## A94    An Assessment of Sexual Dimorphism in the Sternal Fourth Rib:    A 2D Morphometric Approach

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After attending this presentation, attendees will be informed about the presence of measurable sexual dimorphism in the contours of the superior and inferior margins of the sternal two centimeters of the fourth rib.

This presentation will impact the forensic science community by providing data suggesting that the shape of the sternal end of the fourth rib has the potential to be used in the estimation of sex from isolated ribs. In turn, this finding would allow for the construction of biological profiles for unknown decedents for whom more traditional skeletal indicators of sex (e.g., cranium and os pubis) are damaged or unavailable.

This research was conducted using the Hartnett-Fulginiti collection housed at the Forensic Science Center in Maricopa County, AZ. This collection is comprised of more than 600 specimens of pubic symphyses and associated sternal ends of the fourth ribs from decedents of known sex, age at death, and ancestry. Two hundred individuals (100 males, 100 females) were randomly selected from the collection for analysis. Specimens were positioned so they were level and photographed with a scale. Where possible, left fourth ribs were utilized. When left rib ends were damaged or otherwise unavailable, right rib ends were photographed and the resulting digital image was mirrored in order to match the orientation of the left rib images. Specimens that were damaged or less than 2.5cm in length were removed from the analysis, resulting in a final sample size of 140 individuals (70 males and 70 females) ranging from 18 years to 93 years of age.

Each image in the final sample size was calibrated using the photographed scale and a suite of 40 landmarks were digitized at approximately 1.0mm intervals beginning at the edge of the sternal pit and extending for a length of 2.0cm along the contours of both the superior and inferior margins of the rib. Actual interval markings ranged between 0.97mm and 1.03mm due to software and image resolution limitations. Landmark data were then subjected to a Generalized Procrustes Analysis (GPA) to investigate differences in shape between male and female sternal rib contours. As GPA removes the effects of size, location, and rotation within landmark configurations, it should negate the effects of body-size dimorphism and allow for the direct comparison of sternal rib shape between males and females. The resulting Procrustes coordinates were then subjected to a principal components analysis and component scores were evaluated for evidence of sexual dimorphism.

Results indicate that there are significant differences between males and females in regard to their first Principal Component (PC1) scores ($t$=11.326, $v$=138, $p$-value <2.2e-16). In this analysis, PC1 accounts for 57.8% of the total variation in shape and represents (in females) a constriction of the rib shaft near the sternal end as well as an overall more elongate shape to the sternal 2cm of the fourth rib. In contrast, males typically lack such a sternal constriction and exhibit a broader sternal rib morphology, resulting in a slightly flared appearance. These differences are confirmed by a Discriminant Function Analysis (DFA), the results of which indicate a Procrustes distance between male and female landmark configurations of 0.093 and a Mahalanobis distance of 4.045, both of which are significant ($p$-value <0.0001 as determined by permutation tests using 1,000 iterations). Moreover, the results of a leave-one-out cross-validation of the DFA resulted in a 21.4% misclassification rate for females and a 22.8% misclassification rate for males. Decreasing the number of utilized landmarks to 30 increased the percentage of total shape variation accounted for by PC1 to 58.9% and resulted in improved misclassification rates produced by cross-validation (17.1% for females and 20.0% for males).

These results suggest that meaningful sexual dimorphism exists in the shape of the sternal fourth rib and that it may be profitably employed in the estimation of sex for unknown decedents, especially in situations in which more commonly used techniques cannot be employed.

**Fourth Rib, Sex-Estimation, Morphometrics**

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