pubic symphysis

Physical anthropologists have long been confronted with the problem of aging older individuals, particularly those over 50 years of age. Some researchers have even proposed that it may be nearly impossible to determine advanced age with any sort of precision (1–4). Quite often, broad age categories such as 40+, 50+, or 60+ years have been employed to avoid this troublesome issue. Accuracy of aging older individuals is also at issue. Recently, Komar (5) determined that only 20% of the individuals greater than 50 years old were aged accurately (even using large age range estimates) in a Bosnian forensic population. Acceptance of this position implies that estimating age in older individuals is nearly impossible. This severely hampers studies in demography, paleopathology, and forensics, particularly for aged individuals. To this end, various methods have been evaluated and assessed as to their ability to accurately predict age, c.f. the Lamendin dental method, cranial suture techniques, and pubic symphysis methods, sometimes stipulating regional population comparisons (6–13).

Researchers have argued that the pubic symphysis is a reliable age indicator (4,6,14–18), as it appears to move through a series of identifiable and irreversible changes. However, recent criticisms of the various methods have suggested otherwise (2,9,19) and identified several problems. First, very large age range estimates are the norm if the investigator applies statistical probability to a generated point estimate. Second, once an individual breaches ~40 years, the techniques lose precision (the McKern and Stewart [20], Todd [21], and Suchey-Brooks [6] methods all suffer this problem), resulting in even wider age ranges (7,22). During refinement of the Todd method (21), Suchey and Katz (4,23) tried to address this problem by removing individuals greater than 40 years or with advanced morphological patterns from statistical consideration. This approach was determined not to be realistic, particularly for forensic applications, and the authors supported using all individuals rather than truncated populations for both sexes.

A third problem is that while most people progress through the various phases, the rate is subject to a variety of environmental and genetic constraints that are poorly understood leading to variation at both the level of the population and the individual (e.g., some individuals may "age" faster or slower than their cohort). For examples dealing with the symphysis, the "hatch face" symphyseal morphology cannot be reliably aged (6), massive male pubic symphyses may continue unchanged for long periods of time, particularly in the third and fourth decades of life (15), and narrow and/or gracile pubic faces may look relatively older after age 45 and undergo secondary changes more readily than broader faces (2).

The seriation proposed in this paper is based on observations collected from two samples in which Suchey-Brooks (6) criteria for aging the pubic symphysis were originally used. An advanced morphological and structural pattern was found to lie outside the definitions for the Suchey-Brooks phase VI. The observed morphology was hypothesized to be due to bone breakdown through the aging process and the related conditions of osteoporosis and osteopenia. Meindl and Lovejoy (2) have previously noted that erosion on the pubic faces could be related to two conditions, extensive porosity and osteopenic erosion as a consequence of general bone loss. They found only females exhibited the later condition and associated it with postmenopausal osteoporosis (2). No codification of their findings was undertaken other than noting that these conditions were highly variable. Postmenopausal and senile osteoporosis is a function of advancing age. In females, bone loss begins at approximately 35 years (0.75–1.00% per year) and in males at 40 years (0.40% per year) (24). These conditions affect females more adversely than men, in a 4:1 ratio up to 80 years of age, at which point there becomes no difference between the sexes; approximately 50% of women over the age of 60 have significant bone loss (24). Also, erosion of the pubes could be an effect of previous

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pregnancy, as Suchey and Katz (6) have found dorsal lipping to be related to childbearing, though not in all cases. What effect childbearing has on overall bone health in later life has not been extensively documented, though osteoporosis has been linked with pregnancy in certain groups (24).

Materials and Methods

The proposed method for aging adult female pubic bones was devised using two collections of known age individuals. The total sample consists of 189 females. One hundred and four individuals (n = 10 under 40 years, and n = 94 greater than 40 years) were selected from the University of Tennessee William Bass Donated collection (WBD) and several associated forensic cases, while the remainder is from the known age Balkan sample (BK), consisting of 85 individuals (n = 29 less than 40 years, and n = 56 greater than 40 years). Figure 1 illustrates the age structure of each sample. The BK sample can be considered homogeneous Eastern European White, while the WBD collection is predominantly American White. The WBD collection is composed of individuals who donated their bodies to science and are extremely well documented in terms of age and sex. The majority of the skeletal remains are represented by whole or intact bones, largely free from grease.

