



Anthropology Section - 2015

A29 Vertebral Maturation in Age Estimation: Further Testing the Revised Method of Scoring the Timing and Progress of Epiphyseal Ring Union

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After attending this presentation, attendees will gain a more in-depth understanding of the pattern, sequence, and timing of vertebral ring union for the cervical, thoracic, and lumbar vertebrae. The revised method of scoring epiphyseal ring union and the relationship with age-at-death was further explored on a known skeletal sample. Findings from this study may be used to corroborate information from other skeletal age indicators to more accurately estimate age-at-death in cases of unknown identity.

This presentation will impact the forensic science community by explaining how vertebral maturation correlates with age-at-death when using the revised method of scoring the progress of epiphyseal union of the superior and inferior vertebral centra (or “ring” epiphyses). Results of this study may potentially aid in the determination of skeletal age-at-death for pre-teenagers up through young adults which, when considered in conjunction with other skeletal age indicators, may improve the accuracy of age estimation in human identification.

The progress of union of the superior and inferior ring epiphyses of the vertebral centra was documented for the pre-sacral vertebral column, where applicable (i.e., C2 inferior, C3-C7, T1-T12, L1-L5) from a sample of 54 females and 38 males, ages 10 to 30 years at death, from the Lisbon Collection, National Museum of Natural History (Bocage Museum), Lisbon, Portugal.

Epiphyseal union was documented using the revised five-stage method: (1) Stage 0: no fusion, bare centrum; (2) Stage 1: partially fused ring, sections fused and unfused, gaps present; (3) Stage 2: complete fusion, clear demarcation between ring and centrum, no gaps but possibly a groove, no remodeling; (4) Stage 3: complete fusion, ring edges are melded with centrum, a slight groove may be seen in some areas but centrum is fully remodeled in other areas; and, (5) Stage 4: complete fusion, ring edges are melded with centrum, bone is remodeled with no grooves. This modified five-stage scoring method focuses on the distinction between differing appearances of complete union, mainly where complete union may present with or without a groove, indicating that remodeling has not or has occurred.

Spearman’s rank correlation coefficients indicated a relatively high positive (and significant, $p < 0.05$) relationship between vertebral ring union mean values and age at death, $r_s = 0.90$. High positive and significant ($p < 0.05$) correlations were also found when each vertebra type was analyzed distinctly (i.e., cervical, thoracic, and lumbar), for sexes combined, and for the female and male samples separately, ranging from $r_s = 0.84-0.92$.

The sample was then divided into five age groups, sexes combined, to gauge the progression of union: (1) Group 1: 10 to 13 years of age; (2) Group 2: 14 to 17 years of age; (3) Group 3: 19 to 21 years of age; (4) Group 4: 22 to 25 years of age; and, (5) Group 5: 26 to 30 years of age. Analysis of Variance (ANOVA) and most paired samples t-test results showed no significant differences in vertebral ring union mean values between age groups, with sexes combined and when sexes were tested separately, which could be an effect of small sample sizes. Noteworthy were the raw data observations that provided insights into the subtle patterns and progression of vertebral ring union. Specifically, union began as early as 11 years of age in both females and males for each vertebra type — this is earlier than previously shown; prior samples did not include many individuals as young as 10 years of age. Union was complete in all vertebrae (all vertebrae Stage 3 or 4) at 18 years of age for females and 21 years of age for males. Stage 3 persisted up through 30 years of age in both sexes. Stage 4, complete union with remodeling, was first evident in females at 18 years of age for all vertebra types and for males at 20, 21, and 17 years of age for cervical, thoracic, and lumbar vertebrae, respectively.

Findings from this study may be used to either support information from other skeletal age indicators or provide a general guideline for estimating age-at-death if only vertebrae are recovered in forensic cases.

Vertebral Maturation, Epiphyseal Union, Age Estimation