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Technical Note

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Test of an Alternative Method for Determining Sex from the Os Coxae: Applications for Modern Americans*

ABSTRACT: A recently proposed method for determining sex from the os coxae reports a 98% success rate using European collections. The purposes of the present study are to (1) evaluate the success rate of this proposed method using modern American os coxae from different population subgroups; (2) compare the success rate of the new method with that obtained using traditional techniques; and (3) determine replicability of the new method and interobserver error. Eight hundred and seventy-six adult left os coxae were independently evaluated by both authors. Summary statistics for sex classifications were calculated for the total sample and for a random sample of 400 individuals. The impact of sex and ancestry on the success of each method was calculated on the random sample using Pearson's χ^2 values. Results demonstrate that for modern American os coxae, neither sex nor race have a significant impact on the success rate for either the new or traditional methods ($p < 0.01$). Additionally, the success rate of the new method is comparable with that obtained using traditional techniques. Finally, interobserver error using the new method for overall sex determination is low.

KEYWORDS: forensic science, sex determination, forensic anthropology, os coxae

Many techniques exist for determining sex in the skeleton based on skeletal pelvic morphology. These traditional methods yield success rates that vary between 80% and 95% depending on the methodology and population (1–6). A recently proposed method for sexing the os coxae reports a 98% success rate (7). While the accuracy of this method is high, all collections used in this research are European (specifically, French, and Portuguese), and one cannot assume the methodology would yield equally high success rates in other populations. Therefore, further testing, specifically on modern American collections, is necessary to ensure the technique's applicability in the United States.

The purposes of the present study are (1) to evaluate the success rate of the proposed new methodology for modern American os coxae using different population subgroups; (2) to compare the success rate of this method to that obtained using traditional techniques; and (3) to determine replicability of the new method and interobserver error.

Materials and Methods

Both authors independently evaluated 876 left os coxae using the new method and a combination of traditional techniques. The sample is comprised of modern Americans of known age, sex, and ancestry from three collections: the William M. Bass Donated Collection housed at the University of Tennessee, the Robert J. Terry Anatomical Skeletal Collection housed at the National Museum of Natural History, and the Donated Collection housed at Louisiana State University. All individuals evaluated were adults; the epiphyses in the os coxae were partially or fully fused. Individuals with extreme degenerative changes and/or fusion of multiple elements (e.g., sacrum to os coxae, etc.) were eliminated from this study. Figure 1 provides basic demographic information about the sample.

The "traditional techniques" used for determining sex from the skeleton chosen for this study were taken after Rogers and Saunders (6). For each os coxae, eight different traits were visually assessed and scored as male ("M"), female ("F"), or intermediate ("I"). The number of M's, F's, and I's were counted, the most numerous of which determined the overall sex of the individual. If the numbers of M's and F's were equal, the individual was scored as "Indeterminate." Table 1 summarizes the eight traditional traits used in this study.

The following description summarizes the proposed new methodology; for a full description of the technique, refer to Bruzek (7). Bruzek's method is based on the evaluation of "five characters" for each os coxae. Table 2 summarizes the five characters used in Bruzek's methodology and Figs. 2–6 provide photographic examples. All five characters, three of which are "complex" and two of which are "simple," are visually assessed and scored as male ("M"), female ("F"), or intermediate ("I"). "Complex" characters are based on the sum of scores for three different traits (characters 1, 2, and 4 in Table 2). "Simple" characters are based on a score from a single trait (characters 3 and 5 in Table 2). The number of M's, F's, and I's for all characters are counted, the most numerous of which determines the overall sex of the individual. If the number of M's and F's are equal, the individual is scored as "Indeterminate."

