Kinematics Evaluation of Female Head-Neck Model with Reflexive Neck Muscles in Low-Speed Rear Impact

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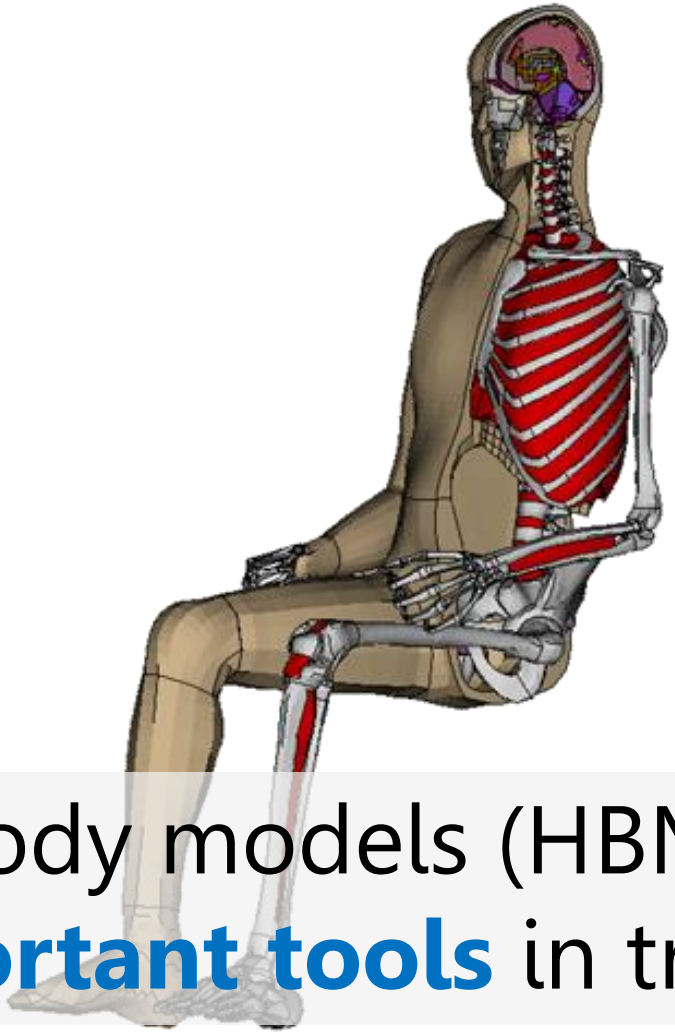
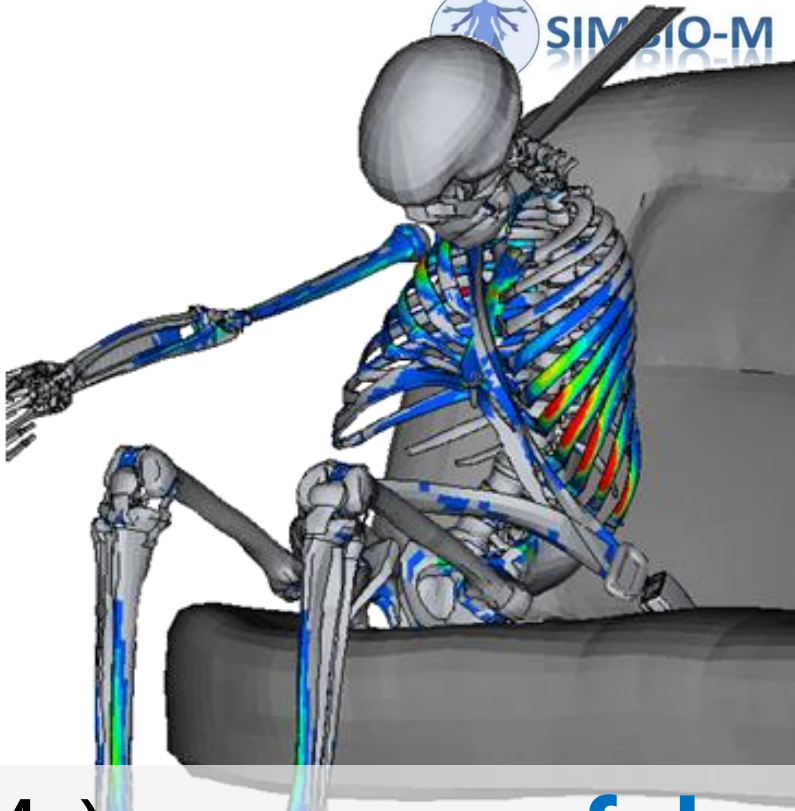
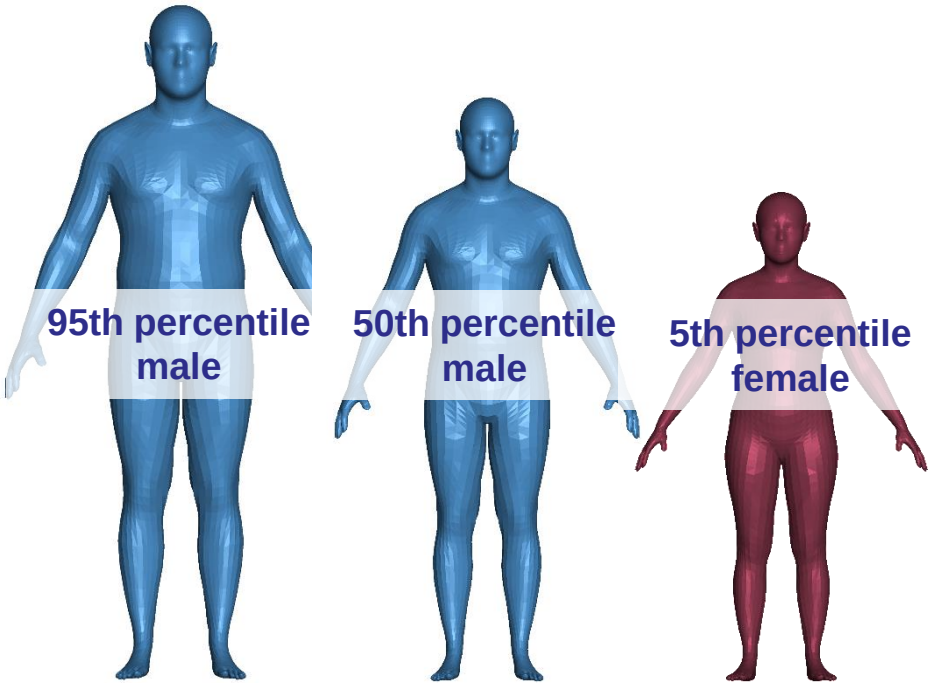
Why we did this study?





