J Forensic Sci, November 2008, Vol. 53, No. 6
doi: 10.1111/j.1556-4029.2008.00855.x
Available online at: www.blackwell-synergy.com

John Albanese,[1] Ph.D.; Greg Eklics,[1] B.A. [H]; and Andrew Tuck,[1] M.A.

A Metric Method for Sex Determination Using the Proximal Femur and Fragmentary Hipbone*,†

ABSTRACT: The pubic bone is considered one of the best sources of information for determining sex using skeletal remains, but can be easily damaged postmortem. This problem has led to the development of nonpelvic methods for cases when the pubic bone is too damaged for analysis. We approached this problem from a different perspective. In this article, we present an approach using new measurements and angles of the proximal femur to recreate the variation in the pubic bone. With a sample from the Terry Collection ($n > 300$), we use these new variables along with other traditional measurements of the femur and hipbone to develop two logistic regression equations (femur and fragmentary hipbone, and femur only) that are not population specific. Tests on an independent sample (Grant Collection; $n = 37–40$) with a different pattern of sexual dimorphism resulted in an allocation accuracy of 95–97% with minimal difference by sex.

KEYWORDS: forensic science, forensic anthropology, human identification, sex determination, skeletal, femur, pelvis

The pelvis is usually the first choice for information when determining sex using human skeletal remains because of the sexual dimorphism related to the morphology of the birth canal. The pubic bone in particular has been used exclusively and in conjunction with other skeletal elements for sex determination using both metric and morphological approaches (1–12). Unfortunately, the pubic bone is highly susceptible to damage in both archeological and forensic contexts. Both taphonomic factors and poor recovery techniques may result in the loss of information. In contrast, the femur is a much more robust bone and less susceptible to damage. Much of the discriminatory power of the pubic bone is due to disproportional growth in the symphyseal end of the pubic bone in females. This growth in females accounts for the Phenice (3) characteristics (13,14), and for the *relatively* longer pubic bone in females which is relevant for metric approaches (12). Sexual dimorphism in the pelvis is due to different selection forces acting on each sex. Some studies indicate that bipedal locomotion is most efficient with the femora directly below the pelvis (see 15,16). However, in direct contrast, there has been selective pressure on females to maximize the diameter of the birth canal to successfully deliver large brained babies, and thus, push the femora apart at the hips (15,16). The evolutionary compromise in females between these two competing forces is visible in the angle and length of the femur neck.

Because of this relationship between the length of the pubic bone and the anatomy of the proximal femur, in this article, we present an approach for reconstructing variation in the pubic bone using the proximal femur. We use a series of measurements to assess the size and angle of the femur neck, which are functionally related to the length of the pubic bone. We use these new measurements and angles, along with traditional measurements of the hipbone and femur to develop two methods for determining sex. One method can be applied in cases where only the proximal femur is recovered. However, information about the pubic bone (whether directly collected or indirectly assessed) is most useful for determining sex when used in conjunction with other skeletal elements (1,12). Therefore, the second method we developed can be applied in cases where the recovered skeletal elements include a proximal femur and a hipbone with damaged pubic bone. We test both methods using an independent sample from a different collection not used to develop the methods. In contrast to other metric approaches, we follow the methodology described by Albanese (12) and develop metric methods that are not population specific.

Materials and Methods

Despite the sexual dimorphism in the neck of the femur, most methods involving the femur have relied on measurements of the femur head for sex determination when the pelvis and cranium are not recovered (17–22). An exception is the work of Purkait (23) who presented a sex determination method using the proximal femur with allocation accuracies ranging from 81% to 87%. At least as good or better allocation accuracies are possible with much simpler univariate population-specific methods for fragmentary femora that use a measurement of shaft or the femur head, respectively (24). Furthermore, the Purkait (23) method suffers from serious limitations that stem directly from the methodology used to develop most metric sex determination methods. A widely accepted but erroneous view has been and continues to be that morphological methods can be applied across populations while metric methods are population specific. Several studies have shown that, in fact, this is not the case. Comprehensive testing of morphological indicators strongly suggests that they are not necessarily applicable

---

[1] Department of Sociology and Anthropology, University of Windsor, Windsor, ON, Canada N9B 3P4.

