Analysis of Occupant Motion in Pre-Crash AEB Manuevres in Current and Future Seating Positions

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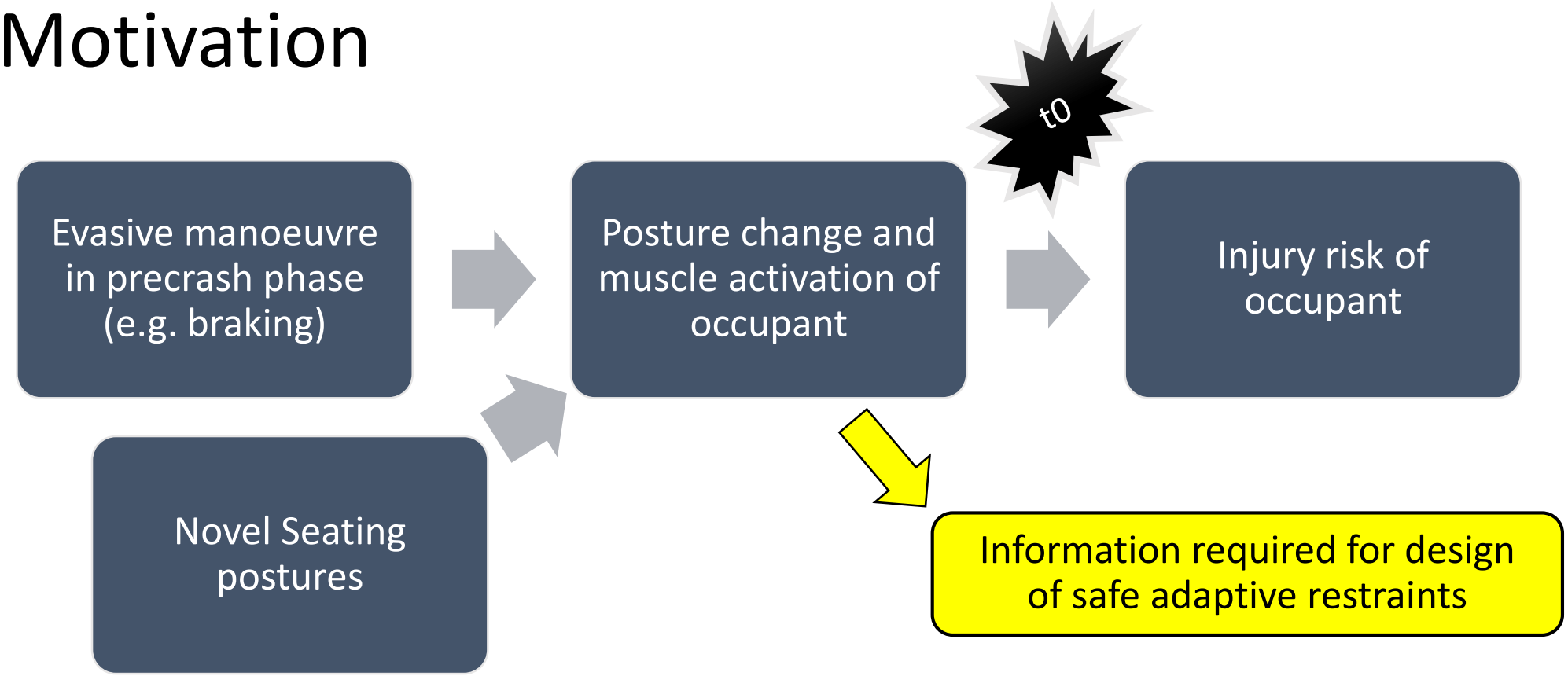
Motivation

