Comparison of Muscle Activated HBMs in a Lane Change Manoeuvre

Christian Kleinbach, Jörg Fehr

I. INTRODUCTION

The upcoming trends in the automotive industry, namely active safety and autonomous driving, will require a new type of occupant model for the development of safety systems. As the focus of vehicle safety is shifting towards scenarios with lower acceleration levels, traditional surrogate models developed for high acceleration levels no longer suffice. The best possible replacement are simulation models of the human body including muscles, which are often described as active human body models (AHBMs).

After implementing muscle activity and muscle activation dynamics into the Global Human Body Model [1], the question arose, if such a model is capable of reproducing real world test results in a low g scenario. It was decided to use a lane change manoeuvre which was tested in the OM4IS project with volunteers [2]. To compare the capabilities of the model, it was tested against an AHBM which is developed for low g manoeuvres explicitly, the Madymo AHBM by TNO [3].

II. METHODS

In this study lane change manoeuvres were simulated in the Madymo multibody software and the LS-Dyna finite element software for a passenger. A trajectory was applied to both seat models which replicated the timing and acceleration found in [2]. An identical seatbelt mechanism was modelled in both setups, which initially removes slack and is then locked, to mimic the experimental setup in [2].

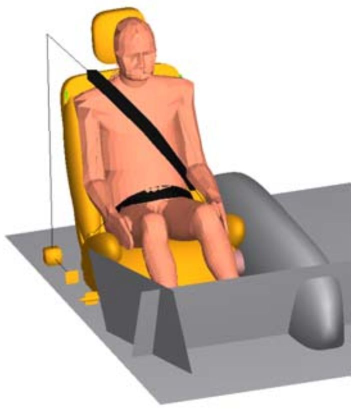

Fig. 1. The Madymo setup with the AHBM.

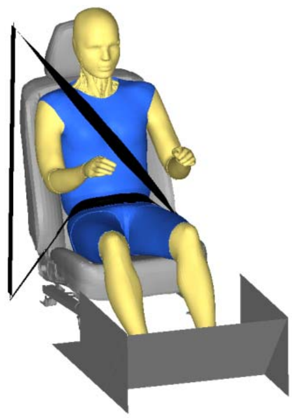

Fig. 2. The LS-Dyna setup with the activated GHBMC.

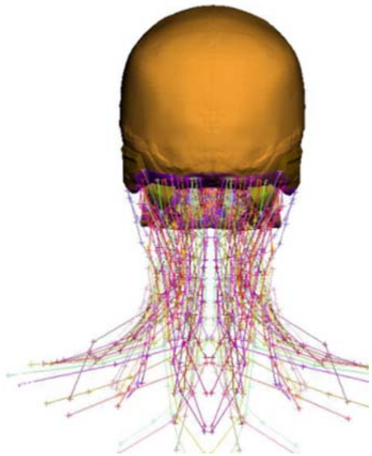

Fig. 3. Detailed view of the neck muscles in the GHBMC.

Madymo Setup

The multibody setup shown in Fig. 1 is based on the Application Model for Integrated Safety [4], the setup is reduced in complexity, i.e., contacts to the door and headrest had been removed. To guarantee that the model is in equilibrium and the AHBM muscles are initialized correctly, a presimulation was conducted. The human body model in Madymo offers several parameters to tune the muscle activation, such as cocontraction level or reaction time. Simulations were run to analyse the influence of these parameters and also force levels of the seatbelt pretensioning on the motion of the AHBM.

Christian Kleinbach is a Research Associate and Doctoral student at the Institute of Engineering and Computational Mechanics at the University of Stuttgart, Germany (christian.kleinbach@itm.uni-stuttgart.de, +49 711 685 66490). Jörg Fehr is Junior Professor at the Institute of Engineering and Computational Mechanics at the University of Stuttgart, Germany.