*Some data were collected with the support the Social Sciences and Humanities Research Council of Canada.

†Various aspects of this paper were presented at the 76th Annual Meeting of the American Association of Physical Anthropologists in Philadelphia, PA, March 28–31, 2007; and at the 34th Annual Meeting of the Canadian Association for Physical Anthropology, Peterborough, ON, October 25–28, 2006.

Received 28 Oct. 2007; and in revised form 3 Feb. 2008; accepted 10 Feb. 2008.

across populations or at the very least lower allocation accuracies should be expected (25–27). At the same time, it is possible to design highly accurate and reliable metric methods that are applicable across populations (12,28–32).

In this article, we use an alternative methodology for developing sex determination methods designed and used successfully by Albanese (12) to develop various metric sex determination methods that have high allocation accuracies but are not population specific. Details are available in a previously published source (12) and are summarized here. The essential elements to the methodology include tests of the reproducibility of measurements, a focus on biologically (rather than just statistically) meaningful combinations of variables that can be applied to realistic taphonomic and recovery situations, an alternative robust statistical approach (logistic regression), and an independent test of the method. However, the key to the approach is that the reference sample used to develop the method is selected to include a wide range of human variation. Thus, the greater the variation sampled by the reference sample, the greater the applicability of the method. In the past, human skeletal variation has been discussed in the context of racial categories or continental origin. However, various studies confirm that human variation does not cluster into racial groups or continental origin and that "race" accounts for very little of the genetic or phenotypic variation in humans (12,33–45). For this research, a racial approach is avoided. Instead, a wide range of human variation is sampled using age at death and year of birth criteria (see 12 for details). The clear advantage of this approach is that metric methods may be applied in various forensic and archaeological situations when individuals are recovered without any context. There is no need to allocate an individual to a poorly defined group before deciding which population-specific approach should be applied.

Data were collected from a sample of over 300 individuals from the Terry Collection (see 46 for details about the collection). The reference sample used to develop the methods is the same Terry Collection sample used by Albanese (12). The method was tested using a sample (*n* = 37–40) from the Grant Collection. The Grant Collection is an identified reference collection curated at the University of Toronto (Toronto, ON, Canada) that was collected following a very similar, strict protocol used by Robert Terry and Mildred Trotter for the Terry Collection (47). As with the Terry Collection sample, the sample from the Grant Collection was selected using age at death and year of birth criteria to include a wide range of human variation. Several standard measurements including hipbone height, iliac breadth, and maximum diameter of the femur head were collected by the first author (2,6,7). Some sources recommend that spreading calipers be used to measure the iliac breadth. Using an osteometric board was found to be much quicker and easier while providing identical results (12). New measurements of the femur neck were collected by the second author. Data were collected from the left femur except in cases where there was damage to the landmarks or the bone was missing. In these cases, data were collected from the right side.

Various traditional and newer options were explored to assess the sexual dimorphism in length and angle of the femur neck (2,23,48). The goal was to capture the variation in the proximal femur with minimal measurement error. We set up trials to collect and re-collect lengths and angles of the femur neck using previously published descriptions. With so much variation in this area of the femur, we found it very difficult to locate landmarks consistently. As a result of the problems with the previously published methods, we developed three new measurements through a series of trials. The new measurements are measured using sliding calipers from the greater trochanter to the fovea capitis or GT to FC; the greater trochanter to the lesser trochanter, or GT to LT; and the lesser trochanter to fovea capitis, or LT to FC (see Fig. 1).

