Evaluating Occupant Kinematic Responses to Low Acceleration Time-Extended Evasive Swerving Events

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Motor vehicle crashes (MVCs) continue to be a prime contributor to mortality and morbidity for children and young adults worldwide to date. Automotive research and safety testing have emphasized the impact phase of MVC, often neglecting the precursors of the event although previous research has shown 60% of crashes involve some form of pre-crash maneuvers. These maneuvers have been defined as low acceleration, time extended (LATE) events. The inertial forces, during this pre-crash phase, have the potential to cause alterations to the occupant's "state" (initial posture, position, muscle tension). In turn, the occupant's state may result in profound consequences for the restraint system's performance. Currently, there is limited understanding of occupant kinematic activity during pre-crash maneuvers and how this activity contributes to protection. Evasive swerving was identified as a vital LATE event that is currently understudied. The objective of this study is to quantify kinematic responses of adult and pediatric restrained human volunteers during simulated evasive swerving maneuvers via a safe and repeatable test fixture, custom constructed for this study that exposes volunteers to low, non-injurious loading conditions that are relevant to the pre-crash event.

Healthy male volunteers (9–40 yrs) were exposed to a series of oscillatory peak lateral accelerations of approximately 0.75 g, while restrained in a seating compartment that simulates the vehicle interior environment including a production vehicle bucket seat, bracing structure, and standard 3-point restraint. The effect of bracing and two countermeasures (a seatbelt pre-tightener and a more sculpted vehicle seat with inflatable torso bolsters) were assessed. In total, each volunteer participated in five randomized testing conditions:

1. relaxed posture-standard seat,
2. braced posture-standard seat,
3. relaxed posture-seatbelt pre-tightener-standard seat
4. relaxed posture-sculpted seat (un-inflated torso bolsters),
5. relaxed posture-sculpted seat (inflated torso bolsters).

Each test condition consisted of four oscillations and was repeated once for a total of 10 trials per subject. Subjects were unaware of test start to capture the response of a naïve occupant. 3D photo-reflective marker trajectories from an eight-camera motion capture system were used to analyze the position of head, torso and seatbelt. Wireless electromyography (EMG) sensors placed on the musculature of the neck, torso, abdomen and extremities were used to quantify muscle response.

Data from 10 adult subjects (18+ years) and a smaller subset of adolescents will be presented. Preliminary data analysis revealed the first oscillation in each trial has a different kinematic response (greater lateral head and torso excursions) than the subsequent oscillations. Additionally, the pre-tightened seatbelt and the bracing conditions restricted kinematics compared to relaxed posture conditions. Kinematics in the sculpted seat, in both the inflated and un-inflated torso bolster conditions, were affected by volunteer torso girth. Those with larger torso girth experienced greater lateral motion as the inflated torso bolster provided a stiff structure that pushed the subject's torso forward such that they moved laterally in front of the seat during the lateral acceleration. In contrast, volunteers with smaller torso girth were restricted to the confines of the bolsters.

References: [1] Kent, R. et al., JSAE, 2014., [2] ITARDAS, 2007, [3] WHO, *Global Status Report on World Safety*, 2009.