LS-Dyna Setup

In the finite element (FE) setup a seat extracted from a 2012 Toyota Camry model [5] was used together with a simplified floor pan, see Fig. 2. The human body model used in the FE simulations is a muscle activated version of the Global Human Body Model Consortium-owned GHBMC Model presented in [1]. The 916 muscle elements depicted in Fig. 3 were activated individually based on element strain taking into account muscle activation dynamics. As shown in Fig. 2 the neck skin was removed because initially the model was too stiff and too little motion was observed in comparison to volunteer tests, as discussed in [1]. For the FE setup, a seating simulation was conducted as well, to get more accurate initial conditions.

III. INITIAL FINDINGS

Analysing the lateral displacement of the head of the AHBM in Fig. 4 the large influence of the muscle activation is visible. The comparison also shows that differences between a lane change to the left and to the right mostly are visible in the second phase of the manoeuvre. Please note, that the displacements for the lane change to the right are inverted in Fig. 4.

In Fig. 5 the lateral displacements of torso and head for the passive GHBMC are plotted for a lane change to the right. Compared to the multibody simulations in Fig. 4 similar peak values are seen. However, the asymmetry between first and second half of the manoeuvre is larger. In comparison with the experimental results, the peak values are probably a little bit too high in both setups. As Fig. 5 shows the passive GHBMC model; the active model might yield displacements very close to the experimental findings.

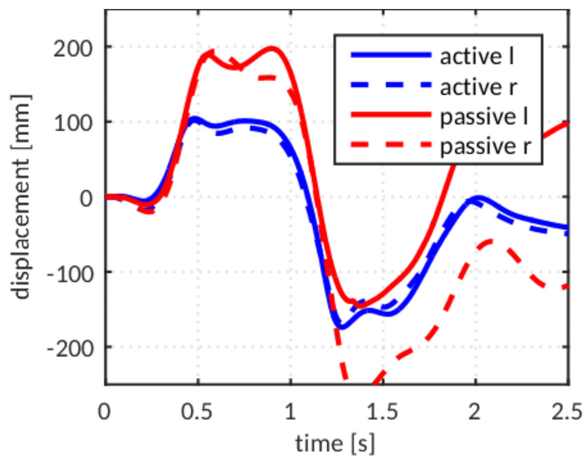

Fig. 4. Lateral head displacement of the AHBM in Madymo of the active (muscle activated) and passive

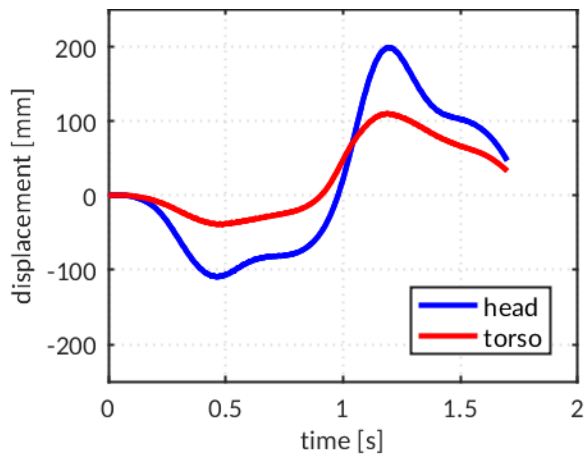

Fig. 5. Lateral head and torso displacement of the GHBMC.

IV. DISCUSSION

The first results presented above show that the peak displacements of the head and torso are close to the corridor of the experimental results in [2], i.e. 107±37 mm (left) and -123±72 mm (right) peak lateral head displacement. However, there are a few open questions remaining, i.e., how much pretensioning force is needed to remove the initial slack of the seatbelt without compromising the rest of the simulation? Unfortunately, no information on the belt force is available from the experiments. The second question focused more on the HBM; how to differentiate correctly between too stiff passive and correct active behaviour? More analysis of the body kinematics is needed here. While the ultimate goal of AHBMs is their application in vehicle simulations, more simple setups are needed to reduce the overall complexity of the development and validation of such models.

V. REFERENCES

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