

## **Parametric analysis to optimize calculated head mass and center of gravity**

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Human body segment properties, such as mass and center of gravity (CG), are critical when studying the biomechanics of the body. Previous studies investigated methods of obtaining physical measures of mass and CG from segmented heads of post mortem human surrogates (PMHS) using a balance and a custom designed support box. These physical values were then compared with values calculated using analysis of CT scans of the segmented heads in a commercial software program, which resulted in some deviation. It is important to find an accurate minimally invasive technique so precise body segment mass and CG could be found on live subjects for any biomechanics research.

The objectives of this study were to: 1) Minimize the error of the segmented head mass computed from a custom MATLAB code when compared with the known physical mass by varying bone and tissue densities and Hounsfield unit (HU) thresholds obtained from previous literature and 2) Quantify differences between the CG locations calculated from a custom MATLAB code using the optimum parameters and those measured from the physical measures.

This study compared physical mass data of the heads of 25 PMHS to CT scans of those same heads to find the most precise tissue densities and HU to use when computing segment mass. The subjects consisted of 10 males and 15 females that had been segmented and weighed for a previous study. A custom MATLAB code was created to convert the pixel values in each CT image to representative masses, which were then summed to find total head mass. Using the most precise density and HU parameters, the code was also developed to calculate the CG of each head. Calculated CG locations were compared with physically determined CG locations of each head.

Trials were tested that used different combinations of possible HU and density values in the MATLAB code. The HU values of -200 to 400 for soft tissue and 401 to 1800 for bone, and 538 to 707 for soft tissue and 708 to 3500 for bone were tested in different combinations with density values of 1.00 g/cm<sup>3</sup> for soft tissue and 1.92 g/cm<sup>3</sup> for bone, and 1.04 g/cm<sup>3</sup> for soft tissue and 1.21 g/cm<sup>3</sup> for bone. The lowest percent error of 4.29% ± 5.79% resulted from using soft tissue density of 1.00 g/cm<sup>3</sup> and bone density of 1.92 g/cm<sup>3</sup> with soft tissue HU between -200 and 400, and bone HU between 401 and 1800. When using these values to calculate CG, the percent error was 10.15±5.52% in comparison to the physical value. Future work could optimize density or HU values to even further decrease the percent error found in this study.

Finding an accurate and non-invasive technique to measure segment body mass and CG would improve accuracy of data determined from kinetic analysis in studies involving human volunteers.