H83 Stature Estimation Utilizing the Crural Index

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After attending this presentation, attendees will have a greater understanding of how body proportions, specifically the crural index, can be used as a categorical variable to group reference data in stature estimation models, which can be an effective alternative to population-based models.

This presentation will impact the forensic science community by introducing a new perspective on stature-estimation models which highlights the utility of body proportions as categorical grouping variables instead of race.

Stature estimation from an unknown individual is ideally derived from a model based on an appropriate reference population. In general, population-based stature-estimation models produce a more accurate point estimate, a narrow prediction interval, and a higher R2 value indicative of a tighter grouping of the reference data along the regression line. However, myriad circumstances exist where even population-based models either cannot be used in cases where ancestry cannot accurately be deduced or the model is derived from a sample that is antiquated, has an inadequate sample size, or does not accurately represent the diversity evident in the true population. Populations are ever-changing entities, both in terms of the volatility of their culturally based definitions as well as the susceptibility of their underlying genetic structure being influenced by stochastic events. As we become increasingly aware of these issues it is important to explore and evaluate the potential of other methods that have a more inherent biological foundation. This is the aim of the method proposed in this presentation, as it utilizes the crural index (tibia XLN/femur XLN) as a categorical variable in place of populations in regression analyses estimating stature from the maximum length of the femur (XLN). The crural index is often cited as an example of Allen's rule and exhibits strong geographic patterning.

This research uses three sample populations, White (n=113), Black (n=52), and Chinese (n=48), with known statures and recorded femur XLN to create the regression equations for analysis. The White and Black sample populations were from a reference dataset for osteometric sorting created by Dr. Byrd and Dr. Adams.[1] The Chinese data is from Stevenson.[2]

Three different models were created to test the utility of the crural index as a grouping mechanism to better estimate stature. All of the models are based on grouping of individual samples based on their crural index, with the group boundaries determined three different ways, all based on the standard deviation of the sample population as a whole. The first model, MeanGr, contains two groups, one containing individuals with crural indices lower than the mean, and the other with indices greater than the mean. The second model, CenterSDGr, designates three groups based on centering the standard deviation around the mean. The third model, MeanSDGr, contains four groups with the cutoff values being one standard deviation below the mean, the mean, and one standard deviation above the mean. Each crural index model was compared to the model containing all samples, as well as models for each population within the sample, representing the population-based stature methods that are widely used in forensic anthropology.

Descriptive statistics were produced for each model; the analysis of variance revealed all models were significant ($p<0.001$). A regression analysis was conducted for each group within each model. The adjusted R2 values for the population-based model ranged from 0.882 for the Black group to 0.638 for the Chinese group, with the White group at 0.765. The adjusted R2 values for the MeanGr are 0.778 for Group 1 and 0.779 for Group 2. The adjusted R2 values for the CenterSDGr are 0.815 for Group 1, 0.759 for Group 2, and 0.731 for Group 3. The adjusted R2 values for the MeanSDGr are 0.872 for Group 1, 0.740 for Group 2, 0.809 for Group 3, and 0.693 for Group 4. Prediction intervals were also calculated in accordance with Giles and Klepinger, along with standard errors, as additional means to evaluate these models.[3] This research demonstrates that stature-estimation models based on the crural index can be an effective alternative to population-based models.

References:

1. Byrd JE, Adams BJ. Osteometric sorting of commingled human remains. J Forensic Sci 2003;48:717-23.
2. Stevenson PH. On racial differences in stature long bone regression formulae, with special reference to stature reconstruction formulae for the Chinese. Biometrika 1929;21(1): 303-21.
3. Giles E, Klepinger LL. Confidence intervals for estimates based on linear regression in forensic anthropology. J Forensic Sci 1988;33(5):1218-22.

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