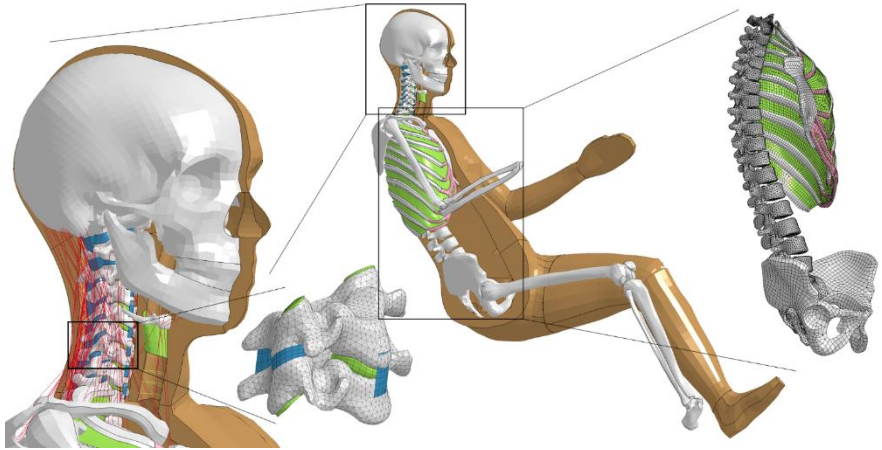
Human body models (HBMs) are **powerful and important tools** in traffic safety

Until recently, finite element (FE) HBMs that represented an **average female anthropometry did not exist**

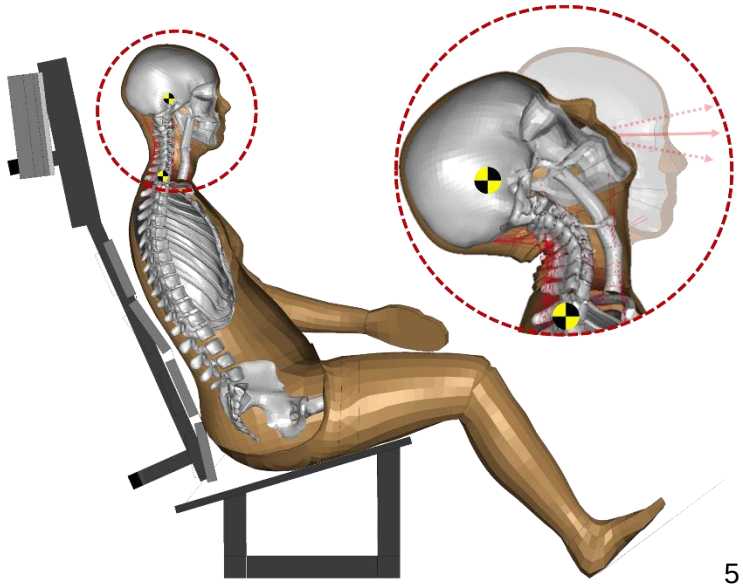


Despite, injury statistics have shown that **females have a higher risk** to sustain injuries compared to males