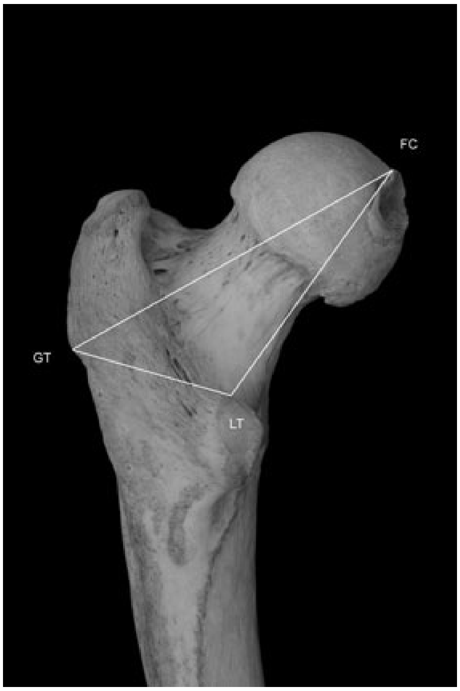

FIG. 1—*Landmarks for three new measurements of the proximal femur to capture variation in size and angle of the femur neck.*

The GT to FC measurement is the distance from the most lateral apex on the greater trochanter to the superior margin on the fovea capitis. The fixed arm of the caliper should be placed on the most lateral apex of the greater trochanter and the sliding arm of the caliper should be placed on the superior margin on the fovea capitis. The landmark on the femur head is generally easy to find. In cases where there is lipping or a depression around the fovea capitis, the landmark is on the superior margin of the lipping or the depression. (see Fig. 2).

The measurement labeled GT to LT is measured from the landmark on the greater trochanter described above to the superior

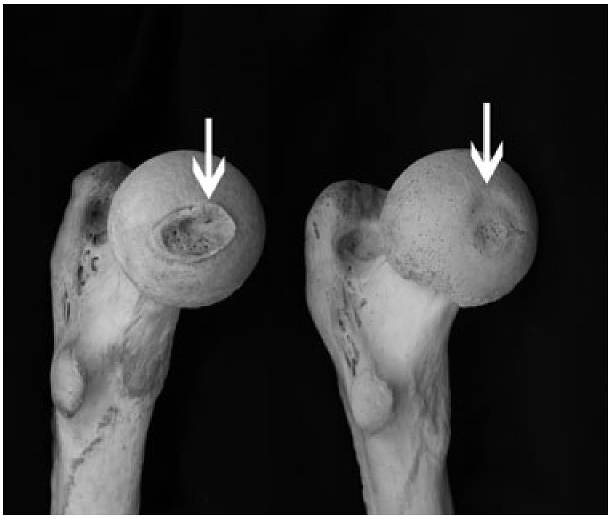

FIG. 2—*Location of landmark at fovea capitis.*

margin of the lesser trochanter. After measuring GT to FC, hold the fixed end of the calipers at the GT landmark and pivot the calipers to the LT landmark. The LT landmark is the most proximal point on the dense compact bone around the base of the lesser trochanter. Occasionally, this landmark may be difficult to see. In these cases, changing the position of bone will help to locate the landmark because this area of smooth, compact bone reflects more light than the surrounding cortical bone.

The measurement labeled LT to FC is the distance between landmarks on the lesser trochanter and the fovea capitis described above. The new measurements were re-collected by the second author from a subsample (*n* = 40) from the Terry Collection sample to assess intra-observer error. The sample was equally divided between males and females. Intra-observer error was calculated in millimeters,

$$\mathrm{Error}_{\mathrm{mm}} = |\mathrm{M}_1 - \mathrm{M}_2|$$

and as a percentage,

$$\mathrm{Error}_{\%} = \frac{|\mathrm{M}_1 - \mathrm{M}_2| \times 100}{\mathrm{M}_1}$$

The measurement of GT to LT had the highest mean error, 1.99% (0.95 mm). The FC to LT measurement and the GT to FC measurement had a 1.7% (1.2 mm) and 0.16% (0.15 mm) error, respectively. Albanese (12) found that when determining sex using metric approaches, misallocation is possible when measurement error exceeds *c.* 2–2.5%. The intra-observer values for all three measurements in the present study are below this threshold.