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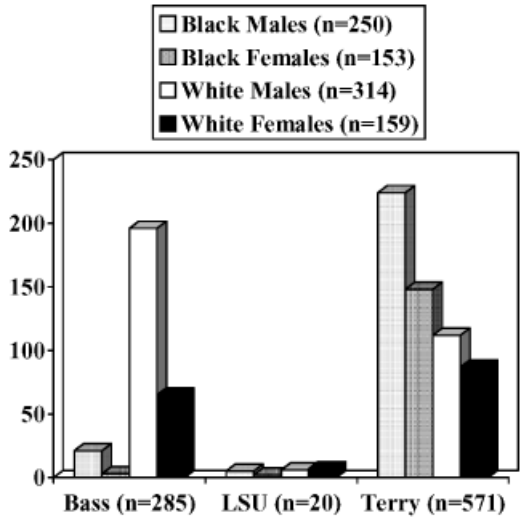

FIG. 1—*Total sample demographic information (n = 876).*

TABLE 1—*Traditional characteristics used for sex determination.*[*]

Variable Number	Trait	Male Form	Female Form
1	Ventral arc	Absent	Present
2	Subpubic angle	Convex/straight	Concave
3	Ridge on ischiopubic ramus	Absent	Present
4	Shape of pubic bone	Rectangular/ narrow	Trapezoidal/broad
5	Sciatic notch size	Deep	Shallow
6	Sciatic notch shape	Narrow	Wide
7	Auricular surface height	Flat	Raised
8	Preauricular sulcus	Absent/slight groove	Present/well defined

[*]After Rogers and Saunders(6).

For this study, a slight modification from Bruzek's methodology was necessary. Where Bruzek proposed the use of photosensitive paper to evaluate character 2, we used photographs instead. Each os coxae was photographed with the laterodorsal iliac surface on a flat surface, which is the same position specified by Bruzek for use with photosensitive paper (7). This position orients the contour of the greater sciatic notch approximately parallel to the flat surface. The chords and arcs necessary to evaluate character 2 were then drawn directly on the photograph using Adobe® Photoshop® 6.0 (8).

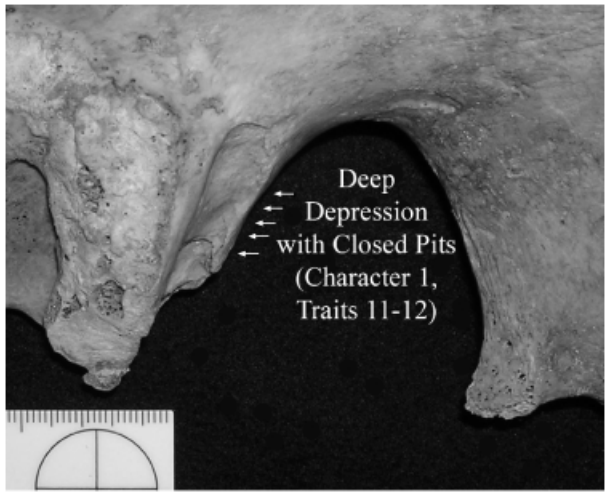

FIG. 2—*Photograph of Bruzek character 1, traits 11 and 12.*

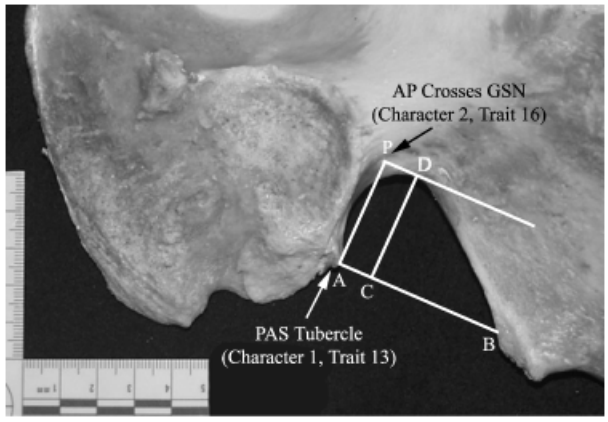

FIG. 3—*Photograph of Bruzek character 1, trait 13, and character 2, trait 16.*

TABLE 2—*Bruzek characters used for sex determination.*[*]