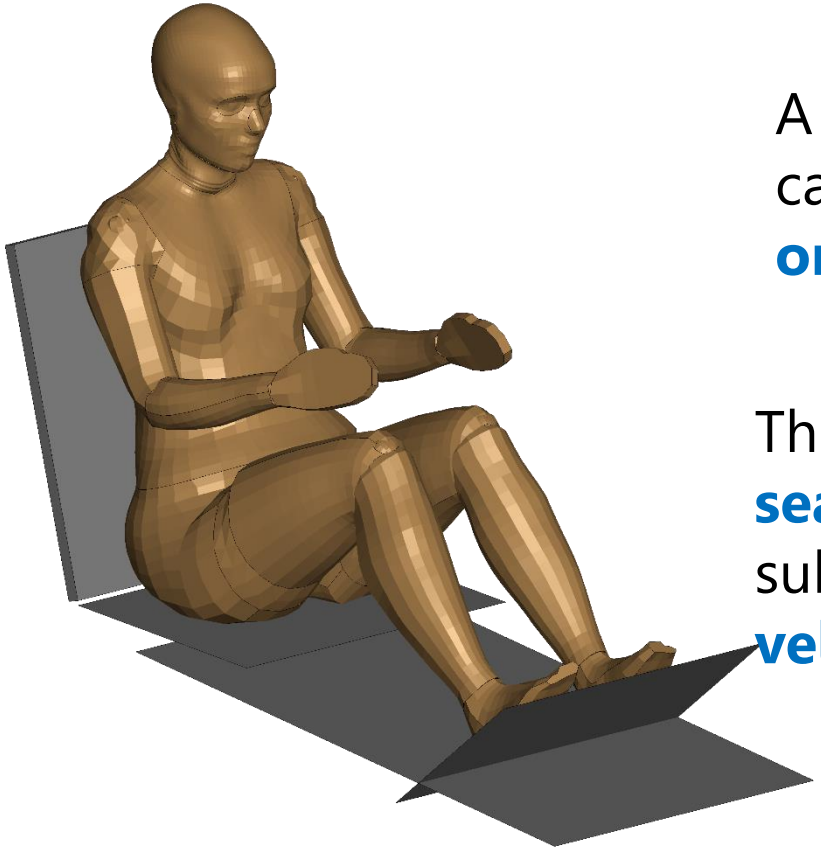
To fill this gap, **an open-source** HBM that represents an average female size called **ViVA OpenHBM was developed**



With muscle controllers, the HBM **kinematics was improved** compared to passive responses



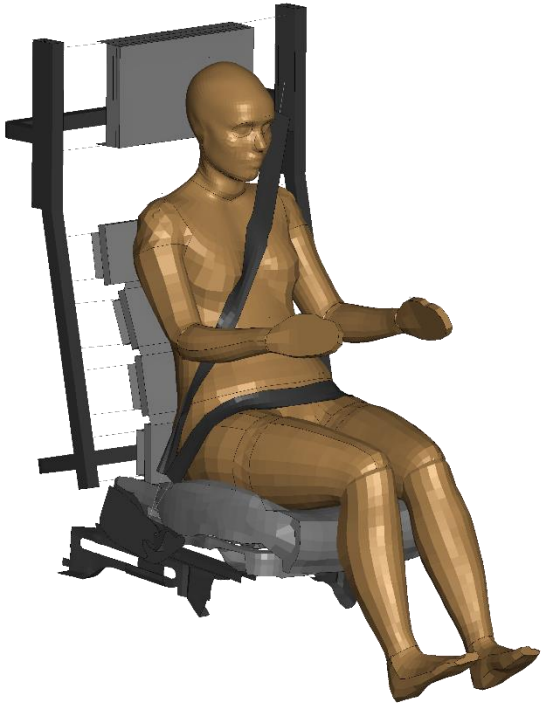
The ViVA OpenHBM has been has been further developed by **adding active reflexive neck muscle controllers**



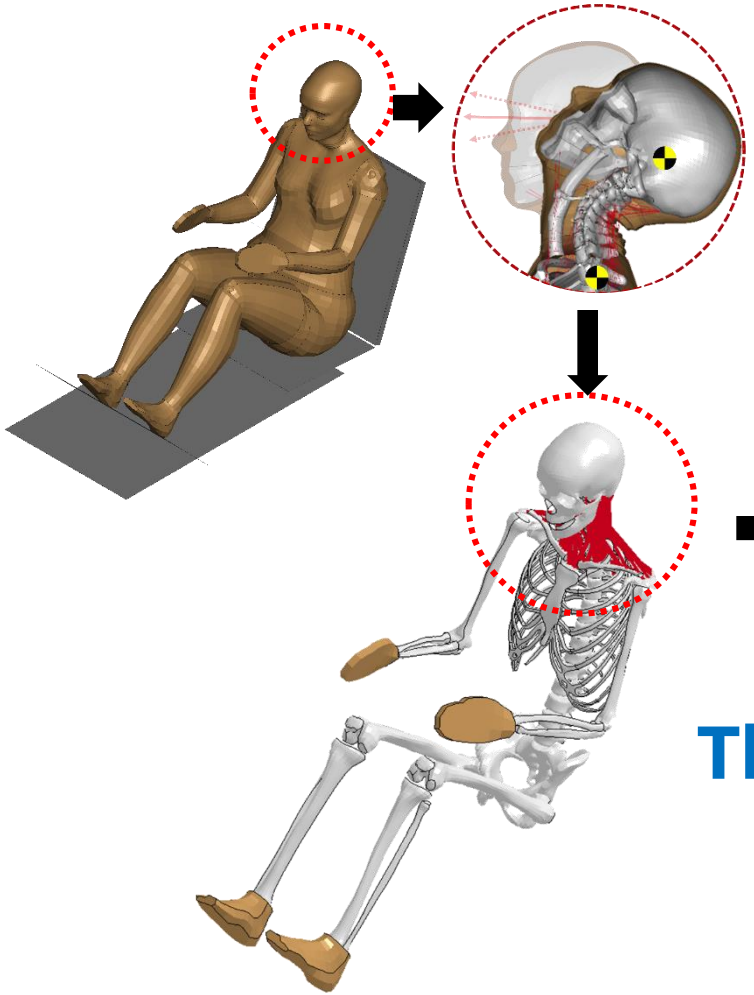
A limitation was that data used to calibrate the controller was based **on only two female volunteers**

