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Institutionen för klinisk neurovetenskap

Car Safety for Children Aged 4-12

Real world evaluations of long-term injury outcome, head injury causation scenarios, misuse, and pre-crash maneuver kinematics

AKADEMISK AVHANDLING

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ABSTRACT

Child casualties in car crashes have decreased over the years. Nevertheless, occupant safety in rear seats, especially for children 4-12 years old, needs further attention because motor vehicle crashes remain the leading cause of death and long-term health consequences for children. The aim of this thesis was to obtain comprehensive knowledge of real-life situations for restrained, forward-facing, rear-seated children aged 4-12 years, in frontal car crashes as a basis for vehicle safety improvements to reduce long-term health consequences.

The thesis is comprised of four studies based on child-specific data from Sweden and the US. Study I was based on injury data from insurance claim files, covering 2619 injured children in Sweden. Study II was an experimental study of restraint misuse, including 130 Swedish children. Study III analyzed crash data included 27 cases from two US databases, to determine injury causation scenarios. Study IV was a driving study of how pre-crash maneuvers affect child occupant kinematics with 16 children included.

The results of Study I emphasized the importance of looking beyond acute, severe injuries and also examine injuries (regardless of initial injury severity) resulting in permanent medical impairment. The vast majority of injuries with the higher degree of permanent medical impairment were severe injuries to the head. The most frequent injuries leading to permanent medical impairment were minor injuries to the neck and head. To reduce the risk of head injuries among children in car crashes, a fundamental step is to ensure that vehicle restraint systems are adapted to the child, physically and behaviorally, and that the child is properly restrained. An experimental study (Study II) of children using integrated booster cushions compared to aftermarket belt positioning booster cushions, showed that misuse related to buckling up, a problem for decades, can be reduced to a minimum by the design of an integrated booster cushion. Minimizing misuse will lead to increases in proper positioning of the restraint on the child and may translate to reductions in head injury risk. Therefore, car manufacturers should focus on integrated booster cushions, preferably as standard equipment.

Even with proper use, however, restrained children in rear seats sustained head injuries in frontal impacts by impacting their heads on the side interior and on the seat back in front of them. Oblique impacts and pre-crash steering maneuvers contributed to both these injury-causation scenarios (Study III). Therefore, pre-crash steering maneuvers were further explored in a driving study and it was confirmed that these common pre-crash maneuvers can result in an unstable restraint situation that may potentially compromise rear occupant safety in the event of a crash (Study IV).

In conclusion, the primary recommendation as a result of this research is to protect the head and neck of child occupants from both minor and severe injuries, since all severity levels of injuries may result in long-term consequences. Frontal impacts, including oblique impacts or maneuvers prior to impact, need to be addressed to develop “tolerant” restraint systems. Furthermore, it is recommendable to design and use vehicle-built-in restraint systems to improve crash safety among children, by facilitating proper use of the restraint and placement on the child, as has been previously done for front-seated adults. To incentivize vehicle manufacturers to accelerate the implementation of child safety improvements within their vehicles, an assessment of child safety for 4-12-year-old children should be included in consumer rating programs and legal requirements.