The Balkan sample is composed of individuals killed in recent genocides. The pubic bones used in the analysis were collected during the identification process and are represented by complete symphyseal faces with attached partial superior and inferior pubic rami, also devoid of grease. All individuals were identified (either presumptively or positively) through forensic work by the International Criminal Tribunal for the Former Yugoslavia (ICTY) and have age-at-death documentation. While some of the identifications were presumptive, the Balkan data used in this paper are considered highly reliable (see Kimmerle et al. "Identification in American and international populations," this volume). The identifications were based on multiple lines of evidence including recognition of clothing, personal effects, etc. in combination with biological and investigative evidence. Permission for the study was given to the University of Tennessee by the ICTY with the expressed goal of sharing data and results that would aid agencies working on human identification in the former Yugoslavia and other areas of the world.

To ensure a blind study, a volunteer selected all female pubic symphyses older than 40 years from the Balkan sample and placed them into a single box, devoid of biological information. The author separated the samples into morphological categories based on observed macroscopic differences. This seriation was not constrained by a predetermined number of morphological categories. Through this process, three distinct morphological groupings were identified in the sample.

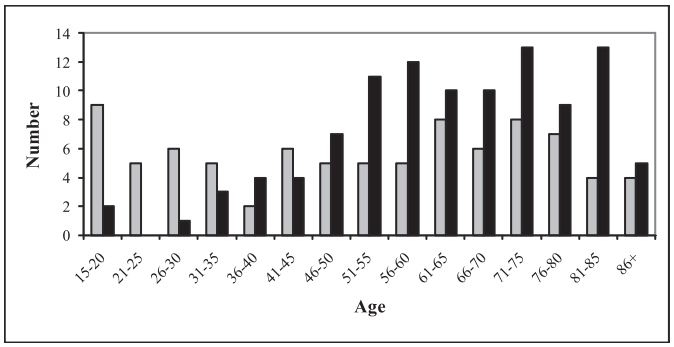

FIG. 1—*Age distribution for the BK (gray) and WBD (black) samples.*

Comparing these morphological categories to the unisex phase descriptions from the Suchey-Brooks method (6,25), it was determined that the first morphology fit well with a modified Suchey-Brooks phase V, the second with a modified phase VI, and the last was undocumented in their phasing system. This last morphological category was designated phase VII. Definitions for the observed morphologies then were written and the pubic symphyses were re-randomized and resorted using the definitions. Problem areas were identified and definition refinement was undertaken, including the use of a standard magnifying glass. A final seriation was then conducted. Age information was withheld until the final grouping was completed.

To determine if the observed morphologies and structural changes extended to other populations, a sample of pubic bones from the WBD collection was analyzed. As before, a volunteer selected pelves from individuals of known age greater than 40 years for the test. The process was repeated, sorting each pelvis using the new definitions. The results included all three phases; the sort was recorded and the pelves were randomized again. A second seriation was conducted and the results of both analyses were compared. Each pelvis was placed into the same phase assignment except for three individuals, one of which was removed from the analysis due to incomplete pubic symphysis morphology (postmortem breakage).

Three observers were asked to sort both the collections using the provided definitions to test replicability between observers using the new phase definitions. Two observers were intimately familiar with the Suchey-Brooks and Todd methods, while the third observer was an experienced forensic anthropologist, but rarely used the Suchey-Brooks aging method. The test included two sorts of the WBD collection and one sort of the BK collection using only individuals over the age of 40 (n = 71 and 56, respectively for the test). In an attempt to mitigate the effects of the participants' short-term memory of each pubic symphysis set, at least 1–3 days elapsed between classifications. The participants were given no guidance for the first sort other than a rough draft of the definitions in order to assess the clarity of the definitions. In between classifications of the WBD collection, the results were recorded and the author discussed the results with the participants, specifically pointing out the various features on the pubic bones. It was clear that additional codification of the definitions was needed. After the first analysis was completed, a set of decision-making rules for moving between phases was produced and the use of the magnifying glass was stipulated. The appendix lists the definitions, decision-making rules, and graphics for scoring the pubic bone. Additional information on the scoring of various attributes and structures can be found there.

