## H96 Ancestry Estimation From the Tibia: Size and Shape Differences Between American Whites and Blacks

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After attending this presentation, attendees will become familiar with size and shape differences between American Black and White tibiae. Attendees will also be provided with measurements that offer the highest discrimination between these two groups.

This presentation will impact the forensic science community by providing criteria for determining ancestry from the tibia.

**Background:** As the United States becomes more of a melting pot, ancestry estimation is an increasingly challenging task for forensic anthropologists. Consequently, gathering ancestry information from multiple skeletal elements can augment assessments based on cranial morphology. While significant ancestral differences exist in cranial dimensions, shape differences are substantial, as well. In addition, researchers have documented ancestry differences in the lower limb, focusing primarily on the pelvis and femur. Stewart (1962) suggested that American Black femora are straighter and less torqued than White femora. In addition, Trudell (1999) reported significant differences in length, curvature, epicondylar breadth, and torsion between American Blacks and Whites. Intercondylar notch height has been shown to be a useful discriminator, as well (Craig, 1995; Gill, 2001). The primary morphological difference in the innominate is that American Whites have wider hips than Blacks (Iscan, 1983; DiBennardo and Taylor, 1982, 1983).

These and other studies have captured size and shape differences in the hip and thigh, but few studies have addressed the leg. Since the lower limb is a functional anatomical unit, it follows that the morphology of the upper leg should influence the form of the lower leg. In fact, only one article has addressed ancestry differences in the tibia in the American population, noting differences in length, width, and proximal breadth between Blacks and Whites (Farrally and Moore, 1975). The present study aims to address the need for documentation of metric and geometric morphometric ancestry differences in the tibia in the modern American population by using three-dimensional bone modeling and automated measurements from computed tomography (CT) scans.

**Methods:** A sample of 112 American Black and White males from the William M. Bass Donated Collection was used for this analysis. The DICOM image slices from the CT-scanned tibiae were manually segmented, and three-dimensional models were constructed of the right tibiae. A subset of the models was used to create ancestry-specific statistical bone atlases. A statistical atlas is an average mold that captures the primary shape variation in the bone and facilitates rapid and accurate generation of automated measurements. The final result is a sample of tibiae that all contain the same number of points and share the same spatial relationship.

Shape analysis was conducted by performing Principal Components Analysis on the atlases to reduce the data space and then using Fisher's Discriminant Ratio to pinpoint the areas of greatest difference. The resulting deviation vector magnitudes were subsequently applied to a color map in order to visualize the areas of greatest difference. Metric differences were evaluated by taking 28 computer-automated measurements on all of the bones in the atlases. These measurements include traditional measures of length and robusticity, as well as measurements of the intercondylar eminences, tibial plateau dimensions, cross-sectional areas of the midshaft, proximal shaft, and distal shaft, and indices and angles designed to capture information about shape, torsion, and position of bony landmarks. T-tests, power tests, and linear discriminant analysis (LDA) with cross-validation and stepwise variable selection was performed on the measurements.

**Results:** The shape analysis of principal components 2-10 (95% of variation) shows relatively low magnitudes of difference in tibial shape between American Blacks and Whites. The area of highest difference is at the tip of the medial malleolus. -tests reveal that the there are significant differences in length and shaft robusticity (reflected by diameters and cross-sectional areas of the middle, proximal, and distal shaft). American Blacks have longer tibiae, larger antero-posterior and medial-lateral shaft dimensions, and larger cross-sectional areas. These results confirm Farrally and Moore's (1975) earlier study. The cross-validated LDA attained 78.6% accuracy with a 6-variable model; Blacks were misclassified more often than Whites. This could be an artifact of the smaller Black sample, but the authors hypothesize that it reflects the phenomenon that American Black skeletal morphology is becoming more similar to the American White morphology. These results indicate that the tibia is useful in ancestry estimation, but that the major differences are due to size, not shape. Combining tibia and femur measurements may offer discriminatory power approaching that of the cranium.

**Ancestry Estimation, Tibia, Discriminant Analysis**