Validation of a Full Body Finite Element Model in Lateral Sled and Drop Impacts

Nicholas A. Vavalle, Daniel P. Moreno, Joel D. Stitzel, F. Scott Gayzik

Virginia Tech-Wake Forest University School of Biomedical Engineering and Sciences

ABSTRACT

Computational modeling via the finite element method is an important tool used in injury biomechanics, and validation is required to give confidence in a model's results. In the validation of the Global Human Body Models Consortium (GHBMC) mid-sized male model (M50), frontal and lateral validation was performed. This study presents a subset of that work, focusing on lateral impacts in full body sled tests at two speeds, and a lateral drop test. The M50 model was created based on medical images of a living subject selected to represent the 50th percentile male based on height, weight, and anthropomorphic measurements [1]. A region-specific development was used with one integration center charged with assembly and validation of the model. The two studies used in lateral full body validation of the model were Pintar et. al. [2] and Stalnaker et. al. [3, 4]. The lateral sled tests involved propelling a seated cadaver into a rigid wall at two velocities, 6.7 m/s and 8.9 m/s. Drop tests were performed on the cadaver from 1m above a rigid surface. Model results were compared to force vs. time curves, peak force, and number of fractures from the studies. Sled test data was filtered to SAE CFC 180 with a matching filter applied to model outputs. An SAE CFC 300 filter was applied to model outputs from the drop tests. Rib fracture was predicted via a piecewise linear model for cortical bone with a failure strain of 0.02 [5]. Force vs. time traces of the sled impacts were compared to model outputs and showed reasonably good agreement. For 6.7 m/s the peak thoracic, abdominal and pelvic loads were 8.7 kN, 3.1 kN and 14.9 kN for the model and 6.0±1.1 kN, 3.6±1.3 kN, and 5.1±2.5 kN for the tests (n = 3). Similarly, in the 8.9 m/s case they were 12.6 kN, 6.1 kN, and 21.9 kN for the model and 8.75±4.5 kN (n=6), 5.0±2.0 kN (n=8), and 15.0±4.5 kN (n=8) for the experiments. Model results for force vs. time from the drop test fit within the established corridors with the exception of an early spike in force that exceeds the corridor by less than 0.75 kN. This is probably due to arm loading. The peak thorax load was 6.7 kN for the model and the range was 5.8 kN to 7.4 kN in the tests. The model predicted Abbreviated Injury Scale (AIS) 4 thoracic injury (via analysis of rib fractures) in the 6.7 m/s sled test while the test subjects injuries ranged from AIS 0 to 4. In the 8.9 m/s sled test, the model predicted AIS 4 thoracic injury which matched the AIS levels in 7 of the 8 test subjects. In both sled test cases the model also predicted pelvic fractures while none were reported in the literature. The model predicted 2 rib fractures in the drop test, which is within the reported range of 0 to 5 fractures for male subjects. These results provide confidence in the GHBMC model's performance in lateral impacts.