In order to document the utility and replicability of the new method, the data were analyzed using a diverse battery of statistical applications. For observer correlation and accuracy, chi-square and Pearson correlation analyses were employed. Descriptive statistics and least squares regression analysis (inverse calibration–see below) were used for comparison purposes between the current study data and that published for the Suchey-Brooks method. These statistical evaluations were conducted using SPSS® version 10.1 (SPSS Inc., Chicago, IL) and SAS® version 9.0 (SAS Institute Inc., Cary, NC) software. Transition analysis also was employed for the Balkan sample. For a description of the Bayesian statistical methods used, refer to Konigsberg et al. (this volume). The models used to calculate the mean, standard deviation, and standard error of the ages-of-transition for each phase were the unrestrictive cumulative

TABLE 1—*Number of correct phase assignments for all observers in each population (number in parenthesis is total possible for each phase).*

	Obs. 1		Obs. 2		Obs. 3		Obs. 4	
	WBD	BK	WBD	BK	WBD	BK	WBD	BK
Phase VII	39 (40)	29 (29)	37 (40)	28 (29)	36 (40)	27 (29)	39 (40)	27 (29)
Phase VI	17 (19)	9 (15)	17 (19)	13 (15)	14 (19)	11 (15)	13 (19)	10 (15)
Phase V	12 (12)	11 (12)	11 (12)	12 (12)	8 (12)	10 (12)	11 (12)	11 (12)

WBD, William Bass Donated collection; BK, Balkan sample.

probit model and the log-age cumulative probit model. Using the log-likelihood of age, the transition distributions appeared more realistic than not using the log-age. The unrestrictive cumulative probit was run in the Fortran based program Nphases developed by Kongisberg (http://konig.la.utk.edu). Other statistical procedures were run in statistical program "R" (http://www.r_project.org). The prior used in this analysis is from the Balkans.

Results

Table 1 lists the observer scores for the final two sorting attempts compared to the seriation as determined by the author. Observer 1 was the author's scoring of the pubic symphyses at a later date, representing intra-observer error, while observers 2–4 were the study volunteers. The average number of misclassified pubic symphyses for the WBD collection for the first sort was 10.3, or 19.7%. The second sort using refined definitions, decision-making rules, and a magnifying glass resulted in an average of 7.5 (10.6%) misses per observer (range = 3–13). The Balkan seriation resulted in an average of 6.5 (11.4%) misclassifications per observer (range = 3–8). It was apparent that some difficulty was present in the correct classification of phase VI individuals, but few difficulties were found in the other phase assignments.

A chi-square analysis for both populations was undertaken to determine if the differences were statistically significant between observers. The data were examined to determine if there was a difference in frequency in phase VII assignments and all other phases between the control (the correct phase assignment from the original seriation) and all observers, resulting in four comparisons per sample. The chi-square tests the null hypothesis that all cell values (observers' results) were independent. If they were independent, then there was no relationship between the observers' phase assignments and morphology/structure (the linkage between observers' phase assignments was pubic morphology and structure), and vice-versa. The main assumption was that phase VII represented an advanced age category. In all cases, the results were highly significant, indicating that the observers' phase assignments were dependent on the pubic symphysis morphology and structure (Table 2). Further, additional chi-squared tests cross-wise between all observers (not listed here) showed that there was no statistically significant inter-observer error in recognizing phase VII morphology. Since only one observer was tested for intra-observer error (control vs. Observer 1, Table 2), it can be generally stated that there was little intra-observer error.

Pearson correlation coefficients were calculated to determine how well each observer fared in comparison to the control as well as between each other. Table 3 lists the correlation coefficients by sample including a combined sample composed of all possible pubic symphyses. All samples have high correlations between the observers as well as between the control and the observers. Observers 1 and 2 consistently had the highest correlations with the control, regardless of sample, even though they did not have the highest correlation between themselves. Observers 3 and 4 changed order between samples as compared to the control. Observers 2 and 3 had the lowest scores in both populations as well as with the overall combined sample, at 0.861, 0.756, and 0.805 respectively. The correlation coefficients showed a high degree of reliability for the method between observers.

