MUSCULAR STABILISATION OF THE HEAD IN CAR COLLISIONS

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INTRODUCTION

Frontal and rear-end collision with low speed are common accident mechanisms in situations with dense city traffic. During a rear-end collision the car occupant of the struck vehicle is pushed forward by the seat-back. Due to its inertia the neck is forced to an extension-flexion movement commonly called 'whiplash'. To improve car safety mainly anthropometric test dummies (ATD) e.g. Hybrid III are used. Although there is an ongoing development of ATD, such as the BioRID P3, and of specific components like the TRID-neck studies in which dummies or cadaver models are used do not reveal neuromuscular control strategies to adjust neck stiffness and to stabilize head position. However: muscular activation is presumably essential for postural control and head stability especially during trunk linear acceleration as they occur in car collisions [1].

The purpose of this study was to investigate differences in muscular coordination patterns of car occupants in frontal and rear-end collisions of small vehicles with low speed.

METHODS

Six male subjects performed five frontal and rear-end collisions with a bumper car (speed = 2.6 m/s) in a randomized order. The instant of car collision and head movement of the occupant were recorded by accelerometers (1000 Hz). Kinematic data was collected using side view high-speed video (1000 Hz). Body motion was related to car motion. In a 2D-model angular amplitude and angular velocity of defined joints located at the cervical spine (C4), between head and neck, neck and shoulder and at the elbow were analyzed in the sagittal plane.

Myoelectric activity of specific neck, upper trunk and arm muscles of either body side was recorded using surface EMG. The signals were pre-amplified and digitized (1000 Hz) to a PDA. After online verification using W-LAN the signals were stored on a PC. EMG-Signals were rectified and filtered using the moving average (MA) method. The analyzed EMG parameters included time, mean amplitude (RMS) and integrals (iEMG) of pre-activation (prior to relative body motion) and main-activation (during relative body motion). RMS and iEMG were described relative to the maximum MA values of the respective muscles and subjects.

In the statistical analysis a MANOVA was performed for the independent factors "subject", "collision type" and "body side". The dependent variables were defined by the measured parameters in the kinematic and EMG analysis.

RESULTS AND DISCUSSION

Within the series of collision types no significant differences between trials were observed. Kinematic data during the frontal and rear-end collisions showed that the complex motion of the head, neck and torso of the car occupant consists of mostly horizontal translational and rotational movements. During

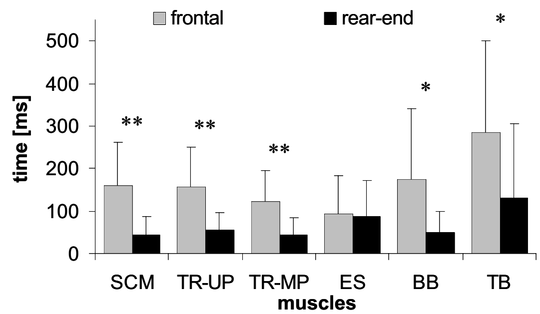

Figure 1 Activation times [ms] of the muscles sternocleidomastoideus (SCM), upper (TR-UP) and middle trapecius (TR-MP), erector spinae (ES), biceps (BB) and triceps brachii (TB) prior to relative head movement (N = 6).

frontal collisions all defined joints except the head-neck joint demonstrated significantly higher flexion compared to the rear-end crashes. During the rear-end collisions a nearly stationary head position observed in the first 70±6 ms of the crash could be attributed to head inertia [2]. This caused significantly higher and earlier maximum flexion in the head-neck joint and higher maximum extension in the other joints compared to frontal crashes.

In frontal collisions all muscles except the erector spinae showed significantly longer activation times prior to relative head movement compared to rear-end crashes (Figure 1). Together with significantly higher mean amplitudes representing the activation intensity this can be attributed to the visual anticipation of the frontal crash. This probably enabled a muscular induced neck stiffness to interlink motion of head and torso. In rear-end collisions EMG showed reflex induced activation time of about 50 ms prior to relative head movement with low intensity for all muscles. This seemed to be insufficient to interlink the head to the forward motion of the trunk.

CONCLUSIONS

In this study a significant difference of the muscular activation during frontal and rear-end collisions was observed. In contrast to currently used passive structures like crash test dummies or human cadavers, the muscular activity seems to play an important role during crashes and therefore should be more considered in future crash-models. Especially the results of the frontal collisions may help to improve occupant safety in the ongoing development of airbag concepts and help to prevent injuries.

REFERENCES

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