講演番号 187

Injury Analysis of Vehicle Occupants in Reclining Seated Posture

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KEY WORDS:**Safety, Occupant protection, Injury prediction,** Reclining seated posture, Submarining [C1]

One approach to reducing fatalities and serious injuries resulting from traffic accidents in the real-world is to understand actual usage scenarios during vehicle occupancy. Occupant seating posture is one such factor; in practice, a wide variety of postures exist beyond the upright posture, and it is important to analyze how these postures are involved in injury mechanisms during collisions and to what extent they influence injury outcomes. Differences in posture alter the skeletal alignment of the human body when seated on an automotive seat and ultimately affect the relationship between pelvic orientation and seatbelt positioning. In previous studies, we analyzed individual variability in skeletal alignment in the upright seating posture and demonstrated that it is influenced by age and body size(1). Among various seating postures, highly reclined postures have attracted increasing global attention in recent years as one of the postures likely to become more prevalent in future highly automated vehicles. In this study, three representative body types were selected from a dataset of 100 subjects. The objective was to investigate body-type-specific trends in skeletal alignment in a reclined posture and to analyze their effects on injury risk during vehicle collisions.

This study was conducted in three steps. First, after providing sufficient explanation and obtaining informed consent, the subjects were seated on an automotive seat and X-ray imaging was performed. Using the acquired images, skeletal angles from the cervical spine to the pelvis were measured, and individual variability was analyzed based on data from all subjects. Next, several representative values were selected from these data, and models reproducing the skeletal posture (lumbar spine and pelvic geometry) of AM50 were developed based on THUMS v4.02. Finally, these models were used to perform crash simulations to analyze occupant kinematics and injury outcomes, and injuries were compared with respect to differences in skeletal alignment.

As a result, it was found that, for all body types, the reclined posture was associated with lumbar lordosis and pelvic rearward. This tendency toward increased lumbar lordosis in the reclined posture was particularly pronounced in the AF05 body type. Examination of the mean skeletal alignment by body type showed that the angular difference from the lumbar spine to the sacrum was greater in this body type than in the others, confirming a larger degree of lordosis. These findings suggest that AF05 occupants are more susceptible to the influence of the seat's lumbar support. Furthermore, deterioration in injury outcomes under the reclined posture was observed in all body regions except the lower extremities, for which the knee airbag provides a direct protective effect (Fig.1). Detailed analyses of the abdomen and lumbar region revealed phenomena such as seatbelt submarining and increased stress generation on the anterior aspect of the lumbar spine. These results provide renewed validation of the increased injury risks associated with reclined seating postures that have been reported in previous studies(2).

This study includes four limitations. First, the automotive seat used for X-ray imaging was limited to a single type, namely a Mazda3 seat, and the subject data were restricted to Japanese individuals. Second, the individual variability analysis focused on only three body types: AF05, AM50, and AM95. In addition, this study, including the model development, primarily focused on the lumbar spine and pelvis. Future work will require analyses that also incorporate the cervical and thoracic spine.

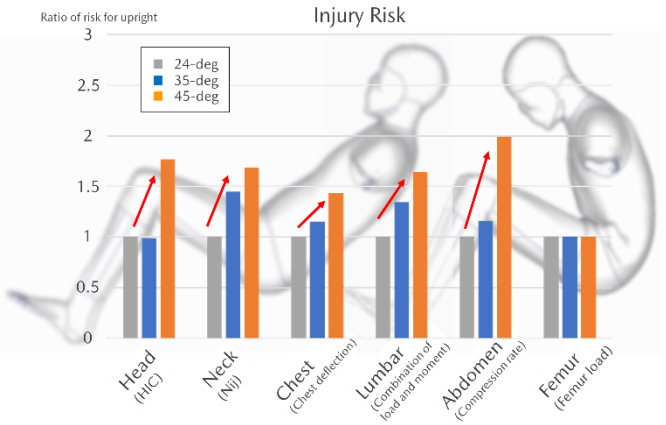

Fig.1 Injury Risk for All Body Regions in Each Posture

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