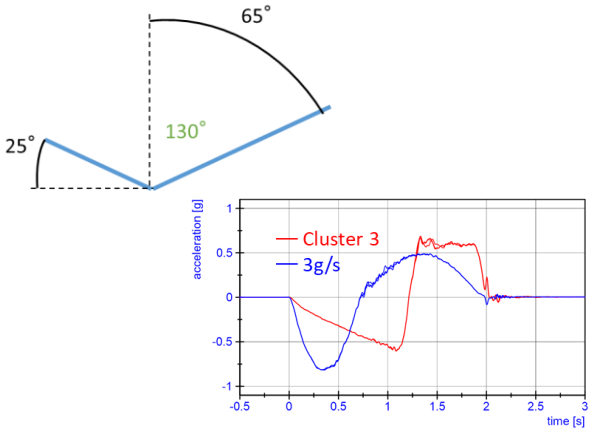


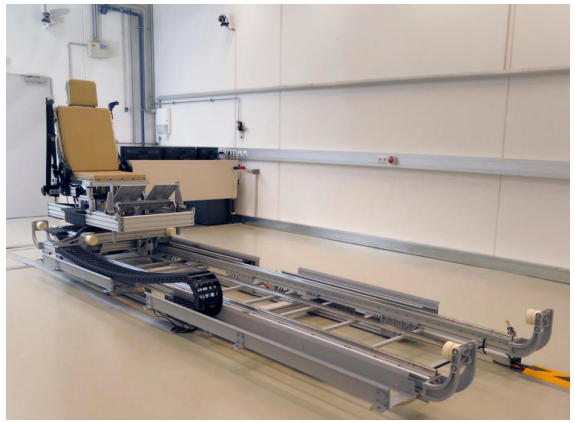
Objectives/RQ:

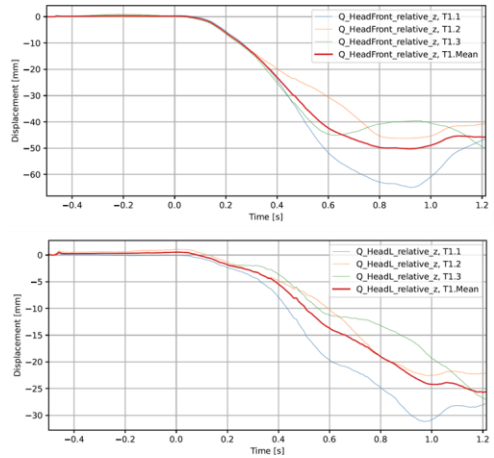
- Difference in occupant kinematics and muscle activation in current and future seating positions
- Gender specific differences
- Influence of AEB characteristic on kinematics and muscle activation

Method

Research approach







Definition of Seat postures and AEB Pulses

- Upright, reclined, 0g seat settings
- Literature based AEB-Clusters, 3g/s

Definition of Test Setup

- LowG testrig
- DAQ
- Distraction of volunteers

Volunteer Tests

- different AEB-pulses and seat postures
- Even share of volunteers

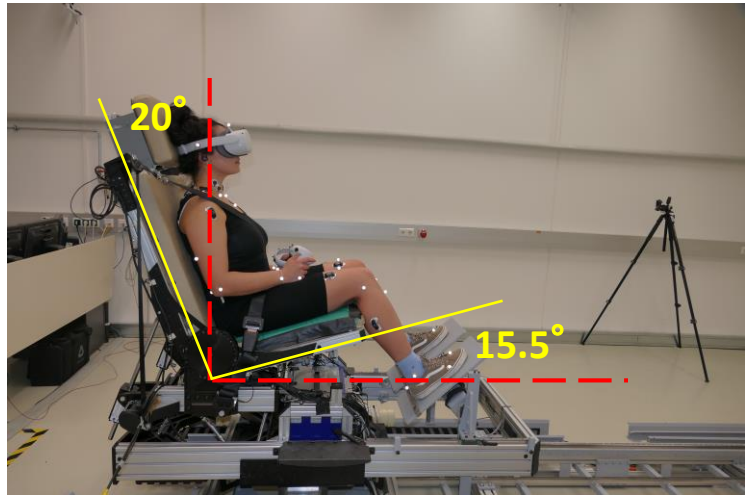
Data Analysis

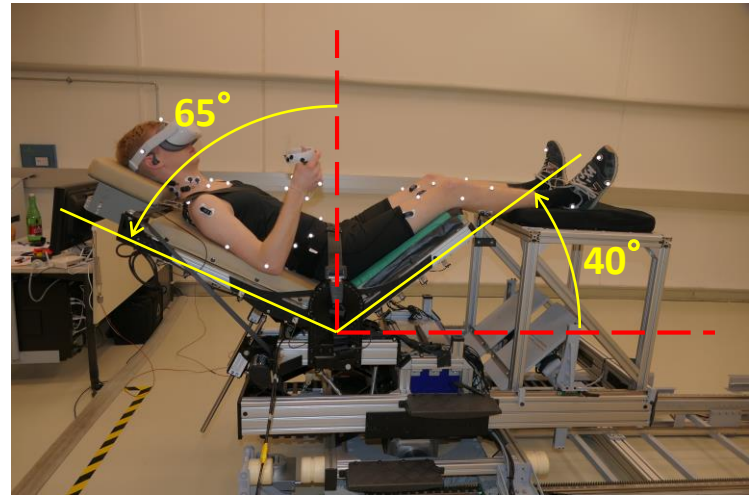
- Results
  - Occupant kinematics
  - Muscle activation
  - Reaction forces (feet, belt)