Because the new measurements create a triangle on the proximal femur, it is possible to assess size dimorphism in the length of the neck as well as dimorphism in the angle of the neck. Using the Law of Cosines, the angles of an oblique triangle can be calculated when the lengths of the sides of a triangle are known. The general equation is,

$$\mathrm{A}_{\mathrm{angle}} = \mathrm{Cos}^{-1}\frac{\mathrm{b}^2 + \mathrm{c}^2 - \mathrm{a}^2}{2\mathrm{bc}}$$

where a, b, c represent the sides of the triangle and A, B, and C represent the angles of the triangle; A is the angle opposite of side a.

For the new measurements,

$$\mathrm{AGT} = \mathrm{Cos}^{-1}\frac{(\mathrm{GT\ to\ LT})^2 + (\mathrm{GT\ to\ FC})^2 - (\mathrm{LT\ to\ FC})^2}{2(\mathrm{GT\ to\ FC}) \times (\mathrm{GT\ to\ LT})}$$

Where AGT is the angle at the landmark GT, and LT to FC is the opposite side in the triangle. The result is a pool of variables including the standard measurements of the hipbone and the femur head; the three new measurements of the proximal femur; the angles at the three new landmarks; and various ratios of lengths to angles.

Most multivariate metric sex determination methods use discriminant function analysis to calculate equations to predict sex (8–10,19,21–23,49–62). In this study, logistic regression analysis was used for several reasons. Generally, logistic regression performs as well or better than discriminant function analysis with fewer statistical assumptions when predicting dichotomous dependent variables (63). Additionally, the logistic regression score or *p*-value (always between 0 and 1) is used to classify an unknown individual and also provides a probability value for the allocation. Scores greater than 0.5 are classified as male and scores less than 0.5 are classified as female. For example, a *p*-value of 0.92 would classify the unknown individual as male (>0.5). Furthermore, given the combination of variables for this individual, there is a 92% probability that the individual actually is male. If discriminant function analysis was used, typicality and posterior probabilities would have to be determined *post hoc* to calculate a probability value. Detailed description of logistic regression and comparisons with discriminant function analysis are available elsewhere (11,12,63).

Results and Conclusion

Two scenarios were considered when determining sex where the pubic bone was too damaged for analysis. In the first scenario, a femur and a hipbone with a damaged pubic bone recovered. In a case where the femur and hipbone are recovered and the pubic bone is intact, we direct the reader to the method developed by Albanese (12). In the second scenario, only the proximal femur is recovered and can be analyzed.

Regardless of the scenario, three ratios of new measurements and angles consistently contributed in a significant way to maximizing allocation accuracy: ratio of Angle GT divided by the length from GT to FC, ratio of Angle LT divided by maximum diameter of femur head, and ratio of Angle LT divided by the length from LT to FC. The ratios, rather than just the angle, are significant predictors of sex for several reasons. As the new measurements form a triangle on the proximal femur, a larger individual may have a larger triangle with no measurable change in the angles of the triangle. The angle data become most relevant when considered relative to the length of the femur neck and the diameter of the femur head.

The three ratios mentioned in the previous paragraph along with the angle of the neck at the GT landmark provided the best results for the scenario where only the proximal femur was used. The allocation accuracy was 90.6% overall with 2.3% difference among sexes for the Terry Collection sample used to develop the method. For the independent Grant Collection test sample, the overall allocation accuracy was 95% with 0.5% difference in allocation accuracy for males and females. In the alternative scenario when measurements of the hipbone were also available for analysis, the allocation accuracy was 95% overall with virtually no difference in allocation accuracy for males and females for the Terry Collection sample used to develop the method. For the independent Grant Collection test sample, the overall allocation accuracy was 97% with 3.2% difference in allocation accuracy for males and females. Allocation accuracies for both methods for each sex and collection are presented in Table 1. The coefficients for the equations are presented in Table 2.