Character Number	Trait Number	Trait Description	Male Form	Female Form	Figure Number
Character 1 (complex)	11	Preauricular surface (PAS)—negative relief	None/very slight	Deep depression with pits	Fig. 2
	12	PAS—grooves/pitting	Depression with open circumference	Pits with closed circumference	
	13	PAS—positive relief	PAS tubercle	No PAS tubercle	Fig. 3
Character 2 (complex)	14	Greater sciatic notch—sciatic notch chord proportions	Posterior chord < anterior chord (Line AC < Line CB)	Posterior chord ≥ anterior chord (Line AC ≥ Line CB)	Fig. 4
	15	Greater sciatic notch—notch contour	Asymmetrical	Symmetrical	
	16	Greater sciatic notch—AP line	AP crosses into GSN	AP does not cross GSN	Fig. 3
Character 3	17	Composite arch	Single arc	Double arc	Fig. 5
Character 4 (complex)	18	External eversion	Absent	Present	NA
	19	Phallic ridge	Present	Absent	Fig. 6
	20	Robusticity	Robust	Gracile	NA
Character 5	21	Ischiopubic proportions	Pubic length < ischial length	Pubic length > ischial length	NA

[*]After Bruzek (7)
GSN, greater sciatic notch.

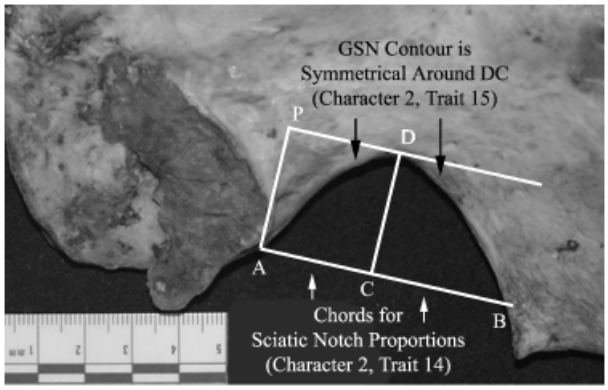

FIG. 4—*Photograph of Bruzek character 2, traits 14 and 15.*

For each observer, summary statistics for correct and incorrect sex classifications were calculated for the total sample as well as for a random sample. The random sample was chosen from the total sample by SPSS (version 11.0) (9) and contained 400 individuals, consisting of 100 individuals randomly chosen from each population subgroup (i.e., 100 white females, 100 black females, 100 white males, 100 black males). Pearson's χ^2 values were calculated on the random sample to compare the success of each method in determining sex, as well as to determine if sex and ancestry affect the success of each method. The level of significance for these tests is $p < 0.01$.

Results and Discussion

For all analyses, individuals scored as "Indeterminate" were classified as "Incorrect" for sex classification. Figure 7 shows the summary statistics for both observers for the total sample. Observer A correctly classified sex for 95% of the sample using traditional techniques, and for 90% of the sample using the Bruzek methodology. Observer B correctly classified sex for 96% of the sample using traditional techniques, and for 92% of the sample using the Bruzek methodology.

Figure 8 shows the summary statistics for both observers for the random sample. Observer A correctly classified sex for 96% of the random sample using traditional techniques and for 89% using the Bruzek methodology. Observer B correctly classified sex for 95%