Definition of Seat postures and AEB Pulses

Seat postures

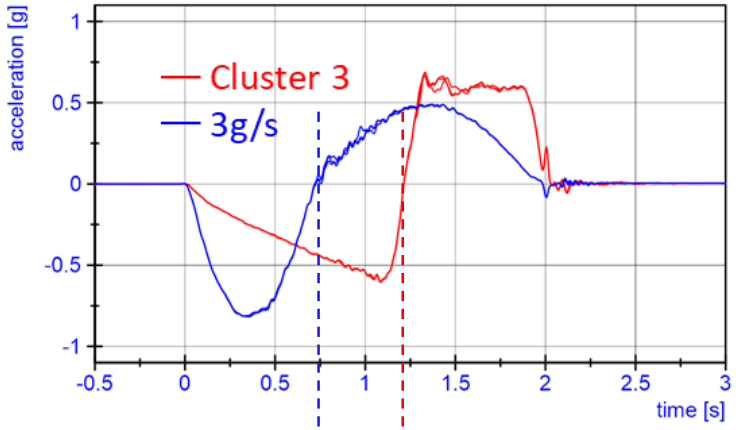
- Upright seating position (e.g. based on Mroz et al. 2021)
- 0g- Seating position based on Stanglmaier et al. 2020
  - Analysis of contact pressure





AEB-Pulses

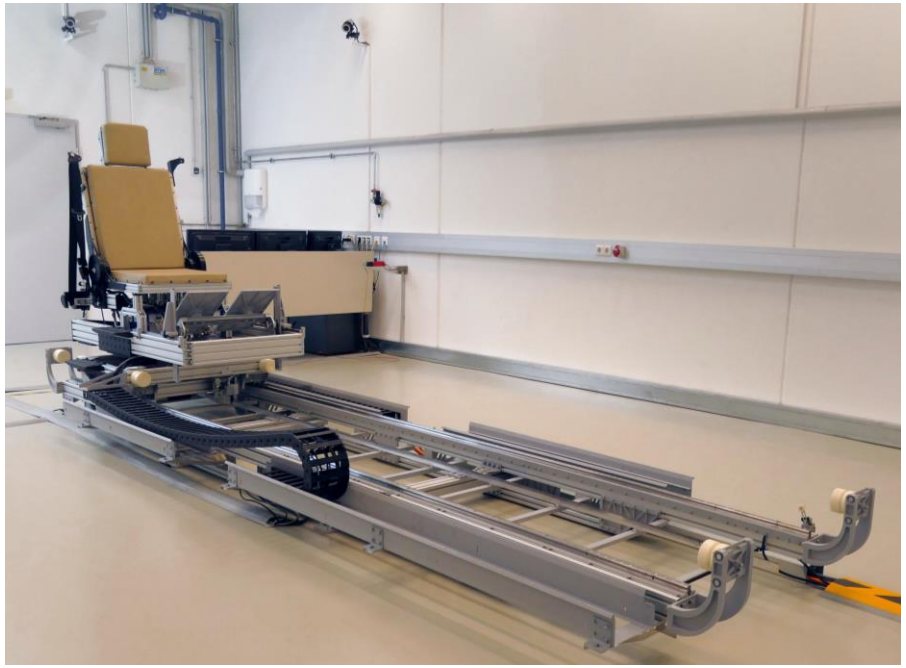
- 2 AEB pulses tested
  - Cluster 3 (onset 0.65g/s) based on Graci et al. (2021)
  - Generic pulse with higher onset (3g/s)
- Evaluation of occupant response during acceleration phase

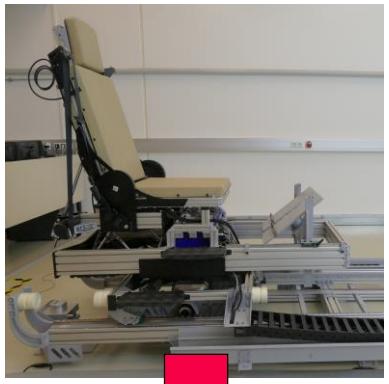


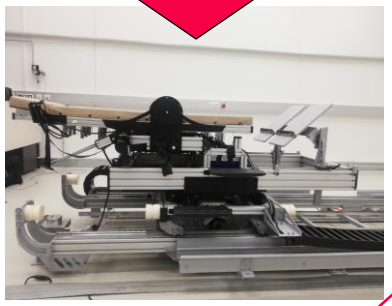
The LowG test bed

Basic information:

- Maximal travel length: 3.75m
- Maximal velocity: 4.3 m/s
- Maximal acceleration: 10m/s²
- High safety standards