At first glance, this method seems to be more complex than necessary. Methods have been published with good allocation accuracies using only the femur head. Although the femur head is an excellent univariate discriminator for determining sex, a sectioning point using the femur head would be sample specific. If a large sample (*n* > 40) is available in an archaeological context, we draw the reader's attention to the approach described by Albanese et al. (24) for determining sample-specific univariate and multivariate sectioning points for determining sex. In contrast, the methods presented in this article are ideal for a situation where one or a few isolated individuals are available for analysis in archaeological or forensic cases with little or no context. One of our new ratios includes data from the highly sexually dimorphic femur head, while the neck length and neck angles help to reconstruct variation in the pubic bone. Because the femur head data are included as a ratio, we can control for size variation across different groups without

TABLE 1—*Allocation accuracies for logistic regression equations, over all and by sex for each collection.*

	Terry Collection*						Grant Collection†					
		Total Correct	Females Correct		Males Correct			Total Correct	Females Correct		Males Correct	
Method	*n*‡	%	*n*	%	*n*	%	*n*‡	%	*n*	%	*n*	%
Femur only	312	89.4	144	88.3	135	90.6	40	95.0	20	95.2	18	94.7
Femur and Hipbone	302	95.0	149	94.9	138	95.2	37	97.0	16	93.8	19	100

*Used to develop equations.
†Independent sample used only to test equations.
‡Sample size varied because of missing data.

TABLE 2—*Coefficients for logistic regression equations.**

	Measurements		Angles		Ratios		
	Hipbone Height	Iliac Breadth	AGT†	AGT/GT to FC‡	ALT/Femur head§	ALT/LT to FC¶	Constant
Femur			1.084	−0.804	−0.163	0.223	−6.217
Femur and Hipbone	0.151	−0.381	1.3	−1.136	−0.215	0.229	39.280

*A spreadsheet is available for download from the first author's website (http://www.uwindsor.ca/users/a/albanese/Main.nsf/) to simplify the calculation of the angles, ratios, and *p*-value. Researchers will only have to collect the three new measurements, and the three standard measurements and enter them in the spreadsheet.
†Angle at landmark GT.
‡AGT/GT to FC × 100 = Angle at landmark GT (AGT) divided by length of GT to FC, multiplied by 100.
§ALT/Femur head diameter × 100 = Angle at landmark LT (ALT) divided by the maximum diameter of the femur head, multiplied by 100.
¶ALT/LT to FC × 100 = Angle at landmark LT (ALT) divided by the length of LT to FC, multiplied by 100.

losing data related to sexual dimorphism in size. As the tests using the Grant Collection sample indicate, the methods work as well or better when applied to an independent sample. There is no need to determine population, ancestry or "race" before applying a sex determination method.

Despite some similarities between the Grant Collection and Terry Collection (see 46,47), there are some important differences between the Terry Collection sample used to develop the method and the Grant Collection sample used only to test the method. Using one-way ANOVA with the Tukey HSD (honestly significant difference) *post hoc* test, we looked for differences in size and patterns of sexual dimorphism in the samples from the two collections using maximum femur length, hipbone height and iliac breadth. The femur length is a good indicator of height and overall size, while the two pelvic dimensions provide information about overall pelvis size. These measurements allow for a comparison of pelvis size to body size for each sex in each collection. The Tukey HSD test was used because it classifies groups into homogeneous subsets.

The results of this analysis indicate that there is a different complex pattern of sexual dimorphism in each of the samples from the two collections. For the femur length, each sex-collection group forms a statistically different homogeneous subset: Grant Collection females are significantly shorter than all Terry Collection females and all males; Terry Collection females are significantly taller than Grant Collection females but significantly shorter than all males; Grant Collection males are significantly taller than all females and significantly shorter than Terry Collection males; and Terry Collection males are significantly taller than all females and Grant Collection males. For the hipbone height, there are three homogeneous subsets: females from both collections; males from the Terry Collection; and males from the Grant Collection. For the iliac breadth, the groups are classified into only two subsets: Terry Collection females, Grant Collection females, and Terry Collection males; and Grant Collection males. In summary, the Terry Collection sample is on average taller than the Grant Collection sample for each sex. However, the Grant Collection males have significantly larger pelvic dimensions. There are two different complex patterns of sexual dimorphism in the samples from each collection but the methods presented in this article consistently perform very well on the indenting sample from the Grant Collection.

