H77 Osteometric Analysis of the Vertebral Column

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After attending this presentation, attendees will have a greater understanding of the relationship of measurements within a vertebral column, as well as, the relationships and correlations of those measurements with other postcranial elements.

This presentation will impact the forensic science community by introducing the utilization of novel measurements for osteometric analysis.

The Joint POW/MIA Accounting Command's Central Identification Laboratory (JPAC-CIL) is analyzing a heavily commingled skeletal assemblage that was unilaterally turned-over to U.S. officials from North Korea. Prior to their turnover, the remains were manipulated in such a way as to appear as single individuals, but gross observations detected major discrepancies. Multiple rounds of mtDNA sampling were conducted in order to sort major elements. Now, in addition to the mtDNA results, analysts use a variety of tools including osteometric sorting, pair matching, articulations, taphonomic and radiographic comparisons to sort the remains. These methods are very useful for sorting the major elements, but are not used as often with the association of vertebrae. In this context, a vertebral column can be associated with a set of remains if a single vertebra in a column segment is cut for mtDNA and yields a valid sequence, or if the column is continuous and has a terminal end that articulates with a major element. However, isolated vertebra and fragmentary columns are much more difficult to associate to individuals or combine.

The purpose of this research is to determine how well a metric analysis classifies a vertebra within a column and how well vertebrae correlate with one another and other postcranial elements within an individual in order to determine the associative value of these measurements and analyses. The sample consists of 19 intact vertebral columns of unknown race, sex and age, sixteen of which have associated postcranial remains. Twelve to eighteen discrete measurements were taken per vertebra throughout the entire vertebral column. Canonical discriminant function analyses were conducted to evaluate the classification and discriminating powers of the combined measurements of vertebrae within a column. In the primary analysis, all of the compatible measurements (14 distinct variables) for C3 through L5 were utilized. Wilks' lambda was significant in the testing of the first seven iterations of discriminant functions ($\lambda = 0.000$, $df = 308$, $p < 0.001$, based on functions 1 through 14 and $\lambda = 0.518$, $df = 128$, $p < 0.001$, based on functions 7 through 14). The first fourteen canonical discriminant functions were used in the analysis and the first four of those functions account for 95% of the variation, with the first accounting for 64%. The variables that are the most correlated with this discriminant function and therefore the most discriminating are related to the vertebral centrum. The classification results for predicted group membership revealed 76.1% of the original grouped cases were classified correctly, and 58.0% of the cross-validated grouped cases were correctly classified. The discrepancy is due in large part to the small sample size. The overall results of the canonical discriminant function analyses reveal that it is best to run the analyses using the optimum number of variables that are the most significant and highly correlated. The level of inter observer error was evaluated for the vertebral measurements by comparing the differences in the measurements of a single column between analysts. Overall the error was minimal (<1 mm), but the error in the pedicles was less than 2 mm.

The vertebral measurements correlate with other postcranial measurements to varying degrees. Several significant correlations (as determined in a bivariate correlation matrix using Pearson's correlations with a p value < 0.001) between appendicular elements and vertebrae were assessed using linear regressions. The purpose of this analysis was to test the null hypothesis that isolated vertebrae are similar enough in size to other isolated elements to have derived from the same individual. This method was tested on a fragmentary vertebral column, and was found to have good potential for sorting vertebrae within a commingled assemblage. The development of this method for correlating vertebrae could serve two purposes when sorting comingled remains: it provides supplemental data for associating unarticulated vertebrae and has potential to provide a size range for each measurement that can be searched within a database developed for the assemblage.

Osteometric Sorting, Postcranial Measurements, Vertebrae

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