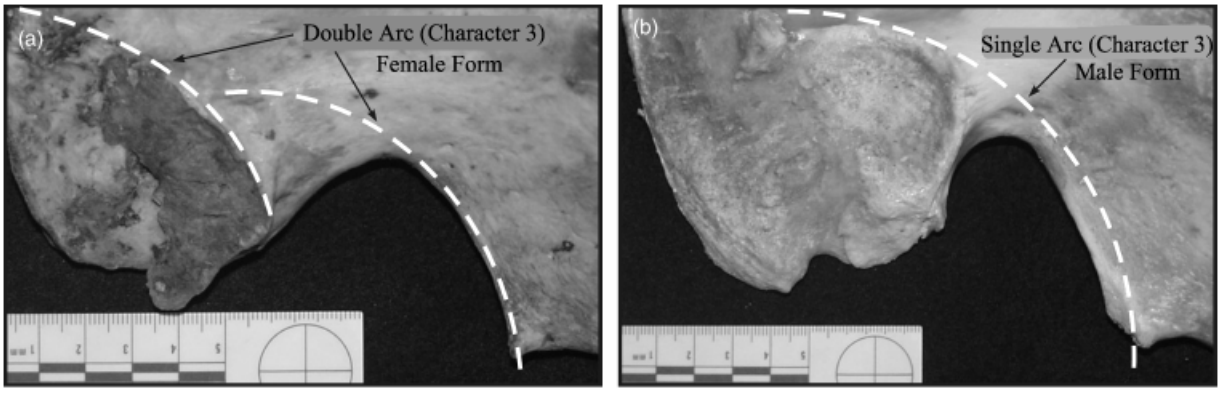

FIG. 5—*Photographs of Bruzek character 3, (a) female and (b) male forms.*

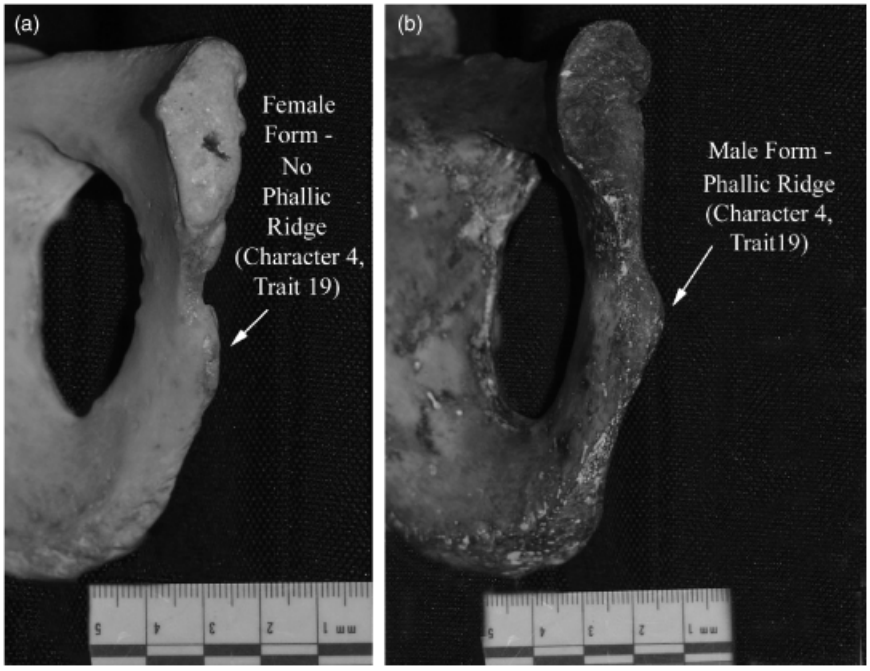

FIG. 6—*Photographs of Bruzek character 4, trait 19, (a) female and (b) male forms.*