When looking at the range of variation in the samples from the two collections, in all but one instance, the entire Grant Collection male sample falls within the range of the Terry Collection male sample, and the entire Grant Collection female sample falls within the range of the Terry Collection female sample. The one exception is hipbone height where one Grant Collection male falls just outside the Terry Collection male sample for this variable. Previous metric methods have failed when applied to unknown and unclassifiable individuals because they violate basic statistical assumptions. Methods should not be used for predictive purposes on individuals who fall outside the range of the reference sample used to develop the method (63). The sampling methodology that drew on age at death and year of birth criteria used to select the reference sample was highly effective in sampling a wide range of human variation, and including outliers allowed us to expand the applicability of the method. This approach did *not* sample variation in the Terry Collection. Rather, with this approach we were able to sample a wide range of human variation through the Terry Collection.

Following the methodology described by Albanese (12), we were able to develop metric methods for sex determination with high allocation accuracies that are not population specific. Testing on an independent sample confirms this conclusion. This metric method works independently of size on large and small individuals without losing useful information about sexual dimorphism in size. The method presented in this article may at first glance appear overly complicated due to the number of calculations involved. We attempted to keep the method as simple as possible without compromising its utility as a method that is not population specific.

Any further simplification would have a negative impact on the utility of the method. To overcome any issues related to calculations required for this method, a spreadsheet is available for download from the first author's website (http://www.uwindsor.ca/users/a/albanese/Main.nsf/) to simplify the calculation of the angles, ratios and *p*-values. Researchers will only have to collect the three new measurements and the three standard measurements using basic osteometric equipment (spreading calipers and osteometric board) available to any researcher working with human skeletal remains, and enter or paste the data into the spreadsheet to determine sex for individual cases and for large samples.

Acknowledgments

Thanks to Dr. David Hunt, Smithsonian Institution, Washington, DC, for assistance with data collection and many helpful suggestions. Photographs in Figs. 1 and 2 were taken by Courtney Strachan.