These volunteers were seated in a **rigid seat without a head restraint** and subjected to a crash pulse with **a delta velocity of 5.8 km/h**

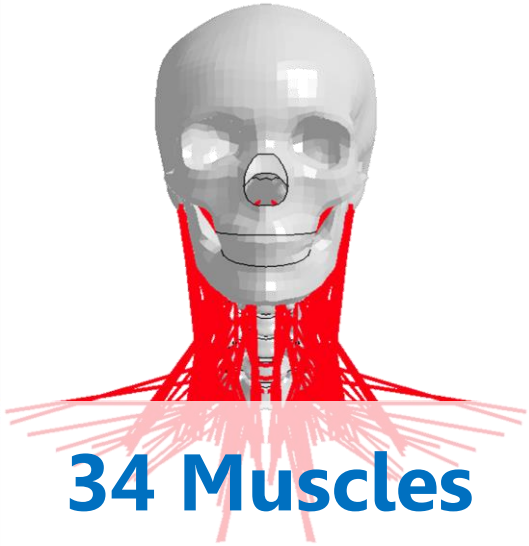
The objective of this study was to **evaluate the active ViVA OpenHBM kinematics** by comparing the model with other volunteer data



How we did this study?



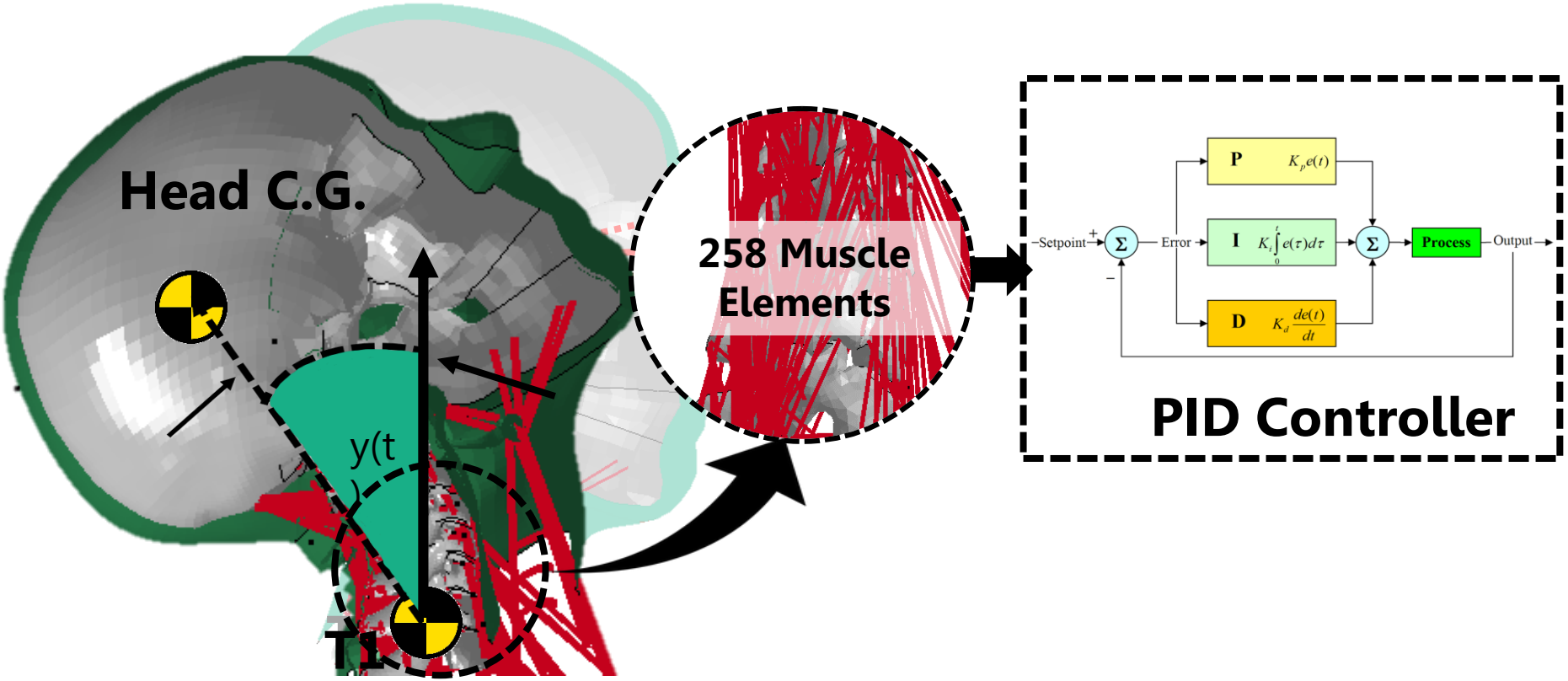
With active muscle controller approximating Vestibulocollic Reflex (VCR)



