

A39 Estimating Sex With Outline Shape Analysis of the Trochlear Constriction and the Olecranon Fossa

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The goal of this presentation is to demonstrate that using statistical modelling combined with outline shape analysis accomplishes a more accurate and unbiased sex estimation of the distal humerus than the non-quantitative visual assessment methods commonly used.

This presentation will impact the forensic science community by introducing attendees to a revised method for estimating the sex of an individual by using the distal humerus while turning the geometric morphometrics approach into a more accessible and easier-to-utilize interactive online application that allows users to control the principal component parameters.

Forensic anthropologists are often asked to establish a biological profile of human remains. Regularly, the skeletal remains are very damaged and the bones commonly used for sex estimation cannot be consulted. Fortunately, the distal aspect of the humerus is usually relatively well preserved due to its compact morphology. Therefore, this research will be particularly useful to researchers working with fragmented remains.

Several studies have investigated whether it is possible to estimate the sex of an individual by examining the distal humerus. A method using visual assessment of the morphology was developed by Rogers, with average accuracies ranging from 74%-91%.¹ Tests of this method in different populations have correctly classified 74%-82% of the individuals.²⁻⁵ An attempt at a landmark-based geometric morphometrics reinterpretation of the method by Vance and Steyn reports accuracies between 78%-91%.⁶

A total of 80 female and 71 male humeri were analyzed using the 21st-Century Identified Skeletal Collection at the University of Coimbra (CEI/XXI) in Portugal. For this preliminary study, only the left humeri were evaluated. All specimens were photographed in a standardized position from the posterior view by placing the subject on a flat table and the camera directly above the olecranon fossa.

Using TPSdig2, a software program used for landmarks and outline digitization, an open curve and a closed outline were marked.⁷ The first evaluated the constriction of the trochlea, with the curve reaching from the most medial inferior aspect to the most lateral inferior aspect of the trochlea. The second described the outline of the olecranon fossa and was recorded clockwise, starting from its most inferior aspect.

All the analyses were performed using the R programming language and the Momocs package developed by Bonhomme et al.^{8,9} All coordinates were superimposed using Generalized Procrustes Analysis (GPA) as first proposed by Gower.¹⁰ GPA allows multivariate statistical analyses on the shape of objects. This is possible, since GPA can superimpose shapes by iteratively rotating, translating, and scaling them until a consensus is reached.

Using 16 sampled points, natural six-degree polynomials fits were calculated for the open curve of the Trochlear Constriction (TC). An elliptical Fourier transformation was used to analyze the closed outline of the Olecranon Fossa (OF). This retained 99% of the harmonic power, which, in this case, resulted in six harmonics. Next, both sets of data were processed with the same statistical algorithms. Principal Component Analysis (PCA) was used to reduce the dimensionality of data and to visualize the morphospace.

Subsequently, Linear Discriminant Analyses (LDA) models were created using the principal components to estimate the sex from shape configurations. These classification models were trained on a $K=n-1$ cross-validation scheme to avoid overfitting.

After selecting the best predictive model, it was implemented into a web app, which was developed using the Shiny package for R.¹¹ This follows the recent trend in forensic anthropology, which attempts to make complicated statistical models more accessible and easier to utilize through interactive online applications.¹²⁻¹⁴

The two shape configurations exhibited strikingly different degrees of sexual dimorphism when evaluated using LDA with leave-one-out cross-validation. The trochlear construction performed poorly, with only 60.9% of the individuals being attributed to the correct sex; however, the olecranon fossa exhibited high sexual dimorphism, and the LDA model presented an accuracy rate of 92.1%. Thus, this character alone, using outline-based morphometrics, performs better than the combination of all four features of the visual assessment method proposed by Rogers.

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