References

1. Stewart TD. Essentials in forensic anthropology. Springfield, IL: CC Thomas, 1979.
2. Olivier G. Practical anthropology. Springfield, IL: CC Thomas, 1969.
3. Phenice TW. A newly developed visual method of sexing the os pubis. Am J Phys Anthropol 1969;30:297–302.
4. Schultz AH. The skeleton of the trunk and limbs of higher primates. Am J Phys Anthropol 1930;2:303–438.
5. Washburn SL. Sex differences in the pubic bone. Am J Phys Anthropol 1948;6:199–207.
6. Moore-Jansen PM, Ousley SD, Jantz RL. Data collection procedures for forensic skeletal material. Report of Investigation No. 48. Knoxville, TN: The University of Tennessee, Department of Anthropology, 1994.
7. Bass WM. Human osteology: a laboratory and field manual. 5th ed. Columbia, MO: Missouri Archaeological Society, 2005.
8. Thieme FP, Schull WJ. Sex determination from the skeleton. Hum Biol 1957;29:242–73.
9. Schulter-Ellis FP, Schmidt DJ, Hayek LA, Craig J. Determination of sex with a discriminant analysis of new pelvic bone measurements: part I. J Forensic Sci 1983;28:169–80.
10. Schulter-Ellis FP, Hayek LA, Schmidt DJ. Determination of sex with a discriminant analysis of new pelvic bone measurements: part II. J Forensic Sci 1985;30:178–85.
11. Saunders SR, Hoppa RD. Sex allocation from long bone measurements using logistic regression. Can Soc Forensic Sci J 1997;30:49–60.
12. Albanese J. A metric method for sex determination using the hipbone and the femur. J Forensic Sci 2003;48(2):263–73.
13. Anderson BE. Ventral arc of the os pubis: anatomical and developmental considerations. Am J Phys Anthropol 1990;83:449–58.
14. Budinoff LC, Tague RG. Anatomical and developmental bases for the ventral arc of the human pubis. Am J Phys Anthropol 1990;82(1):73–9.
15. Lovejoy CO. The natural history of human gait and posture. Part 2. Hip and thigh. Gait Posture 2005;21:113–24.
16. Bramble DM, Lieberman DE. Endurance running and the evolution of *Homo*. Nature 2004;432:345–52.
17. Asala SA. Sex determination from the head of the femur of South African whites and blacks. Forensic Sci Int 2001;2(1–2):15–22.
18. Asala SA. The efficiency of the demarking point of the femoral head as a sex determining parameter. Forensic Sci Int 2002;2(1–2):114–8.
19. Asala SA, Bidmos MA, Dayal MR. Discriminant function sexing of fragmentary femur of South African blacks. Forensic Sci Int 2004;145(1):25–9.
20. Purkait R, Chandra H. A study of sexual variation in Indian femur. Forensic Sci Int 2004;1:25–33.
21. Purkait R. Sex determination from femoral head measurements: a new approach. Leg Med 2003;5:347–50.
22. Steyn M, Iscan MY. Sex determination from the femur and tibia in South African whites. Forensic Sci Int 1997;2(1–2):111–9.
23. Purkait R. Triangle identified at the proximal end of femur: a new sex determinant. Forensic Sci Int 2005;3(2–3):135–9.
24. Albanese J, Cardoso HFV, Saunders SR. Universal methodology for developing univariate sample-specific sex determination methods: an example using the epicondylar breadth of the humerus. J Arch Sci 2005;32:143–52.
25. MacLaughlin SM, Brice MF. The accuracy of sex identification in European skeletal remains using the Phenice characters. J Forensic Sci 1990;35:1384–92.
26. Lovell NC. Test of Phenice's technique for determining sex from the os pubis. Am J Phys Anthropol 1989;79:117–20.
27. Rogers T, Saunders SR. Accuracy of sex determination using morphological traits of the human pelvis. J Forensic Sci 1994;39:1047–56.
28. Albanese J. Determining sex using the upper limb. Am J Phys Anthropol Suppl 2007;44:61.
29. Eklics G, Albanese J. How to determine sex using the pubic bone even when it is not recovered? Am J Phys Anthropol Suppl 2007;44:105.
30. Eklics G, Albanese J. A metric method for sex determination using the femur neck: how to assess variation in the pubic bone when it is not recovered. Paper presented at the 34th Annual Meeting of the Canadian Association for Physical Anthropology; 2006 Oct 25–28. Peterborough, ON: Canadian Association for Physical Anthropology, 2006.
31. Tuck A, Albanese J. New equations for estimating stature in forensic cases. Am J Phys Anthropol Suppl 2007;44:234.
32. Tuck A, Albanese J. A new universal method for estimating stature from long bone length: but professor, what 'race' is my femur? Paper presented at the 34th Annual Meeting of the Canadian Association for Physical Anthropology; 2006 Oct 25–28. Peterborough, ON: Canadian Association for Physical Anthropology, 2006.
33. Livingstone F. On the non-existence of human races. Cur Anthropol 1962;3:279–81.
34. Lewontin R. The apportionment of human diversity. Evol Biol 1972;6:381–98.
35. Templeton AR. Human races: a genetic and evolutionary perspective. Am Anthropol 1998;100:632–50.
36. Keita SOY, Kittles RA. The persistence of racial thinking and the myth of racial divergence. Am Anthropol 1997;99:534–44.
37. Armelagos GJ, Goodman AH. Race, racism, and anthropology. In: Goodman AH, Leatherman TL, editors. Building a new biocultural synthesis: political-economic perspectives on human biology. Ann Arbor, MI: University of Michigan Press, 1998;359–78.
38. Brown RA, Armelagos GJ. Apportionment of racial diversity: a review. Evol Anthropol 2001;10:34–40.
39. Smay D, Armelagos G. Galileo wept: a critical assessment of the use of race in forensic anthropology. Transform Anthropol 2000;9(2):19–29.
40. Cartmill M. The status of the race concept in physical anthropology. Am Anthropol 1998;105:114–5.
41. Lieberman L. How "Caucasoids" got such big crania and why they shrank. Cur Anthropol 2001;42:69–95.
42. Relethford JH. Global analysis of regional differences in craniometric diversity and population substructure. Hum Biol 2001;73(5):629–36.
43. Relethford JH. Apportionment of global human genetic diversity based on craniometrics and skin color. Am J Phys Anthropol 2002;118(4):393–8.
44. Albanese J. A new metric sex determination method using the clavicle and humerus. Paper presented at the 30th Annual Meeting of the Canadian Association for Physical Anthropology; 2002 Oct 24–26. Ottawa, ON: Canadian Association for Physical Anthropology, 2002.
45. Albanese J, Saunders SR. Is it possible to escape racial typology in forensic identification? In: Schmitt A, Cunha E, Pinheiro J, editors. Forensic anthropology and medicine: complimentary sciences from recovery to cause of death. Totowa, NJ: Humana Press, 2006;281–315.
46. Hunt DR, Albanese J. History and demographic composition of the Robert J. Terry anatomical collection. Am J Phys Anthropol 2005;127(4):406–17.
47. Albanese J. Contributions of J.C.B. Grant to Anthropology. Paper presented at the 34th Annual Meeting of the Canadian Association for Physical Anthropology; 2006 Oct 25–28. Peterborough, ON: Canadian Association for Physical Anthropology, 2006.
48. Isaac B, Selvakumar V, Rajendra P, Jeyaseelan L, Chandi G. Prediction of the femoral neck-shaft angle from the length of the femoral neck. Clin Anat 1997;10:318–23.
49. Giles E, Elliot O. Sex determination by discriminant function analysis of crania. Am J Phys Anthropol 1963;21:53–68.
50. Giles E. Sex determination by discriminant function analysis of the mandible. Am J Phys Anthropol 1964;22:129–36.
51. Steele DG. The estimation of sex on the basis of the talus and calcaneus. Am J Phys Anthropol 1976;45:581–8.