34 Muscles

The Active ViVA 50th Percentile Female Head-Neck Model

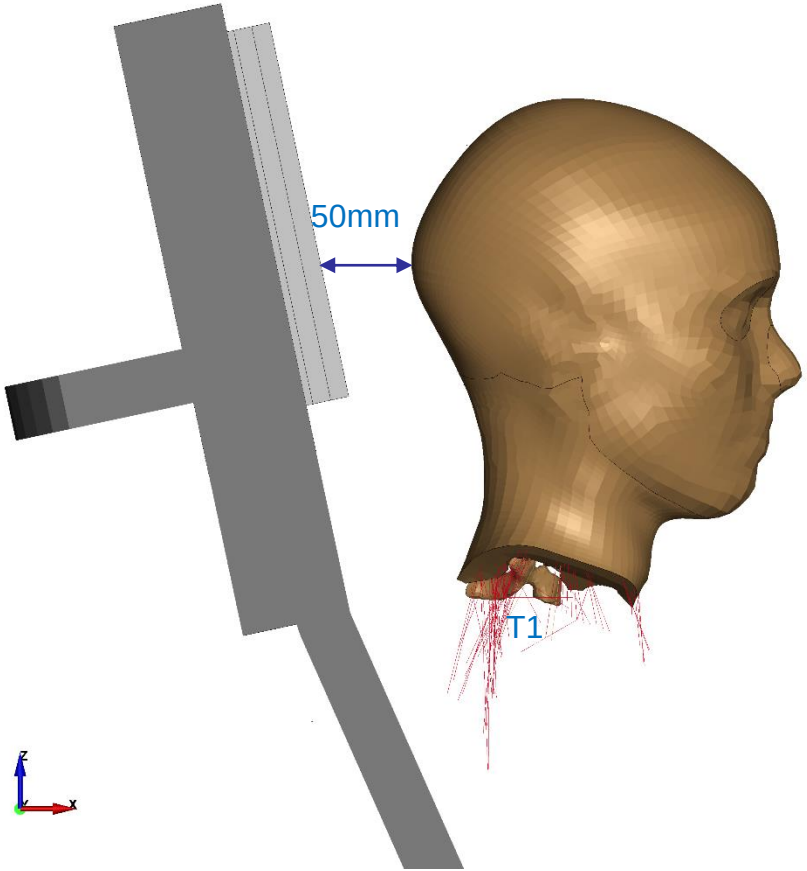
Approximating function of Vestibulocollic Reflex (VCR)



A low-speed rear impact volunteer test

- **6 female volunteers**
- Velocity changes of **5.1±0.1 km/h** and **6.8±0.1 km/h**
- Average **stature and mass were 164cm and 59kg**
- The lab seat was developed to represent a commercial car seat in **terms of shape and deformation properties**

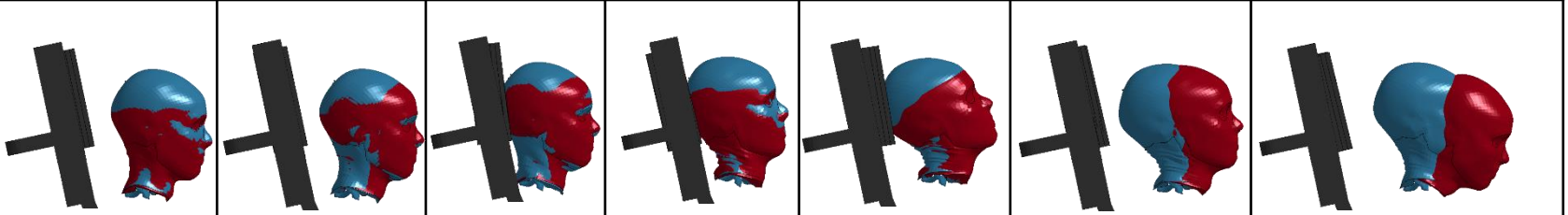
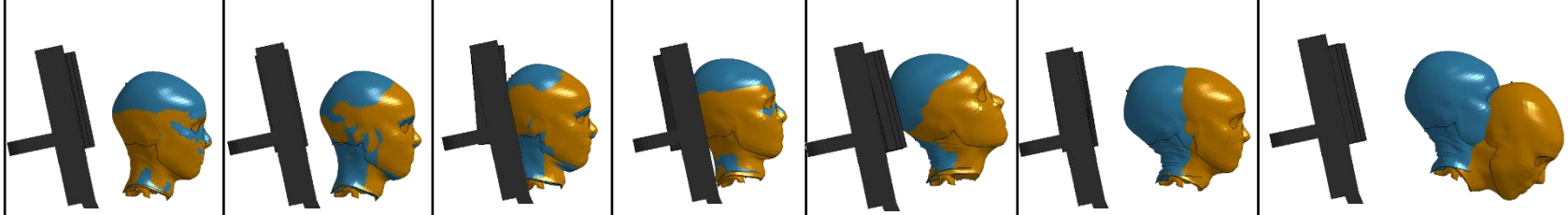
Boundary Condition



