USE OF MUSCULOSKELETAL MODELLING FOR THE ANALYSIS OF VOLUNTEERS' TESTS IN THE FIELD OF MOTORCYCLE SAFETY

Ioannis Symeonidis[1,2], Gueven Kavadarli[2], Erich Schuller[2] and Steffen Peldschus[2]

[1]Hellenic Institute of Transport, Center for Research and Technology Hellas, Greece; [2]Institut für Rechtsmedizin, Ludwig Maximilian Universität Muenchen, Germany

Introduction

The use of computational human models for simulations in the field of traffic safety provides not only more biofidelic results from the use of dummies but also the ability to use active models that can produce a reaction closer to reality during a crash by activating their modelled muscles.[Verriest 2005]. This reaction can seriously alter the injury outcome of an accident [Ejima 2008]. The creation of these models demands the performance of biomechanical experiments with volunteers with various type of equipment for the recording of the human reaction (motion capture (MoCap), ElectroMyoGraphy (EMG), accelerometers, force plates, etc). The quantity and variability of the data types produced from these experiments hinders the analysis of the experiment's results. In the frame of creation of such a model for the head and neck complex of a motorcyclist during emergency braking, we performed an experiment with volunteers. Objective of this presentation is the analysis of the performed experiment with the use of biomechanical multi-body simulation software.

Methods

Eight volunteers with average age 29 years old participated in the experiment [Symeonidis 2012]. A motorcycle mock-up was designed and attached on a platform. The platform could move with constant accelerations until 0.7 G for 3 m distance. The platform was moving backward to the forward facing volunteer; in this way the platform motion was simulating the deceleration of motorcycle braking. A MoCap was used to capture the volunteer's kinematics while EMG electrodes were placed on specific neck muscles on the volunteer. An accelerometer was recording the platform acceleration. All signals were synchronised.

Two models were used for this analysis. A simple inverted pendulum on a cart was used as the model of the displacement of the moving platform (u), the torso rotation (q1), the neck (q2) and head rotation (q3). The kinematics data was used for the calculation of the joint angles, while the equations of motion allowed the calculation of the joints' torques. In a more detailed analysis an anatomical correct head neck musculoskeletal model [Vasavada 1998] with muscles, bones and joints was used with the biomechanical simulation software OpenSim ®. The analysis followed the next steps: (a) Scaling of the model to the volunteer's anthropometry, (b) Inverse kinematics calculation, (c) Inverse dynamics calculation, (d) Optimal distribution of the calculated joint torques to the neck muscles, (e) Forward simulation with the calculated muscle forces.

Discussion

Even though we were able to extract valuable results only by performing a kinematics analysis [Symeonidis 2012] the connection of kinematics with the muscle activity can offer a better insight in biomechanical experiments. However the study of the cause- result relationship between EMG and kinematics in complex systems as the head and neck produces the following difficulties: (a) Many articulations with many degrees of freedom each, (b) Large number of muscles with complex motion functionality, (c) Agonist-antagonist muscles. These difficulties are impossible to be faced with direct study of the recorded biomechanical signals while on the other hand the use of biomechanical model simulation software can offer useful results to the researcher.

References

Ejima, S. et al.(2008). Proc. of IRCOBI Conference on the Biomechanics of Impact, 163-178

Symeonidis, I. et al. (2010). J. Accident Analysis and Prevention, 2012(49): 212–222.

Verriest, J.P., & Vezin P., (2005). Proc. of the 19th International Technical Conference on the Enhanced Safety of Vehicles, paper no 163

Vasavada, A. et al., (1998). Spine, 23(4):412-422.