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The effect of seatbelt pre-tensioners and load limiters in the reduction of MAIS 2+, MAIS 3+, and fatal injuries in real-world frontal crashes

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Abstract-

Contemporary research has pointed out that while newer cars are contributing to the decrease of AIS2+ and AIS3+ injuries in several body regions, this effect is not shown for thoracic injuries like rib or sternal fractures. The objective of this study is to assess the effectiveness of advanced seat belt systems incorporating pre-tensioners and load limiters in the prevention of fatal, AIS2+ and AIS3+ injuries overall and then focus only on the head-face-neck and thoracic areas. Data from the NASS CDS database between 2000 and 2015 was augmented with specific vehicle information taken from NHTSA’s NCAP tests to identify the characteristics of the seat belt of each vehicle involved in a collision. Multivariate logistic regressions were developed to assess the likelihood of injuries for belted front seat occupants in frontal impacts. The presence of pre-tensioners and load limiters with a low load limiter (<4.5 kN) was significantly associated with a decreased risk of fatal and AIS3+ in the whole body (OR = 0.31 (p < 0.05) and OR = 0.70 (p < 0.1)), while high load limiters were significant in the prevention of fatal injuries (OR = 0.42). These effects should be considered always in combination with the delta-v of the collision, as the interaction term between delta-v and advanced seat belt features was significant. In the crashes considered, the model predicted a higher risk of injury for women compared to men, controlling for other occupant and crash factors. Impacts with a slightly oblique component increased the risk of injury compared to pure frontal impacts. After controlling for the presence of pre-tensioners and load limiters, the vehicle model year variable was found to be insignificant in any of the regression models. This study shows that the real-world effectiveness of advanced seat belts still requires further analysis. Other effects like age or impact direction might be more influential in the injury outcome than these seat belt features.

Index Terms- Seat belts; Pre-tensioners; Load limiters; Frontal impacts

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