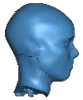
- The **T1 vertebral and seat back frame motion was prescribed** according to the volunteer test results
- Head to headrest **distance** was **50mm**
- The **corresponding seat FE model** was adopted **from published-validated model**
- Total simulation time was **400ms** including **100ms of settling time**

What were our main results?

Kinematics Comparison

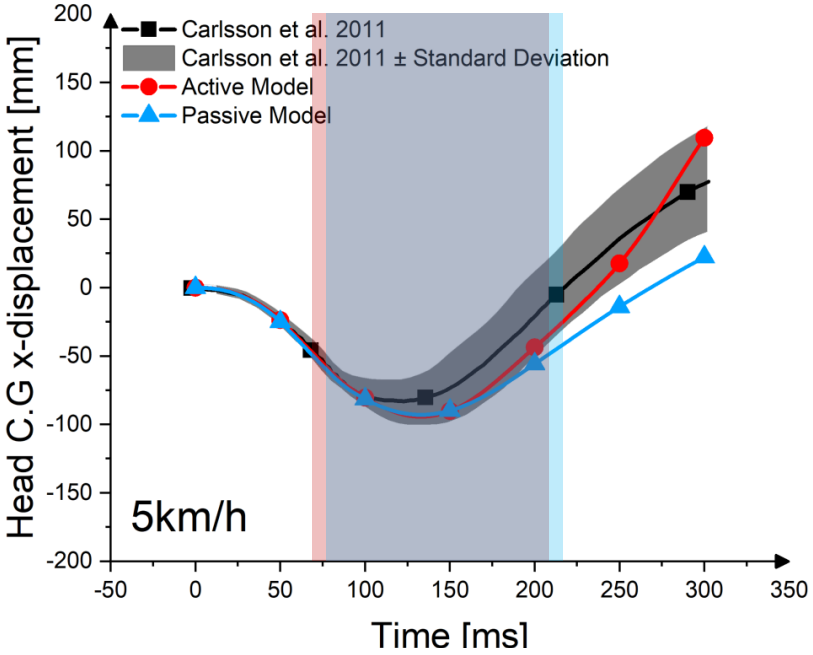
Impact Speed	0ms	50ms	100ms	150ms	200ms	250ms	300ms
5km/h							
7km/h							