To partially compare the study data with the Suchey-Brooks method (25), examination of the mean age and standard deviations associated with each phase was undertaken. Since the study samples were biased toward older individuals, it was not feasible to compare all phase categories. The mean ages and standard deviations for the Suchey-Brooks method and the results of this analysis (including phase VII) are listed in Table 4. Examination of the table shows several noteworthy observations. First, the mean ages from all three samples were relatively similar for phases IV and V, but there was a large amount of variability for phase VI. This is

TABLE 2—*Chi-square statistical analysis of inter-observer differences between phase VII and all other phases.*

	WBD			BK		
Comparison	df	χ^2	*p*	df	χ^2	*p*
Control—Obs. 1	1	59.34	<0.0001	1	45.11	<0.0001
Control—Obs. 2	1	59.48	<0.0001	1	44.67	<0.0001
Control—Obs. 3	1	45.51	<0.0001	1	38.22	<0.0001
Control—Obs. 4	1	52.33	<0.0001	1	37.79	<0.0001

WBD, William Bass Donated collection; BK, Balkan sample.

TABLE 3—*Correlation coefficients for inter-observer variation for phase VII assignments.**

	Control	Observer 1	Observer 2	Observer 3	Observer 4
BK (*n* = 56)					
Control	1.000				
Observer 1	0.910	1.000			
Observer 2	0.959	0.897	1.000		
Observer 3	0.906	0.872	0.861	1.000	
Observer 4	0.892	0.911	0.906	0.882	1.000
WBD (*n* = 71)					
Control	1.000				
Observer 1	0.965	1.000			
Observer 2	0.930	0.895	1.000		
Observer 3	0.825	0.842	0.756	1.000	
Observer 4	0.906	0.897	0.842	0.807	1.000
Combined (*n* = 127)					
Control	1.000				
Observer 1	0.938	1.000			
Observer 2	0.942	0.895	1.000		
Observer 3	0.861	0.855	0.805	1.000	
Observer 4	0.900	0.903	0.870	0.840	1.000

WBD, William Bass Donated collection; BK, Balkan sample.
*All correlations are significant at the 0.001 level.

TABLE 4—*Mean and standard deviations for the study and a comparison sample.*

	Suchey-Brooks*			BK			WBD		
Phase	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD
IV	39	38.2	10.9	4	33.5	8.1	6	35.5	3.8
V	44	48.1	14.6	12	52.5	12.7	18	49.7	5.8
VI	51	60.0	12.4	15	56.0	14.1	27	64.2	9.0
VII				29	74.4	10.4	50	74.2	10.9

WBD, William Bass Donated collection; BK, Balkan sample.
*Data from Suchey and Katz (6).

likely a product of small phase sample sizes; if the BK and WBD samples are averaged together ($n = 42$), their combined mean age is 61.0 years with a standard deviation of 11.8 years, which corresponds well to the Suchey-Brooks value. Alternately, the variability could be due to the impact of phase VII on the analysis. Second, the mean age for phase VII was within 1 year for the two study samples, indicating that the new phase was well described. A final observation was the amount of variance in the samples, as shown by the standard deviations. In only the BK phase VI was the departure from the mean greater than those reported by Suchey (6), suggesting that a seriation incorporating seven phases was potentially better suited for the pubic symphyses, particularly in light of the small phase sample sizes.

The least squares regression analyses (inverse calibration method) conducted in the current study used all possible individuals from both samples and a combined total. Age was regressed on phase in these analyses and all models were highly significant (Table 5). The WBD sample's *r*-value was slightly lower than the Balkan sample and in the combined model, all *r*-values were very strong. The discrepancy between samples is likely due to the lack of individuals in phase II and the small sample sizes in phases I, II, and IV for the WBD collection.

