Development and Validation of a Six-Year-old Pedestrian Finite Element Model

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Abstract

Pediatric pedestrians have a higher risk to be involved in a car-to-pedestrian (CPC) crash because of their size which makes them less visible. Children ages five to nine face to the highest mortality rate in crashes among all pedestrians. Sub-system tests proposed by the EEVC are commonly used in the development of regulations and in the development of technologies for pedestrian protection. However, with exception of a child headform impact test, all other subsystem tests are designed for prediction of adult pedestrian injuries. The development of a computational child model could be a better alternative, to characterize the whole-body response of vehicle–pedestrian interactions, and assess the pedestrian injuries. These existing pediatric finite element (FE) models have several inherent limitations due to the lack of pediatric material data and age-dependent anatomical data. The objective of this study is to develop an advanced and computationally efficient FE model of a six-year-old pedestrian child.

The geometry of the six-year-old pedestrian model is based on published surface scans of six-year-old children, and supplemented with head and neck medical images available in the Wake Forest University Medical Image Database. The FE mesh of the pediatric model was obtained by morphing the GHBMC 5th percentile female pedestrian model to the child model. The material properties are based on the literature data as well. Standing posture was chosen in simulation as specified in the EuroNCAP testing protocol. In this protocol, simulations are used in concert with physical testing for the detection of vehicle to pedestrian contact with a range of human models, including a six-year-old child.

A pelvis impact simulation has been performed based on published PMHS data. The model outputs showed reasonable biofidelity responses in terms of changes in impact force, compression and Viscous Criterion over time. Bending tests were also performed using the FE model to validate the reliability of the leg and femur. The model responses were within the range of scaled PMHS adult data. Finally, a CPC simulation was performed using the entire six-year-old pedestrian FE model. The child model showed numerical stability under the tested CPC configuration. First, the child's right lower extremity was impacted by the car bumper and a femoral fracture and a MCL rupture were predicted. Then, a LCL rupture was also predicted in the left leg. The thigh and pelvis impact with the hood edge caused the torso to rotate toward the hood. Future work will be focused on further model improvements and model validation based on real-world accident data.