**Complete Vehicle Testing of Car Occupant Muscle Responses for Integrated Safety Simulation**

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Active safety systems such as autonomous emergency braking systems, already on the market, have a large potential for improving vehicle safety (Strandroth *et al.* 2012). Future active systems might include autonomous steering interventions to avoid collisions in even more situations. In order to fully assess the injury reduction potential of active safety systems, the effect on occupant position and muscle tonus in the pre-crash phase must be known, as these parameters affect the injury outcome in a subsequent crash (Bose *et al.* 2010). Therefore, research in numerical modeling and volunteer testing of car occupant pre-crash kinematics and muscle responses are conducted at Chalmers.

Driver and passenger muscle responses were tested for 20 (11 Male, 9 Female) volunteers who were driving a Volvo V60 on rural roads with little traffic (Ólafsdóttir *et al.* 2013; Östh *et al.* 2013). The volunteers were instrumented with electromyogram (EMG) electrodes on 16 muscles of the upper body. Planar kinematics was acquired through film analysis of markers attached to the skin of the volunteers, and seat belt force and pay-out was measured. The occupant muscle and kinematic response was evaluated for driver and autonomous braking interventions, with a standard and a motorized seat belt that applied 170 N of pre-tension force 0.2 s before brake intervention.

The application of a motorized 170 N pre-tension of the seat belt significantly altered the muscle responses of car occupants, in both driver and passenger positions. Muscle activation occurred closely in relation to belt pre-tension, and in some volunteers a simultaneous contraction of all muscles was found, indicating a startle reflex response. Pre-tension of the seat belt led to a reduction of forward displacements, but the effect of the driver braking on his or her own led to a larger reduction of forward displacements compared with autonomous braking.

Future volunteer testing will focus on occupant responses to voluntary and autonomous lateral maneuvers. In order to investigate the muscle response, EMG will be recorded synchronized with occupant kinematics. In addition, the driver and occupant response to external threats such as a simulated on-coming vehicle would be of outmost interest to investigate. Resulting data will be used to further develop and validate a finite element occupant model for pre-crash and crash simulations.

**Keywords:** Occupant Kinematics, Integrated Safety Systems, Electromyography, Numerical Modeling

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