A108 Variations in Skeletal and Dental Growth and Development Patterns and Their Effect on Age Estimation: A Preliminary Study of Five Populations

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Learning Overview: After attending this presentation, attendees will understand the effects of genetic and environmental factors on skeletal and dental growth and development patterns and if these factors can affect resulting age estimates.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by participating in the debate on global versus population-specific methods for subadult age estimation and by increasing knowledge regarding the effects of genetics and the environment on age estimates.

Skeletal and dental indicators of growth and development, such as bone measurements, epiphyseal fusion stages, and dental development stages, are widely used for subadult age estimation in forensic anthropology. However, these age indicators can present with different patterns among different groups, as they are influenced by various genetic and environmental factors. Consequently, children of the same age from different populations may present different values for these indicators, which can lead to misinterpretations of age, sometimes with serious legal consequences. Because variation increases with age, the risk of error increases with age, especially from late childhood onward. This study seeks to qualify the differences in skeletal and dental growth and development patterns between five different populations characterized by different origins and Socio-Economic Status (SES) and evaluate the impact of these differences on age estimation.

Diaphyseal and pelvic dimensions, epiphyseal fusion stages, and development stages of the permanent dentition were collected from approximately 2,000 contemporary children between birth and the age of 15 years. Two countries, Colombia and South Africa, are considered to be of low SES (i.e., high Gini Coefficient), and three countries, France, the Netherlands, and the United States, are considered to be of high SES (i.e., low Gini Coefficient). Differences between growth and development patterns were assessed using simple visualizations (boxplots and scatterplots) for each indicator and population. A hierarchical modeling approach was employed to account for variability at different levels (i.e., within-country and between-country). The Hierarchical Linear Model (HLM) enables us to examine whether different environments (different countries in the data) would influence the relationship between age and the indicators. Age estimates were derived from a Bayesian mixed probit model. Models were built for all populations pooled and separated according to three life history age groups: birth to 3 years, 3 to 7 years, and 7 to 12 years. Accuracy was measured as the difference between estimates and true chronological age.

Diaphyseal growth shows a similar growth pattern in all groups, but the HLM models identified differences among the populations. Boxplots of dental development and age show country-level differences; children from higher SES countries present with earlier dental development than Colombian or South African children. HLM models corroborate the visual comparison; each country presents with a unique slope and intercept. These differences seem to point to a population-specific approach rather than a universal approach for age estimation. While growth and development indicators were statistically different in the HLM model, the resulting 95% confidence intervals generated for each country-specific Bayesian mixed probit model overlapped and the pooled sample presents with low overall root mean squared error values. Based on these findings, it seems possible to use a global approach. However, the reference samples chosen to inform the model should ideally be similar in population history and economic status.

Indicators with the highest predictive power retained in the life-history models mirror the ongoing sequence of growth and development activity in accordance with age. These indicators are femoral, tibial, and humeral diaphyseal lengths and first mandibular molar stages during the first life history stage; femoral diaphyseal length and second maxillary molar stages during the second life history stage; and femoral diaphyseal length during the third life history stage and in the model with all ages combined. This study demonstrates that accurate age estimates can be obtained for subadults using multivariable models based on skeletal and dental data, independent of their population of origin.

Growth Patterns, Mixed Probit, Socio-Economic Status