EVALUATION OF REGRESSION EQUATIONS USED TO ESTIMATE AGE AT DEATH FROM CRANIAL SUTURE CLOSURE

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During a skeletal analysis, age at death is one of the primary components of the biological profile that the forensic anthropologist constructs. The study of cranial suture closure and its relationship with age dates back to the 16th century. However, since that time and continuing into the present, there have always been doubts about the applicability of suture closure to age estimation. Even with this skepticism, researchers continue to examine suture closure as an indicator of age at death. Most recently, Nawrocki (1998) introduced 14 regression equations to estimate age using cranial suture closure. Testing of the performance of these equations as well as their applicability as age estimators has been limited. This study examines 6 of the regression equations (Equations 1, 2, 3, 4, 7, and 8) created by Nawrocki using a new sample of recently-deceased individuals. This test sample contains 388 individuals (121 females, 267 males) of European ancestry. The majority of the test sample is derived from documented skeletal collections curated by the University of Tennessee and the Maxwell Museum at the University of New Mexico. A small percentage of individuals were forensic cases processed by the University of Indianapolis Archeology and Forensics Laboratory.

Up to 31 landmarks were scored on each specimen in the test sample: 18 ectocranial (external) surface, 7 endocranial (internal) surface, 2 facial, and 4 from the palate. Following Meindl and Lovejoy (1985), one-centimeter segments along the cranial sutures were scored from 0 to 3, where 0 is no closure, 1 is 1-50% closure, 2 is 51-99% closure, and 3 is complete obliteration of the suture. The palatal sutures were scored following Nawrocki's guidelines. Kendall's and Pearson's correlation matrices were calculated and compared to values obtained from Nawrocki's Terry Collection sample. Age was estimated for each individual using up to 4 different equations: 2 general equations and 2 group-specific equations (e.g., all females, European females, etc.). Inaccuracy and bias statistics were calculated for each equation to assess its performance. The percentage of individuals whose estimated ages fell within each equation's ± 1 and ± 2 standard error intervals was also calculated. An analysis of covariance (ANCOVA) was used to determine if suture closure is influenced by an individual's sex. Then the sample was culled to create an even distribution by age and the statistical analyses were repeated. This procedure was conducted in order to correct for any biases caused by a different mean age at death for the test sample when compared to Nawrocki's original Terry sample.

The correlation matrices show that correlation strength is dependent on sex and suture location. Inaccuracy was greater for both the original and culled test samples when compared to Nawrocki's published values. Bias ranged from 1.31 to –17.07 years and tended to be negative, indicating systematic underestimation of age. However, these error rates decreased when culling the sample to more closely match the mean age of Nawrocki's Terry sample. The ANCOVA results suggest that summed suture score is influenced by sex. Of the 6 equations tested, the 2 general all group equations (Equations 1 & 2) performed best, followed by Equation 4 (all males). However,

overall, the original equations work relatively well and can play a role in age estimation in modern American populations. In conclusion, cranial suture closure does correlate with age and sex influences the pattern and/or rate of suture closure, although the effects of sex are not so great that they preclude one from combining the sexes into a single equation. Also, while the modern sample is more variable (making age estimation less accurate), there seem to be no systematic secular trends that would prevent the use of Nawrocki's (1998) equations on modern individuals from forensic contexts. This study reaffirms the need to carefully control the reference samples used to test age estimation methods.

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