(1) Presentation Title: Analysis of Variance to Assess Statistical Significance of Effects of Gelatin and Salt Concentrations on Resistance of Phantom Model

(2) Research Focus: Biomedical Engineering

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(7) Presentation Preference Type: Poster

(8) Abstract:

While several studies have looked into effects of gelatin and salt concentrations on resistance of phantom models even the most recent ones like [1] have a number of limitations. Most notably, no statistical analysis of obtained results has been performed which also means that significance of interaction between these factors has not been studied, there were no replicates included in the experiments, factor level ranges were limited, etc. Therefore, the purpose of this study was to address all the limitations of previous studies including [1] using full factorial analysis of variance (ANOVA) after verifying all of its assumptions to ensure validity.

ANOVA was performed using Design-Expert software (Stat-Ease Inc., Minneapolis, MN, USA) with two categorical factors [2]. The first factor (A) was the concentration of salt (NaCl) presented at three levels corresponding to 1g (1.7%), 3g (5.2%), and 6g (10.3%) concentrations. The second factor (B) was the concentration of gelatin presented at four levels corresponding to 9g (15.5%), 12g (20.6%), 15g (25.8%), and 18g (31.0%) concentrations. The response variable was the resistance of the phantom model measured in Ohms using B&K Precision 2840 Series DC resistance meter (B&K Precision Corporation, Yorba Linda, CA, USA) for each of the 3 * 4 = 12 combinations of levels of two factors with two replicates (24 runs total). Held constant factors included temperature of phantom models (61- 62°F), ballistic gelatin powder (Fit Lane Nutrition, Conroe, TX, USA), and distilled water as well as age of and size of phantoms. ANOVA assumptions including normality, homogeneity of variance, and independence of observations were verified with no studentized residuals being outliers (falling outside of the [-3, 3] range) [2]. Factors A, B, and their interaction (AB) had statistically significant effects in the model (d.f. = 11, $F = 107.09$, $p < 0.0001$). Goodness-of-fit metric R-squared (R^2) representing the percentage of total variation in the data explained by the model was equal to 0.9899. Individual effects of both factors and their interaction were: A (d.f. = 2, $F = 17.89$, $p = 0.0003$), B (d.f. = 3, $F = 258.23$, $p < 0.0001$), and AB (d.f. = 6, $F = 61.26$, $p < 0.0001$).

ANOVA results confirmed statistical significance of effects of both gelatin and salt concentrations on resistance of the phantom model for the first time. In terms of relative significance of effects comparison of F and p-values suggests that the order (highest to lowest) may be: B, AB, and A, but two factors had different numbers of levels that affected their respective numbers of degrees of freedom. Directions of future work include adding more factors to the model and treating them as numerical as well as randomizing the order of runs to balance out the effect of nuisance factors.

[1] A. Y. Owda and A. J. Casson, "Investigating gelatine based head phantoms for electroencephalography compared to electrical and ex vivo porcine skin models," *IEEE Access*, vol. 9, pp. 96722–96738, 2021.

[2] D. C. Montgomery, *Design and analysis of experiments*. John Wiley & Sons, 2008.