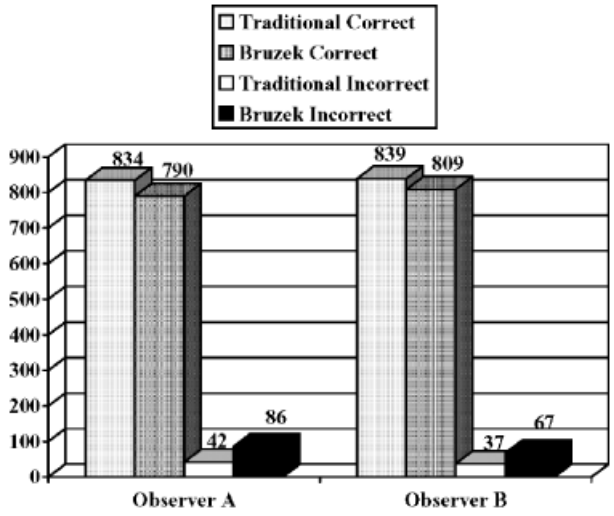

FIG. 7—*Summary statistics for total sample (n = 876).*

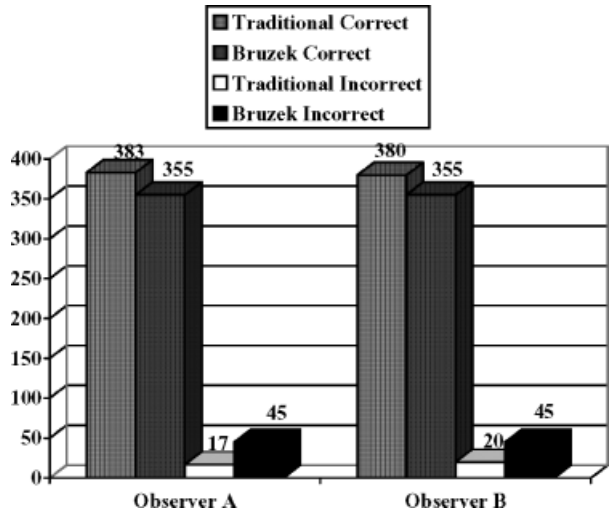

FIG. 8—*Summary statistics for random sample (n = 400).*

of the random sample using traditional techniques and for 89% using the Bruzek methodology.

Summary statistics and Pearson's χ^2 values evaluating the influence of sex on the success rate for both methods for Observers A and B are presented in Table 3. For both observers, the number of correct sex assignments is less for the Bruzek method than for traditional methods; however, this difference is not significant. Additionally, for both observers, more females are misclassified using the Bruzek method than traditional methods; however, this difference is not significant.

Summary statistics and Pearson's χ^2 values evaluating the effects of ancestry and sex on the success rate of each method for Observers A and B are presented in Table 4. For both observers, both the Bruzek and traditional methods assign sex equally well on black and white subsamples.

In reviewing the summary statistics, the potential accuracy of 98% was not achieved in this study; however, the authors found that the Bruzek methodology yields a success rate comparable with traditional methods for samples of American black and white individuals. Furthermore, though both observers misclassified females more often than males using Bruzek's methodology, neither sex nor race has a significant impact on the success rate for either the Bruzek or traditional methods.

The Bruzek methodology evaluates five characters in the os coxae, which are composed of 11 traits, that are visually assessed and assigned a score of "male," "female," or "intermediate." The authors found that some of the traits that make up the characters are simple to assess and understand, whereas others are complicated and difficult to replicate. Some of Bruzek's traits are similar to traditional traits. For example, the assessment of "pits" and "depressions" in the preauricular surface area (Table 2, character 1, traits 11 and 12) is similar to the traditional analysis of the presence or absence of the preauricular sulcus (Table 1, trait 8). Other aspects of Bruzek's methodology offer a standard way to evaluate a conventionally subjective region of the hip. For example, the standardization of the greater sciatic notch by dividing it into proportions (Table 2, character 2) makes the analysis of this region more objective than that which occurs using traditional methods (Table 1, traits 5 and 6). Still others, for example, Bruzek characters 3–5, are challenging because they lack a standard procedure for assessment. Ultimately, the difficulty with assessing these characters may be a result of the authors' lack of familiarity with Bruzek's methodology compared with traditional methods and may have contributed to its slightly lower success rate.

The authors also noted that even though many of Bruzek's characters are "new" in the sense that they do not overlap with traditional techniques used in this study, os coxae that are difficult to classify using strictly traditional techniques remain ambiguous. Bruzek's methodology offers no additional insight for predicting sex in individuals whose os coxae do not clearly exhibit traits that are specifically male or female.

TABLE 3—*Summary statistics and Pearson's χ^2 for random sample (n = 400): sex determination by method for (a) Observer A and (b) Observer B.*

	Correct		Incorrect	
	Traditional	Bruzek	Traditional	Bruzek
(a) Observer A				
Males	190 (50%)	181 (51%)	10 (59%)	19 (42%)
Females	193 (50%)	174 (49%)	7 (51%)	26 (58%)
Total	383 (100%)	355 (100%)	17 (100%)	45 (100%)
Pearson's χ^2(p value)	0.1399 ($p = 0.7084$)		1.366 ($p = 0.243$)	
(b) Observer B				
Males	191 (50%)	187 (53%)	9 (45%)	13 (29%)
Females	189 (50%)	168 (47%)	11 (55%)	32 (71%)
Total	380 (100%)	355 (100%)	20 (100%)	45 (100%)
Pearson's χ^2 (p value)	0.4278 ($p = 0.5131$)		1.605 ($p = 0.205$)	

