A75 A Large-Scale Evaluation of Intraperson Isotopic Variation Within Human Bone Collagen and Bioapatite

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Learning Overview: After attending this presentation, attendees will have an in-depth understanding of the intraperson variation of Carbon (C) and Nitrogen (N) isotopic compositions of human bone collagen and C and Oxygen (O) isotopic compositions of human bone apatite. Forensic interpretative values for determining different individuals from isotope results will be presented.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by improving understanding of how isotope values of collagen and bioapatite vary within an individual.

Isotopic compositions of human tissues, such as bone or tooth enamel, are tied to diet or drinking water sources, thus allowing investigators to predict geographic origin of an unknown individual.[1] Some organizations, including the Defense POW/MIA Accounting Agency (DPAA), use isotope testing as a part of identifying unknown human remains. Isotope testing has multiple positive down-stream effects, such as limiting DNA testing and potentially separating commingled human remains.

Separating commingled human remains via isotope analysis is particularly important as mitochondrial DNA (mtDNA) can be shared between multiple individuals. For example, one DPAA commingled group has a skeletal Minimum Number of Individuals (MNI) of 23 individuals that all have similar mtDNA sequence information; to segregate them, additional full genome or autosomal DNA testing is necessary. Since autosomal DNA testing may fail half of the time for any one sample, other avenues are needed to solve this problem. Isotopic variation between individuals could potentially be used, but first we must determine what forensically meaningful intraperson variation is for each isotope and bone component.

The first widely cited "intra-individual" isotopic variation study was completed on rabbits and minks fed a monotonous diet.[2] This study concluded that the δ^{13}C and δ^{15}N values of a single bone will be within 1‰ of the values obtained from other bones from the same individual, or from other individuals eating the same diet (to include humans). Since that 1983 publication, few other studies have explored this topic and only recently with human bone. Olsen et al. found that the maximum intraperson variation from four bones in six individuals was 0.6‰ for δ^{13}C values and 1.6‰ for δ^{15}N values, with a mean variation of 0.2‰ and 0.8‰, respectively. Fahy and colleagues[4] published on 10 skeletal elements from 10 individuals, finding the maximum intraperson variation to be 1.6‰ for δ^{13}C values and 3.1‰ for δ^{15}N values and mean variation to be 0.9‰ and 1.6‰, respectively.[4] Finally, a comprehensive literature review has not revealed any published intraperson variation data for δ^{13}C and δ^{18}O values of human bone bioapatite.

This study isotopically analyzed both collagen and apatite from 5-6 long bone elements from 21 individuals for δ^{13}C, δ^{15}N, and δ^{18}O values (n=112 samples, 448 analyses). Samples were prepared at California State University, Chico; collagen was analyzed at the University of California, Davis, while apatite was analyzed at IsoForensics, Inc. This resulted in the largest known dataset of intraperson isotopic variation for human bone collagen and (per this study's research) the only dataset for human bone apatite.

Initial results indicate that the maximum intraperson variation for collagen was 0.7‰ for δ^{13}C values and 0.9‰ for δ^{15}N values, with a mean variation of 0.2‰ and 0.6‰, respectively (SD=0.2‰ each). For the apatite fraction, the variation was 1.1‰ for δ^{13}C values and 1.2‰ for δ^{18}O values, and the mean variation was 0.7‰ each (SD=0.2‰ each). These results generally agree with the previously reported collagen data, though this study's δ^{15}N values have a smaller intra-individual range (possibly due to more consistent diets of forensic versus archaeological cases).

Using a two and three standard deviation from the mean model, it is proposed that any two bones that have differing collagen δ^{13}C values greater than 0.75‰ are *probably* from different individuals, and those that have differing values greater than 0.95‰ *are* different individuals. Likewise, δ^{15}N values greater than 1.0‰ are *probably* different, and greater than 1.2‰ *are* different. For apatite, the proposed values change slightly to 1.2‰ and 1.5‰ for δ^{13}C values; for δ^{18}O values, >1.2‰=*probably* different, while >1.4‰=*are* different. Following these parameters, sorting commingled human remains based on a triage of the isotope values of human remains can be undertaken.

Reference(s):

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3. Olsen K.C., White C.D., Longstaffe F.J., von Heyking K., McGlynn G., Grupe G., and Ruhli F.J. Intraskeletal Isotopic Compositions (δ^{13}C, δ^{15}N) of Bone Collagen: Nonpathological and Pathological Variation. *Am J Phys Anthrop*. 2013:153(4):598-604.
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