Comparison of the Compressive Response of the PMHS and 50th% Hybrid III ATD Thorax Utilizing Nonparametric System Identification Techniques

Kyle Icke[1], Kevin Moorhouse PhD[2], John Bolte IV PhD[1]

[1]The Ohio State University, Injury Biomechanics Research Lab
[2]National Highway Traffic Safety Administration

ABSTRACT

Passenger restraint systems found in vehicles are designed to increase the safety of occupants involved in motor vehicle accidents. The effectiveness of these passenger restraint systems is evaluated using an anthropomorphic test device (ATD) representative of a 50th percentile sized male adult. In a frontal motor vehicle accident the interactions of the thorax with the vehicle's restraint system and components dictate the kinematic behavior of the head, neck, and spine. The response of the ATD thorax to an applied anterior compressive force is imperative to its ability to accurately exemplify a vehicle's occupant. The greater the biofidelity of the ATD's thoracic force-deflection characteristics, the more the efficacy of restraint systems can be improved. The purpose of this study is to compare the frontal compressive response of the adult hybrid III 50th% male ATD thorax with an adult post mortem human surrogate (PMHS) thorax in an effort to improve the biofidelity of the ATD thorax at sub-injurious levels. In order to compare the chest deflection biofidelity of the adult ATD thorax with a PMHS thorax a technique to define the properties of the thorax is necessary. To accomplish this, a device was designed and built to load the thorax with small, non-injurious compression perturbations, while measuring the corresponding thoracic response forces. The device is capable of applying 10mm perturbations up to a nominal 2.5m/s. The system is comprised of a vector motor, parallel shaft gear reducer, high inertia flywheel, cam, and pushrod. To characterize the response of the adult ATD and PMHS thorax, input displacement perturbations are applied at varying rates and levels of initial thoracic compression, the corresponding thoracic response forces are measured, and the mechanical properties of the thorax (i.e., mass, damping, stiffness) are obtained utilizing nonparametric system identification techniques. Although the thorax is a nonlinear system, using sufficiently small displacement perturbations allows for the assumption that the thorax is operating within a linear zone or operating point. By obtaining the linear response of the thorax at many of these operating points, an overall nonlinear model of the thorax can be compiled and compared. For this study the mass, damping, and stiffness of the ATD and PMHS thorax will be compared at three rates of compression, 0.5, 1.5, and 2.5m/s. Additionally, three levels of initial thoracic compression, 5, 10, and 15%, will be considered allowing a total of nine operating points. This study will help to better understand the limiting factors of the ATD thorax's force-deflection characteristics in accurately depicting the human thorax.