TABLE 4—*Summary statistics and Pearson's χ^2 for random sample (n = 400): race and sex by method for (a) Observer A and (b) Observer B.*

	Correct				Incorrect			
	Traditional		Bruzek		Traditional		Bruzek	
	Black	White	Black	White	Black	White	Black	White
(a) Observer A								
Males	96 (49%)	94 (50%)	87 (50%)	94 (52%)	4 (67%)	6 (55%)	13 (50%)	6 (32%)
Females	98 (51%)	95 (50%)	87 (50%)	87 (48%)	2 (33%)	5 (45%)	13 (50%)	13 (68%)
Total	194 (100%)	189 (100%)	174 (100%)	181 (100%)	6 (100%)	11 (100%)	26 (100%)	19 (100%)
Pearson's χ^2 (p value)	0.0024 ($p = 0.9608$)		0.1327 ($p = 0.7156$)		0.235 ($p = 0.627$)		1.527 ($p = 0.217$)	
(b) Observer B								
Males	98 (52%)	93 (49%)	95 (55%)	92 (51%)	2 (20%)	7 (70%)	5 (19%)	8 (42%)
Females	92 (48%)	97 (51%)	79 (45%)	89 (49%)	8 (80%)	3 (30%)	21 (81%)	11 (58%)
Total	190 (100%)	190 (100%)	174 (100%)	181 (100%)	10 (100%)	10 (100%)	26 (100%)	19 (100%)
Pearson's χ^2 (p value)	0.2632 ($p = 0.6080$)		0.5055 ($p = 0.4771$)		5.051 ($p = 0.025$)		2.796 ($p = 0.094$)	

Interobserver error for overall assignment of sex using Bruzek's method is low; however, the difference between the authors in the evaluation of individual characters has not yet been assessed. In future analyses of individual characters and, more specifically, traits, the authors expect interobserver error to increase, particularly for characters that are more subjective.

Finally, the Bruzek methodology requires considerably more time than traditional methods. Though all of the characters are visually assessed, analyses of the greater sciatic notch region and composite arch (Table 2, characters 2 and 3) require a photograph be taken and chords drawn. This added time investment might only be warranted in situations where the remains are fragmentary.

Questions that the authors will address in future analyses include the impact of age on the success rate of both Bruzek's and traditional techniques, and the contribution of each individual character and trait in the Bruzek method to the overall determination of sex.

Conclusion

The research presented here tests a proposed new method for determining sex from the os coxae. The potential accuracy of 98% was not achieved in this study; however, the authors found that the Bruzek methodology yields a success rate comparable to traditional methods for samples of American black and white individuals. Furthermore, though both authors misclassified females more often than males using Bruzek's method, results demonstrate that neither sex nor race had a significant impact on the success rate for either the Bruzek or traditional methods ($p < 0.01$). Finally, interobserver error for overall sex determination using the Bruzek method was low.

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References

1. Phenice TW. A newly developed visual method of sexing the os pubis. Am J Phys Anthropol 1969;30:297–302.
2. Sutherland LD, Suchey JM. Use of the ventral arc in pubic sex determination. J Forensic Sci 1991;36:501–11.
3. Lovell NC. Test of Phenice's technique for determining sex from the os pubis. Am J Phys Anthropol 1989;79:117–20.
4. Işçan MY, Derrick K. Determination of sex from the sacroiliac joint: a visual assessment technique. Fla Scientist 1984;47:94–8.
5. MacLaughlin SM, Bruce MF. The accuracy of sex identification in European skeletal remains using the Phenice characters. J Forensic Sci 1990;35:1384–92.
6. Rogers T, Saunders S. Accuracy of sex determination using morphological traits of the human pelvis. J Forensic Sci 1994;39:1047–56.
7. Bruzek J. A method for visual determination of sex using the human hip bone. Am J Phys Anthropol 2002;117:157–68.
8. Adobe Systems Inc. Adobe® Photoshop® Version 6.0. Windows® Version. San Jose, CA: Adobe Systems Inc.; 2000.
9. SPSS, Inc. Statistical Package for the Social Sciences, Release 11.0.1. Windows® version. Chicago, IL: SPSS, Inc.; 2001.

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