As noted above, transition analysis is arguably a better methodological approach to data of this nature and was therefore used to determine if the proposed seven-phase seriation was a valuable tool for age estimation. The transition analysis was employed to calculate the age at which one phase becomes another, given the parameters of the unique populations (3,26). The point estimate associated with a transition between phases was a mean value with an associated standard deviation. The transitional ages are shown in Table 6 for the Balkan sample. The control seriation was used to calculate the probability density functions for the sample and upper and lower bounds were then constructed around the highest posterior density point estimates to provide useful prediction estimates for unknown individuals related to this sample. Table 7 lists the highest posterior density estimated age for each phase and 95%, 90%, 75%, and 50% lower and upper bounds.

TABLE 5—*Least squares regression analyses for the WBD and BK samples.*

Sample	df	Sum of Squares	Mean Square	*F*	*p*	*r*	R^2
WBD							
Model	1	100.46	100.46	204.62	<0.0001	0.817	0.667
Error	103	50.07	0.49				
BK							
Model	1	295.20	295.20	264.17	<0.0001	0.872	0.761
Error	83	92.75	1.12				
All							
Model	1	436.65	436.65	534.43	<0.0001	0.861	0.741
Error	188	152.77	0.81				

WBD, William Bass Donated collection; BK, Balkan sample.

TABLE 6—*Listing of transitional ages for the Balkan sample.*

Population	Phase I/II	Phase II/III	Phase III/IV	Phase IV/V	Phase V/VI	Phase VI/VII
Balkan	23.6	26.6	30.9	35.2	50.3	65.9

TABLE 7—*Highest posterior density regions (age in years) with upper and lower bounds by phase for the Balkan sample.*

	Phase V	Phase VI	Phase VII
Highest posterior density	45.9	59.4	78.3
95% lower/upper bounds	27.0, 75.2	26.7, 82.4	52.9, 95.0
90% lower/upper bounds	29.4, 70.8	31.9, 79.6	57.4, 92.9
75% lower/upper bounds	33.5, 63.1	40.4, 74.4	64.3, 89.1
50% lower/upper bounds	38.0, 55.5	48.6, 68.7	70.4, 85.0

Discussion

The data presented here indicated an overall high degree of accuracy using the new seriation in conjunction with a relatively low intra-observer error. Observer correlations were high including the one observer that had not frequently used the Suchey-Brooks method. Mean ages were comparable between populations and standard deviations were relatively low. For comparison purposes with the Suchey-Brooks aging method, least squares regression analyses were conducted on these samples. In their analyses of male pubes, Katz and Suchey (22) created a series of linear regression models regressing age on the variables generated for their analyses. Their published correlation matrix, listing their best-fit variable—Todd phases I through X (variable *T*)—had an *r*-value of 0.848 for male individuals. In a different analysis, Katz and Suchey (23) reported *r*-values of 0.83 for White males, and 0.78 for Black males, and 0.79 for Mexican males that ranged in age from 14 to 92 years. While female aging criteria were presented in a later paper (25, citing a paper presented in 1982), it is the combination of females and males as a unisex aging method that has become widely disseminated. Unfortunately, no statistical correlations were reported for the unisex publications (6,25).

The current study produced *r*-values consistently better than those reported for the Suchey-Brooks method (4,22), even though the samples included not only young individuals, but also large quantities of older females. This is contrary to the position taken by most researchers that aging the elderly is not reliable (1,6,22,25,27,28) and that female pubic symphyses are difficult to age properly, depending on the criteria employed (29). A last point regarding regression analysis should be emphasized. Least squares regression analysis was undertaken as a way to compare between the results reported for the Suchey-Brooks method and the current results; least squares linear regression analysis should not necessarily be carried out due to the noted problems with over-aging younger individuals and under-aging older individuals [cf. (8)].

Using a transitional analysis model, graphical inspection of the method's phases was allowed. If the transitional curves significantly overlapped, particularly at the mean age of transitions between phases, the resulting interpretation would be that those certain phases should be collapsed into one phase; if there was no significant overlap, modifications were not needed. Clear separation was

