E32 Correlation of Bioelectric Impedance Metrics to Accumulated Degree Days Among Body Segments Using Gel Pad Electrodes

Eriek S. Hansen, PhD, Dept Biological Science, Colorado Mesa University, 1100 North Avenue, Grand Junction, CO 81501; Sophia I. Reck*, 959 Northern Way, #4, Grand Junction, CO 81501; and Melissa A. Connor, PhD, Colorado Mesa University, 406 Lowell Heiny Hall, 1100 N Avenue, Grand Junction, CO 81501-3122*

After attending this presentation, attendees will understand the relationship between bioelectrical impedance metrics and Accumulated Degree Days (ADD).

This presentation will impact the forensic science community by providing an example of a new quantitative method for estimating Postmortem Interval (PMI).

Preliminary research conducted at Colorado Mesa University's Forensic Investigation Research Station (FIRS) demonstrated that Bioelectrical Impedance Analysis (BIA) metrics correlate with ADD. This research compared these correlations for different body segments on human cadavers using conductive gel pad electrodes.

Present methods for estimating PMI are limited by both subjectivity and the circumstances under which remains are found. The goal of this research was to develop an objective and quantitative technique that estimates PMI. BIA is a technique currently used to evaluate nutrition and body composition in humans and animals; however, it has also demonstrated the potential for forensic application. Forensic research using non-human study organisms also found relationships between BIA metrics and the PMI. For example, in rat abdominal walls, there was a relationship between resistance and PMI.[1] Similarly, in rat spleens, there was a statistically significant linear regression relationship between impedance (Z) and PMI.[2]

Between fall 2014 and winter 2015, BIA was conducted on human donors at the FIRS. For this experiment, conductive gel pad electrodes were attached to six human donors at anatomically defined landmarks. Gel pad electrode pairs were attached at a fixed distance of 10cm to measure four different body segments (hand-foot, hand-shoulder, shoulder-foot, and thigh-foot) on one side of the body. Single frequency BIA was used to measure the resistance (R, Ω) and reactance (X, Ω) of a 400μA and 50KHz Resistor Capacitor (RC) current passed through tissue daily throughout the decomposition event. Measurements ceased when the loss of tissue infrastructure was sufficient to result in failure to conduct a current. The BIA measurements were derived to mathematically convert each body segment into a cylinder. Circuit models in both series (s), and in parallel (p) were used for calculation of six BIA metrics: Resistance (R), Reactance (X), impedance (Z), phase angle (degrees), and R/X. Ambient temperatures were measured hourly using an on-site weather station. Mean daily temperatures were used to calculate ADD. Statistical analyses were conducted using Pearson product-moment correlation between ADD and each BIA metric. Separate correlation analyses were conducted for each individual human remains to correct for seasonality (statistical significance $\alpha = 0.05$).

The range of maximum PMIs yielding measurements within the sample for the hand-foot body segment was 10-45 days. The range of maximum ADD within the sample for the hand-foot body segment was 150°C-335°C. Because the hand-foot segment is the longest circuit — and therefore the most vulnerable to tissue breakdown and circuit disruption — this serves as a conservative estimate for the longitudinal efficacy of the method.

The correlation with ADD varied by BIA metric and by individual remains. The highest correlation for each body segment was hand-foot (15-07, *Xs* = 0.93), hand-shoulder (15-06, *Rs* = 0.97), shoulder-foot (15-02, *R/X* = 0.97), and thigh-foot (15-02, *Xs* = 0.97 and *Zp* = 0.97).

The percentage of statistically significant correlations between ADD and all BIA metrics varied more among body segments than BIA metric. For body segment, the percentage of significant correlations were hand-foot (67%), hand-shoulder (36%), shoulder-foot (24%), and thigh-foot (43%). For BIA metrics, the percentage of significant correlations was 43% for all metrics except Rs (48%) and Xp (33%).

Bioelectrical impedance analysis measurements significantly correlated with ADD for multiple body segments in human remains. This research highlights the difference among body segments, BIA metrics, and their relationships with ADD. Ultimately, multiple regression models will be developed to predict ADD as an indice of PMI.

Reference(s):

1. Querido D. Postmortem changes in resistivity of the anterior abdominal wall during the early postmortem period in rats. *Forensic Science International* 1993; 60: 163-77.
2. Mao S., Dong X., Fu F., Seese R.R., Wang Z. Estimation of postmortem interval using an electric impedance spectroscopy technique: a preliminary study. *Science and Justice.* 2011; 51: 135-8.

Forensic Science, Bioelectrical Impedance, Postmortem Interval