52. Dibennardo R, Taylor JV. Classification and misclassification in sexing the black femur discriminant function analysis. Am J Phys Anthropol 1982;58:145–51.
53. France DL. Sexual dimorphism in the human humerus [dissertation]. Boulder, CO: University of Colorado, 1983.
54. Iscan MY, Miller-Shaivitz P. Discriminant function sexing of the tibia. J Forensic Sci 1984;29(4):1087–93.
55. Iscan MY, Miller-Shaivitz P. Determination of sex from the tibia. Am J Phys Anthropol 1984;64(1):53–7.
56. Holland DJ. Sex assessment using the proximal tibia. Am J Phys Anthropol 1991;85:221–7.
57. Holman DJ, Benett KA. Determination of sex from arm bone measurements. Am J Phys Anthropol 1991;84:421–6.
58. Marino EA. Sex estimation using the first cervical vertebra. Am J Phys Anthropol 1995;97:127–33.
59. Ousley SD, Jantz RL. FORDISC 2.0: Personal computer forensic discriminant functions [computer program]. Knoxville, TN: University of Tennessee, 1996.
60. Smith SL. Attribution of foot bones to sex and population groups. J Forensic Sci 1997;42:186–95.
61. Seidmann RM, Stojanowski CM, Doran GH. The use of the superior-inferior femoral neck diameter as a sex assessor. Am J Phys Anthropol 1998;107:305–13.
62. King CA, Iscan MY, Loth SR. Metric and comparative analysis of sexual dimorphism in the Thai femur. J Forensic Sci 1998;43(5):954–8.
63. Norušis MJ. SPSS advanced statistics student guide. Chicago, MI: SPSS Inc., 2003.

Additional information and reprint requests:
John Albanese, Ph.D.
Department of Sociology and Anthropology
401 Sunset Avenue
University of Windsor, Windsor
ON, Canada N9B 3P4
E-mail: albanese@uwindsor.ca