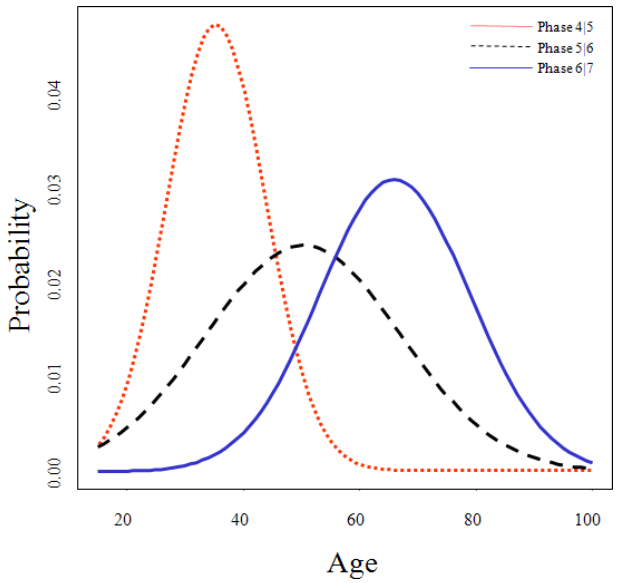

FIG. 2—*Transitional curves for the BK sample, phases IV–VII.*

present for the ages of transition (Fig. 2). Most of the ages-at-transition between phases V–VII were separated by approximately 10–15 years (Table 6). Differences between observers in phase assignments were statistically negligible (as seen from the chi-square analysis), but some differences were apparent in the calculated age-at-transition for observer 3 in the both samples. Observer 3 classified several individuals into earlier phases when they were in fact very old, skewing the analysis toward a younger age division. Given that the results from observer 3 slightly departed from the remainder of the group, it is believed that the phase VII is valid and the refinements to phases V and VI were beneficial.

The analysis also highlighted the increasing age difference between the early and late phases (Table 6); as the phases increased, the difference between the transitional ages became greater (e.g., 4 years between phase III and IV, 5 years between phase IV and V, 15 years between phase V and VI, 15 years between phase VI and VII). This was probably a product of two processes: (i) small sample sizes were present at the younger age ranges and (ii) changes to the pubic symphysis occurred more quickly during "growth," and more slowly or variably during degeneration. Therefore, the "fine-graininess" of phasing the pubic symphysis was better for younger individuals and became much more coarse through the aging process, as has been suggested by other authors (2,6,19). While this latter point seemed self-evident, it has been used to argue that we cannot reliably age older individuals. The inclusion of a phase VII into future analyses will hopefully rectify this problem.

Conclusion

The analysis has shown several important points. First, the definitions for the proposed phases were clear; multiple investigators applied them and came to similar conclusions. While there was some misclassification, it was not statistically significant, indicating little inter- and intra-observer error. Second, using a Bayesian statistical approach appropriate for this type of data, transition analysis, phase VII was found to be clearly separate from the other phases, indicating its uniqueness and usefulness to characterize older age individuals. The highest posterior density region ages, as well as the associated lower and upper bounds were determined for the Balkan sample. Due to the lack of an appropriate prior for the American sample, a transition analysis was not undertaken. In the future, if an appropriate prior can be determined for American populations, this type of modeling can be undertaken. Until that time, the mean ages and standard deviations for the WBD collection are presented for use (as is the current apparent standard for aging methods based on American samples). Third, there were differences between the reported values for the Suchey-Brooks method (6), the WBD collection, and Balkan samples in terms of median ages for phases IV–VII. Visual comparisons suggested that the model presented here is potentially superior to the current published results for females. Fourth, the differences found between the study samples in terms of median ages (Table 4) potentially argue for the need for regional comparative samples. In general, the highest posterior density ages and associated upper and lower bounds should be used for populations similar to the Balkan sample (Table 7), while the median ages and standard deviations for the WBD sample can be applied to American populations (Table 4). The differences between the samples is expected due to a variety of environmental and genetic factors—populations vary regionally and physical anthropologists should expect them to have differing morphological and structural variation based on the sum of their life-ways.

In the current literature, older adult individuals are typically classified into broad age categories once the age-sensitive bones have achieved late morphological patterns, as seen in the pubic symphysis, auricular surface, and rib ends. This study has shown a new terminal phase, phase VII, can be used in conjunction with refined definitions for the Suchey-Brooks pubic symphysis aging method phases V and VI. The proposed phase and phase refinements are not only morphological changes to the pubic bone symphyseal face, but also incorporate into the definitions a physiological change—that of osteoporosis/osteopenia. While not strictly a morphological method, the incorporation of the structural shifts does appear to account for additional age-related change in this region of the body. In general, while this analysis suffers somewhat from small phase sample sizes in younger individuals, there are solid grounds to accept the new phases and apply them in future analyses.

