# A99 Estimation of Age-at-Death Using Femoral Cortical Thickness, Biomechanical, and Histological Variables

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After attending this presentation, attendees will see that standardized locations of the adult human femoral midshaft lose cortical thickness differentially with increasing age. Discovery of a uniform pattern of bone loss among this variability may allow for production of age-at-death estimates from unidentified skeletal remains.

This presentation will impact the forensic science community by eliminating a method proposed to utilize multiple types of femoral midshaft cross-sectional data to produce age-at-death estimates from unidentified adult human skeletal remains.

Literature review indicates that once the femur is fully developed, biomechanically adapted, and periosteally adjusted, a net loss of cortical bone begins as the amount of bone deposited on the periosteal surface lessens in comparison to the amount of bone removed from the endosteal surface. Decreasing bone gain on one surface and increasing loss from another changes the size, shape, and strength of the femur throughout adulthood.

To determine whether differential cortical bone loss occurs that can be exploited for production of age-at-death estimates, cortical thickness data was collected from 16 standardized locations (0º (anterior), 22.5º, 45º, 67.5º, 90º (medial), 112.5º, 135º, 157.5º, 180º (posterior), 202.5º, 225º, 247.5º, 270º (lateral), 292.5º, 315º, and 337.5º) around each of 200 adult femoral midshaft cross-sections originally harvested by M.F. Ericksen from George Washington University (GWU) dissecting room cadavers. The sample was composed of 97 males and 103 females largely of European descent, ranging in age from 30 years to 97 years (mean=71 years, standard deviation=12 years).

Results indicate median cortical thickness differs significantly around the femoral midshaft (X2(15)=609.567, $p$ <0.0005). Specifically, post-hoc pairwise comparisons discovered 71 statistically significant differences between median cortical thicknesses ($p \leq 0.05$). From these results, a general pattern emerges where the smallest median cortical thicknesses occur in the anteromedial and posterolateral quadrants of the femoral midshaft, while the anterolateral quadrant possesses all of the largest cortical thicknesses, with the one exception of the posterior 180º location — the linea aspera. Additionally, Pearson and Spearman's rank order correlations found moderately negative statistically significant correlations between age and all cortical thickness locations, with the highest grouped among the anterior, anteromedial, posterior, and posterolateral femoral cortices, and lowest among the medial and lateral femoral cortices. This finding, combined with locally weighted scatterplot smoothing curves of the data, suggests cortical thickness is not lost uniformly with age; rather, the anterior and posterior cortices lose more thickness beginning earlier than the medial and lateral cortices.

An age-predicting linear regression equation utilizing all cortical thickness location data revealed Standard Error of Estimate (SEE) and adjusted R2 values (±10.82 and 0.1957, respectively) comparable to those produced using standard histological methods. Unexpectedly, equations composed from only anterior and posterior cortex data did not perform superiorly. Rather, the best performing equation, Age=89.18+(1.99×135º)+(-2.08×157.5º)+(-3.66×225º), revealed similar SEE and adjusted R2 values (±10.58 and 0.2314, respectively). This equation was tested on an independent sample of 22 femoral midshaft cortices obtained from The Ohio State University Department of Anatomy. Comparison of known ages at death to point age estimates revealed inaccuracies as high as 40 years.

Given these results, previously collected biomechanical and histological data were additionally included to determine what combination of cortical thickness, biomechanical, and histological variables was associated with the lowest SEE and highest adjusted R2 value. The best performing equation, Age=96.10+(-7.49×Ix/Iy)+(-3.67×225º), again produced a high SEE and poor adjusted R2 value (±10.58 and 0.2307, respectively).

Overall, these findings reinforce how femoral midshaft variables primarily reflect mechanical environment regardless of age and suggest there is too much variation in mobility among modern humans for femoral shape, thickness, or remodeling data to be useful indicators of age at death, in any combination.

**Age-at-Death, Cortical Thickness, Multiple Linear Regression**