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Assessment of the sensitivity of thoracic injury criteria to subject-specific characteristics using human body models

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Abstract-

Introduction: Chest deformation has been proposed as the best predictor of thoracic injury risk in frontal impacts. Finite Element Human Body Models (FE-HBM) can enhance the results obtained in physical crash tests with Anthropometric Test Devices (ATD) since they can be exposed to omnidirectional impacts and their geometry can be modified to reflect specific population groups. This study aims to assess the sensitivity of two thoracic injury risk criteria (PC Score and Cmax) to several personalization techniques of FE-HBMs.
Methods: Three 30° nearside oblique sled tests were reproduced using the SAFER HBM v8 and three personalization techniques were applied to this model to evaluate the influence on the risk of thoracic injuries. First, the overall mass of the model was adjusted to represent the weight of the subjects. Second, the model anthropometry and mass were modified to represent the characteristics of the post-mortem human subjects (PMHS). Finally, the spine alignment of the model was adapted to the PMHS posture at t = 0 ms, to conform to the angles between spinal landmarks measured in the PMHS. The following two metrics were used to predict three or more fractured ribs (AIS3+) of the SAFER HBM v8 and the effect of personalization techniques: the maximum posterior displacement of any studied chest point (Cmax), and the sum of the upper and lower deformation of selected rib points (PC score).
Results: Despite having led to statistically significant differences in the probability of AIS3+ calculations, the mass-scaled and morphed version provided, in general, lower values for injury risk than the baseline model and the postured version being the latter, which exhibited the better approximation to the PMHS tests in terms of probability of injury. Additionally, this study found that the prediction of AIS3+ chest injuries based on PC Score resulted in higher probability values than the prediction based on Cmax for the loading conditions and personalization techniques analyzed within this study.
Discussion: This study could demonstrate that the personalization techniques do not lead to linear trends when they are used in combination. Furthermore, the results included here suggest that these two criteria will result in significantly different predictions if the chest is loaded more asymmetrically.

Index Terms- human body model (HBM), injury metrics, nearside, oblique impact, thoracic injury risk, personification

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