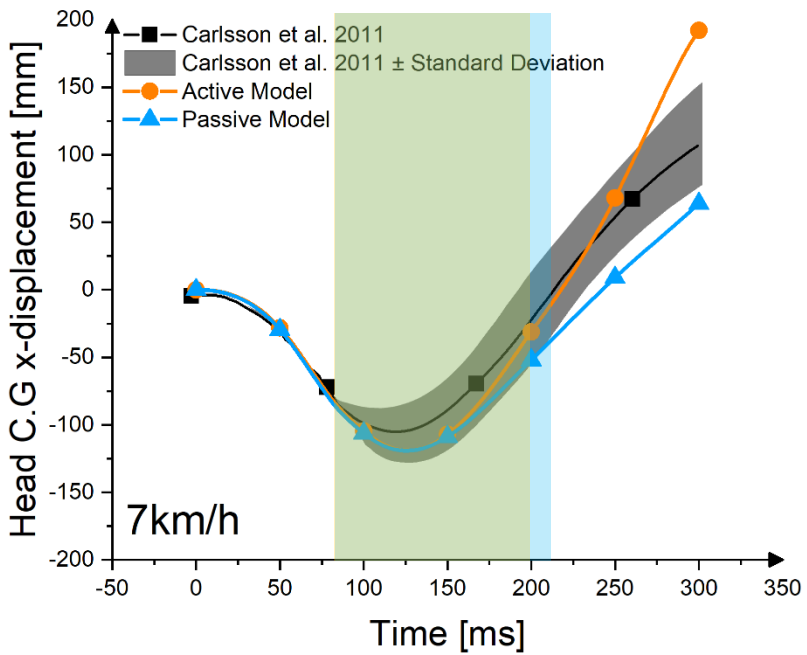

Active model at 5km/h


Passive model at 5km/h and 7km/h


Active model at 7km/h

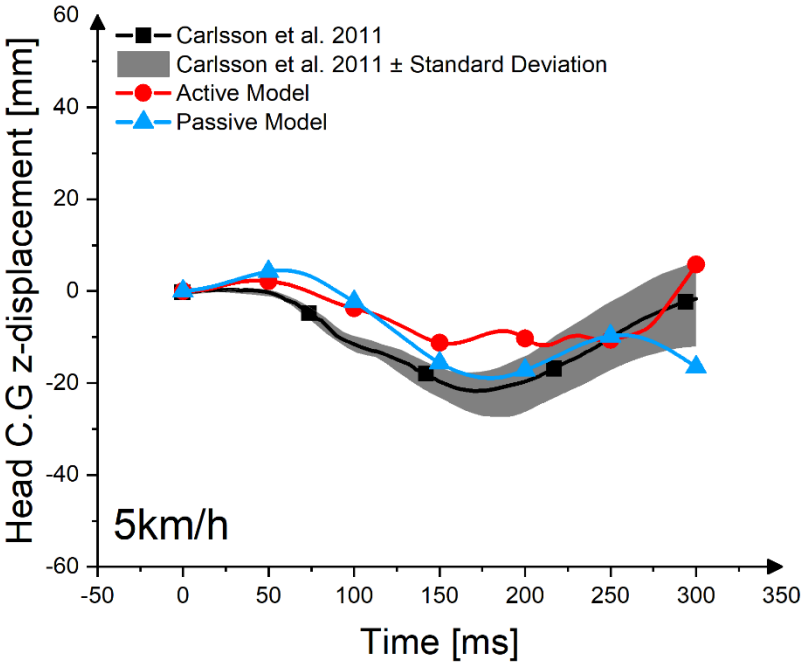
Head Horizontal Displacement

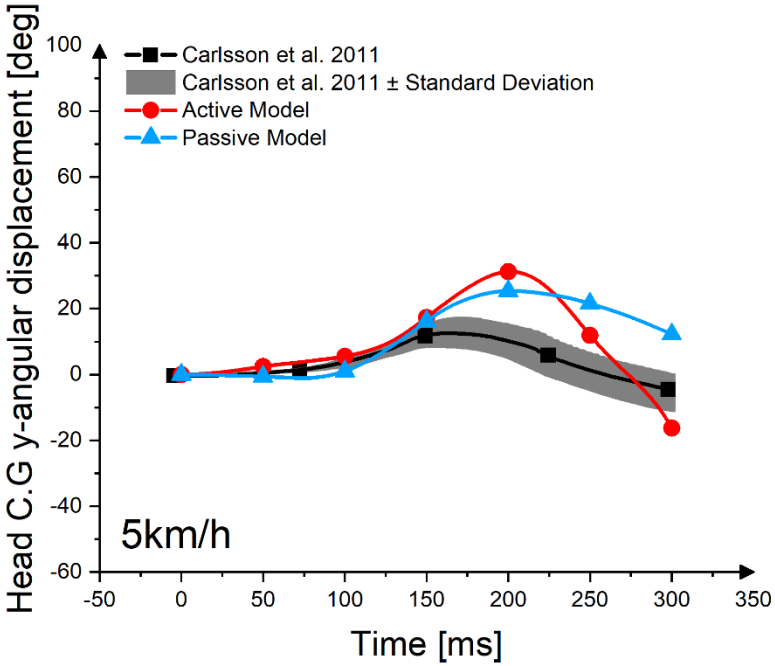




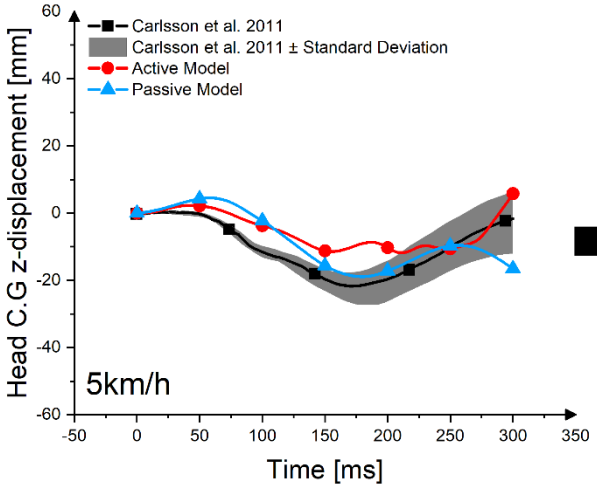
- The inclusion of **reflexive neck muscle** response resulted in **a better agreement** for **horizontal head displacements** compared to the PMHS-like passive model at both delta velocities

