A72 Sex Estimation of the Modern Human Pubic Bone Using a 3D Geometric Morphometric Approach

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After attending this presentation, attendees will have gained a greater understanding of the morphological differences seen between male and female modern pubic bones and how those shape differences can be captured using a 3D geometric morphometric approach.

This presentation will impact the forensic science community by quantifying non-metric shape analyses that are widely used in sexing human pubic bones through a 3D geometric morphometric approach for analysis. Using a 3D geometric morphometric approach allows for the utilization of landmarks and semi-landmarks to accurately capture the slight shape differences that non-metric observations are unable to obtain.

Sex estimation methods for human skeletal remains have been a highly researched and debated topic in biological anthropology. A plethora of studies have been performed using various statistical methods, in part because os coxae variation spans a large spectrum and does not always fit into distinct nonmetric categories. Growing in popularity is the utilization of 3D geometric morphometric techniques; studies have been performed using landmarks and semi-landmarks to sex os coxae with a high degree of accuracy.

Generally, it is believed that male pubic bones tend to be shorter and triangular in shape, while females have a longer and squarer shape. Previous studies acknowledge the need to quantify non-metric methods while sexing os coxae, but do not specifically test the widely used non-metric visual method of sexing males on the basis of short or triangular pubic bones and females on the basis of long or square pubic bones.

In this research, 35 known male and 35 known female specimens from the William M. Bass Donated Skeletal Collection at the University of Tennessee (UT) and 24 unknown specimens from the Forensic Anthropology Unit at the New York City Office of Chief Medical Examiner (NYC OCME) were scanned using a NextEngine® 3D laser scanner. The os coxae were edited in Geomagic® and eight landmarks were placed on the left pubic bone. The landmarks were chosen to highlight the portion of the pubic bone associated with the triangular and rectangular shape differences between males and females. These points were placed on the dorsal aspect of the bone since there are fewer irregularities and span from the superior and inferior portions of the pubic symphysis, along the obturator foramen opposite the symphysis points, and up to the most superior point of the obturator foramen. The points were aligned using a Generalized Procrustes Analysis, and then a Principal Components (PC) analysis was employed to distinguish meaningful shape differences. A Discriminant Function Analysis (DFA) was then run on the PC scores to determine how accurate the captured portion of the pubic bone is in determining sex. The known specimens were placed in their proper sex categories for the DFA analysis, while the unknown specimens were left ungrouped to compare the non-metric analyses of those os coxae found in their case reports versus their assigned group in the DFA analysis.

Using the 12 PC scores that contained significant shape information, the DFA analysis was able to classify 95.7% (94% males, 97% females) of the known UT pubic bones correctly into their skeletal sex groups with a 92.9% (91% males, 94% females) leave-one-out cross-validation accuracy. For the unknown NYC OCME specimens, 83.3% of the specimens matched their case reports. Intra-observer error was tested by placing the landmarks on the specimens a second time and running the same analyses. The results were an original classification accuracy of 97.1% (94% males, 100% females), a cross-validation accuracy of 91.4% (86% males, 97% females), with 87.5% of the unknown specimens matching their case reports. The differences in percentages between these two analyses are slight and the changes were due to specimens that fell within the overlapping regions found on the PC plots.

The results capture the major morphological differences between male and female pubic bones. These differences match the non-metric categories of a triangular shape in males and a square shape in females, which were found on the first PC, but it also captures 11 other significant PC variations that cannot be observed from visual assessments. This experiment has high accuracy results and can be a good categorization method for unknown specimens in future studies.

Geometric Morphometrics, Sex Estimation, Discriminant Function Analysis