

Longitudinal Trend and Patterns in Lower Extremity Injuries Sustained in Frontal Motor Vehicle Crashes

Xin Ye , Dipan Bose , Jeff Crandall

University of Virginia

Abstract

This study aims to investigate changes in frequency, risk, and patterns of lower limb injuries due to vehicle and occupant parameters as a function of vehicle model year. Using the National Automotive Sampling System – Crashworthiness Data System, 10988 cases were sampled and analyzed, representing 4.7 million of belted drivers involved in frontal crashes for the year 1998-2010.

A logistic regression model was developed to estimate the risk of sustaining below-knee lower limb injuries of moderate or greater severity (AIS2+) as a function of the vehicle type and model year, toe pan and instrument panel intrusions, as well as the occupant's age, gender, height and weight. Toe pan intrusion greater than 2cm was significantly associated with an increased injury risk (OR: 9.10, CI: 1.82-45.42). Females had a higher likelihood for sustaining distal lower limb injuries (OR: 6.83, CI: 1.56-29.93) than males. Weight was found to be related (OR: 1.04, CI: 1.02-1.06), while occupant age and height were not associated with injury risk (ORs of 1.02 and 0.99, respectively). Relative to passenger cars, vans exhibited a significant decrease in sustaining lower limb injury (OR: 0.24, CI: 0.07-0.78), whereas light trucks showed no significant association (OR: 1.31, CI: 0.69-2.49).

To compare the NASS trends with crash testing results, data from moderate offset frontal crash tests performed by the Insurance Institute for Highway Safety (IIHS) were examined. For vehicle model years from 1995 to 2013, IIHS data indicated a decreasing trend in vehicle foot well and toe pan intrusion, foot accelerations, tibia axial forces and the tibia index in relation to increasing vehicle model year. Over 90 percent of vehicles reached the highest rating (i.e., Good) developed using the lowest composite score obtained from the upper and lower tibia index, tibia axial force and the resultant foot acceleration considering both extremities. Passenger cars achieved the highest rating followed by SUVs and light trucks, while vans attained the lowest score. The apparent injury risk for the lower limb as a function of vehicle type for crash tests differed from the NASS-CDS findings and may be due to a combination of the weighting factors of specific injury predictors and/or occupant position and loading scenarios.

The mechanisms of injury for the distal lower limb were assessed by reviewing 34 frontal crash cases selected from the Crash Injury Research and Engineering Network (CIREN). Case inclusion criteria involved adult belted drivers with a total of 42 AIS2+ lower limb injuries. Talus fractures (N=20) and calcaneus fractures (N=10) were the most frequent hind-foot skeletal injuries observed among the cases. The leading injury mechanism was axial compression causing 18 injuries while 11 injuries involved inversion or eversion, and 7 resulted from dorsiflexion. The results presented demonstrate that while there has been steady improvement in vehicle crash test performance, below-knee lower extremity injuries remain the most common AIS 2+ injury in frontal crashes. The analysis of ankle injury mechanisms suggests efforts to limit axial loading of the lower limb should be prioritized in future injury evaluation and in the development of appropriate countermeasures.