Disclaimer

Permission to use and publish this data was granted by the United Nations, International Criminal Tribunal for the Former Yugoslavia, Office of the Prosecutor and Registry. This study does not represent in whole or in part the views of the United Nations or official DOD policy, but those of the author.

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Appendix

The following definitions and decision-making rules are presented for aging pubic bone morphology and structure. A portion of the decision-making rules focuses on osteopenia and osteoporosity. In some cases, osteopenia/osteoporosity is to be judged on bone weight, with lighter than expected bone being more osteopenic than heavier bone. This judgment is necessary only in borderline cases; typically it is used to decide between phase VI and VII in instances where the ratio of compact to porous bone on the symphyseal face is nearing equality. Finally, each pubic bone should be scored with the aid of a standard desk magnifying glass. The proposed definitions and decision-making rules for older age females are as follows:

Phase V: The rim is complete at this stage, but the symphyseal face may show a slight depression as it begins to erode (Figs. A1 and A2). The pubic tubercle is separated from the face. The quality of bone on the articular surface is still good and very compact. In a few cases, a slight amount of porosity may be present, but it usually affects less than 15% of the symphyseal face. Only extremely mild signs of osteoporosity/osteopenia are present (if any) and the ventral aspect of the symphysis is typically not porous.

Decision-making traits are: (i) if the articular surface still has majority of compact bone with less than 15% porosity anywhere on surface, and (ii) osteoporosity/osteopenia is absent or extremely mild, score as a phase V. If either of these two traits is observed greater than specified, then score as greater than a phase V.

Phase VI: The symphyseal face is usually depressed and the rim begins to erode, beginning with the superior ventral aspect (Figs. A1 and A2). The quality of bone on the articular surface is breaking down, no longer retaining the smooth, compact surface. The symphyseal face is eroded, in the form of either porosities or small channel-like structures—coalescences of smaller porosities into oblong pores/channels. Osteoporosis is mild to moderate in this phase. Lipping of the articular surfaces can be present.

Decision-making traits are: (i) less than 50% of the symphyseal surface is porous, and (ii) lipping is mild to moderate then it is scored as a phase VI. If the symphyseal face appears to be borderline (40–60% of face is porous but still a fair amount of compact bone), then osteoporosity/osteopenia should be used as the deciding feature. If this trait is moderate to severe, then it is scored as a phase VII. The weight of bone should be the primary indicator, though other indications of osteoporosity/osteopenia can be found

FIG. A1—*Line drawings of each phase. Top row: phase V from the BK sample (left), phase V from the WBD sample (right). Middle row: phase VI from the BK sample (left), phase VI from the WBD sample (right). Bottom row: phase VII from the BK sample (left), phase VII from the WBD sample (right).*

FIG. A2—*Photographic exemplars of phase V: Top row is from the BK sample, bottom row is from the WBD sample. Center WBD symphysis has some minor postmortem breakage along the rim.*

FIG. A3—*Photographic exemplars of phase VI: Top row is from the BK sample, bottom row is from the WBD sample. Note increasing porosity and disfigurement of the faces.*

FIG. A4—*Photographic exemplars of phase VII: Top row is from the BK sample, bottom row is from the WBD sample. Note frequent and large porosities and disfigurement of the symphyseal faces.*

on the ventral aspect of the pubis where porosity may be present and the bone may have a striated quality.

Phase VII: The symphyseal face is extremely porous and eroded with >50% of its surface (Figs. A1 and A4). Osteoporosity/osteopenia is present and is typically moderate to severe in nature (often, the bone is light in weight). The symphyseal face appears to be relatively flat, since the rim is highly eroded and is losing definition. The ventral surface of the symphysis is typically scarred or has striated bone with ligamentous outgrowths, occurring typically near the obturator foramen. Lipping of the articular surfaces is often moderate, but may be mild or severe. This character is highly variable.