A144 An Analysis of Computerized Tomography (CT) -Derived Bone Density Values and Volumetrics for Age and Sex Estimation From the Proximal Femur

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After attending this presentation, attendees will understand how the application of Hounsfield Unit (HU) values and the 3D volume of the proximal femurs can assist in the estimation of age and sex. Attendees will also gain a deeper understanding of how 3D models can contribute to forensic identification, even in fragmentary remains.

This presentation will impact the forensic science community by: (1) providing the results of a methodology that will assist in the forensic analysis of age and sex estimation; (2) enhancing existing research of osteological materials by adding data of a living modern American sample of the proximal femur *in situ*; and, (3) providing insight into the age-related decline of bone density and explaining how the HU values can be used as a predictor for age with an average accuracy of ±10 years. The total volume of the proximal femur can be used with a 94% accuracy in estimating an individual's sex.

The confirmation of identification for an unknown individual is a critical part of forensic practice. The age and sex of an unknown individual are key components in establishing a biological profile. Previous studies utilizing the 2D projections of the proximal femur derived from Dual X-ray Absorptiometry (DXA) estimated sex with a 90%–91.7% accuracy; however, the usefulness of bone density as an age estimate was not examined.[1] The purpose of this study was to determine if the average HU value of the proximal femur derived from CT can be a reliable method to estimate age in an unknown individual. Additionally, this study examined the effectiveness of volumetric quantification of 3D CT-derived proximal femurs to capture sexual dimorphism for the estimation of sex.

The University of South Florida (USF) Health Department of Radiology maintains an anonymized research database of all patient image data collected from 2009 to the present. A series of 200 femurs were acquired from abdominal-pelvic CT scans from living patients. The dataset consisted of 100 males and 100 females. Ages ranged from 18-90 years and were distributed evenly between the sexes. Any individuals with documented pathologies, implants, or clear surgical intervention were excluded from the study. Models of the proximal femur were initially isolated in a modeling software package using a threshold of 226–1,577. The medullary cavity and spongey bone of the femoral head were filled in via hand segmentation. The region of interest was limited from the femoral head to just inferior to the greater trochanter, cut 90° to the long axis of the femur.

For the statistical analysis, a paired *t*-test was run comparing the left and right proximal hip average HU (p=0.2) and volume (mm^3) (p=0.57). No statistical differences between sides were found. A stepwise analysis was used to construct a linear regression model for age estimation. A stepwise analysis was also used to perform discriminant function analysis, which was used to assign sex. All measurements with a $P < 0.05$ were considered statistically significant.

The results of the stepwise linear regression model revealed only the HU average was significant in model creation for age estimation ($p < 0.001$), with an R^2 of 0.63. The resulting model can be used as a predictor for age with an average accuracy of ±10 years. The results for the discriminant function analysis for sex estimation determined the proximal volume was the only relevant predictor with an overall 94% grouping cross-validated accuracy. Females were placed with a 100% accuracy. Males were placed with an 88% accuracy.

With the increasingly widespread use of postmortem CT (PMCT), there is an opportunity to utilize 3D volumetrics and bone density as tools for quick identification. The use of HU values as an age estimator should be limited to freshly deceased or fragmentary remains with soft tissue; however, the use of the proximal femur as a sex estimator can be utilized in any setting from the living to dry bone. The accuracy of the sex estimation found in this study reinforces the distinct dimorphism between sexes while also providing forensic practitioners more tools of analyses. The use of proximal femoral volume as a sex estimator need not be limited to CT scans but can also be used in laser surface scanning or photogrammetry.

Reference(s):

1. Curate, Francisco, Anabela Albuquerque, Izilda Ferreira, and Eugénia Cunha. 2017. Sex estimation with the total area of the proximal femur: A densitometric approach. *Forensic Science International.* 275:110-116.

CT, Age Estimation, Sex Estimation

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