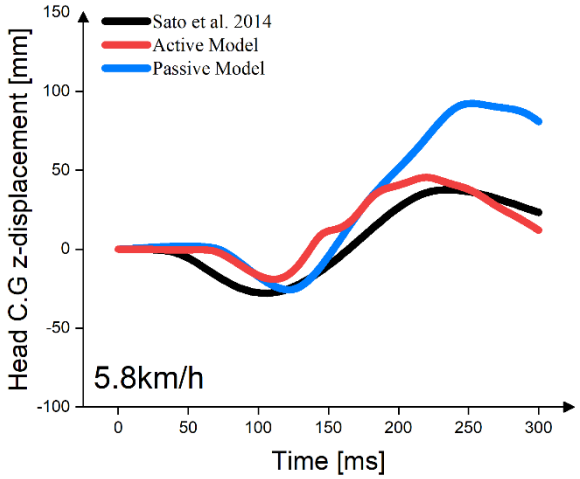
Head Vertical and Rotational Displacement

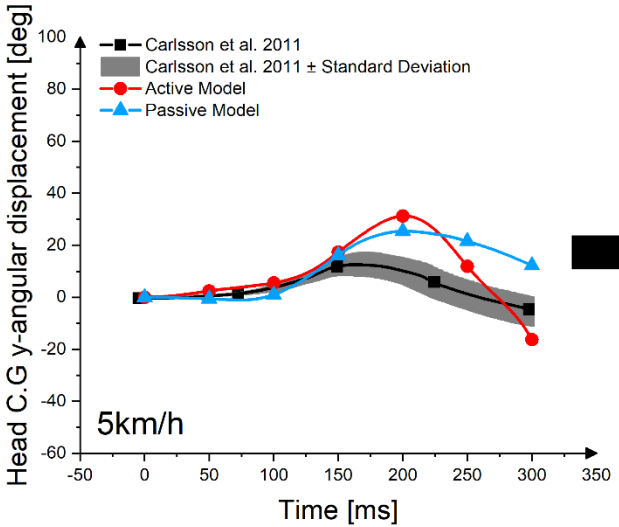


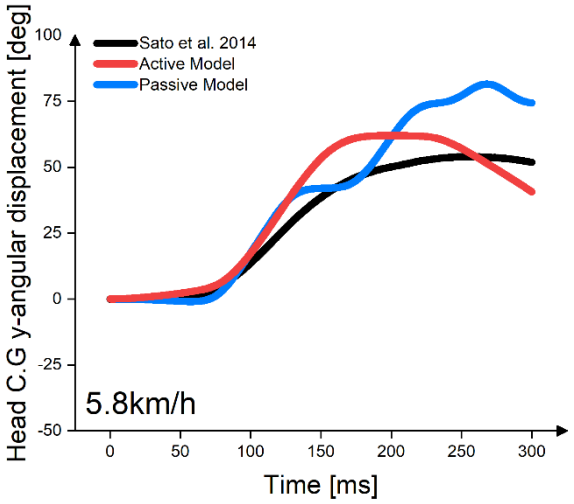


- The active model **produced limited improvement** to the vertical and rotational motion biofidelity
- These trends are **similar to previous results** from the calibration study









- The active model **could not fully capture** the volunteer history responses
- But still **provided some improvements** over the passive model in the first **100-150ms** of the event
- This time period is the **critical time** for some **proposed whiplash injury mechanisms**

What were the conclusions?

Conclusions

- This study shows that the model with active muscle controller can **give similar kinematics results** when was used **in a more complex setup and at different impact speeds.**
- This study highlights that an **additional calibration study needs to be conducted** to increase the kinematic agreement of the active model **in head vertical displacement and rotation.**
- This study demonstrates **the importance of including an active muscle controller** to achieve more **realistic modeling of occupant kinematics.**

Acknowledgments

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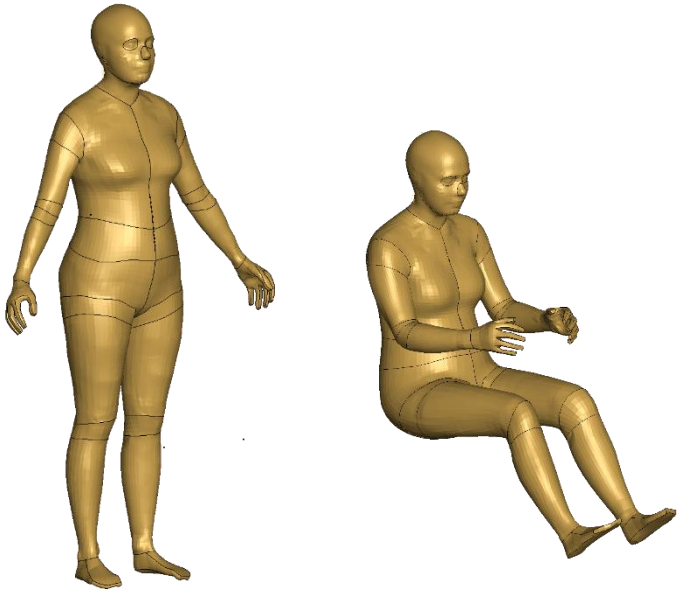
ViVA II Project

A new version of the 50th percentile open-source female HBMs **are being developed…**



More info: **https://projectvirtual.eu/**