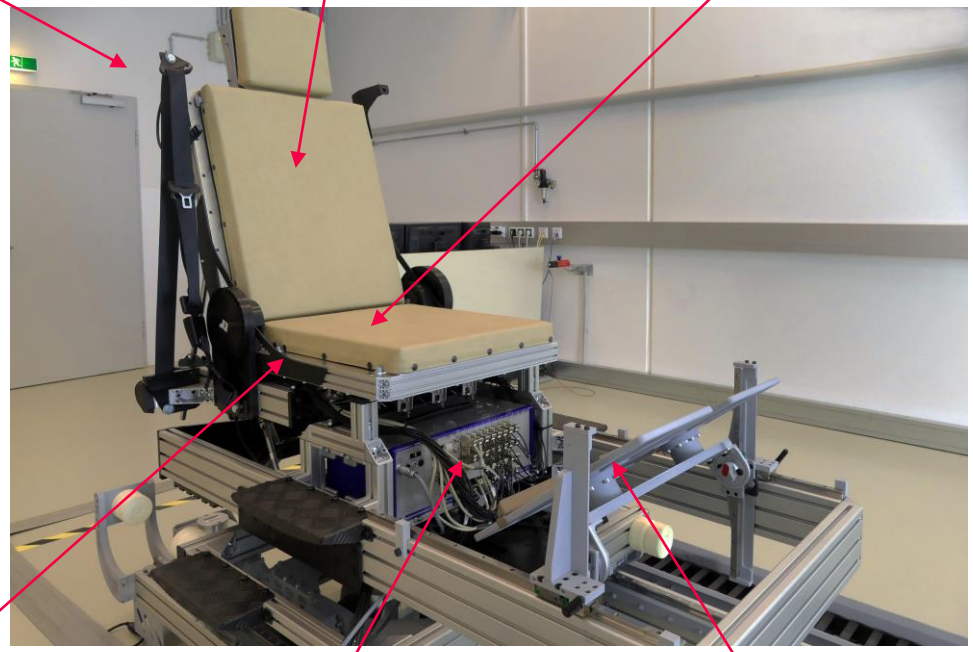




Belt adaptable for driver and passenger

Back rest rotation possible from vertical (90°) to flat (0°)

Simple geometry of seat foam



Seat cushion rotation possible from flat (0°) to vertical (80°)

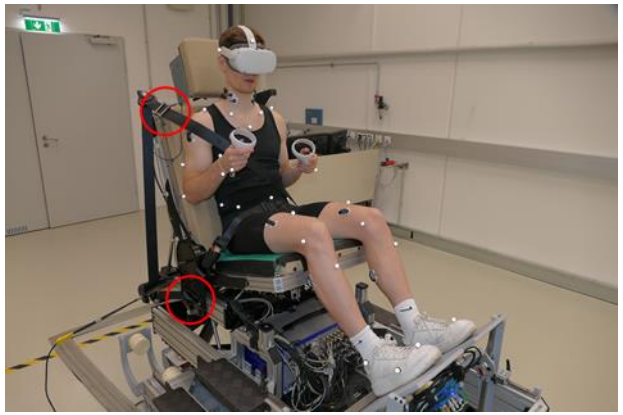
Onboard DAQ

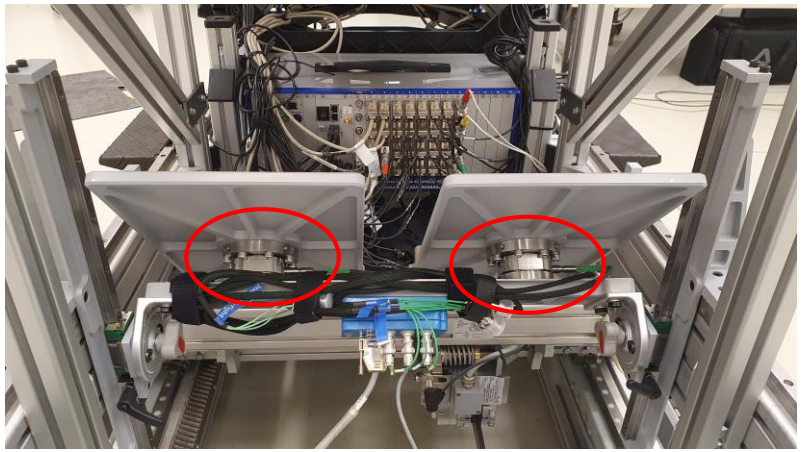
Footrest adjustable for all anthropometries

Data Aquisition

- 3D Motion capturing of reflector targets (Qualysis)
- Wireless EMG-System
  - 24 channels with focus on muscles active in torso/neck rotation
- Forces of shoulder- and lapbelt
- Feet support forces (upright position)

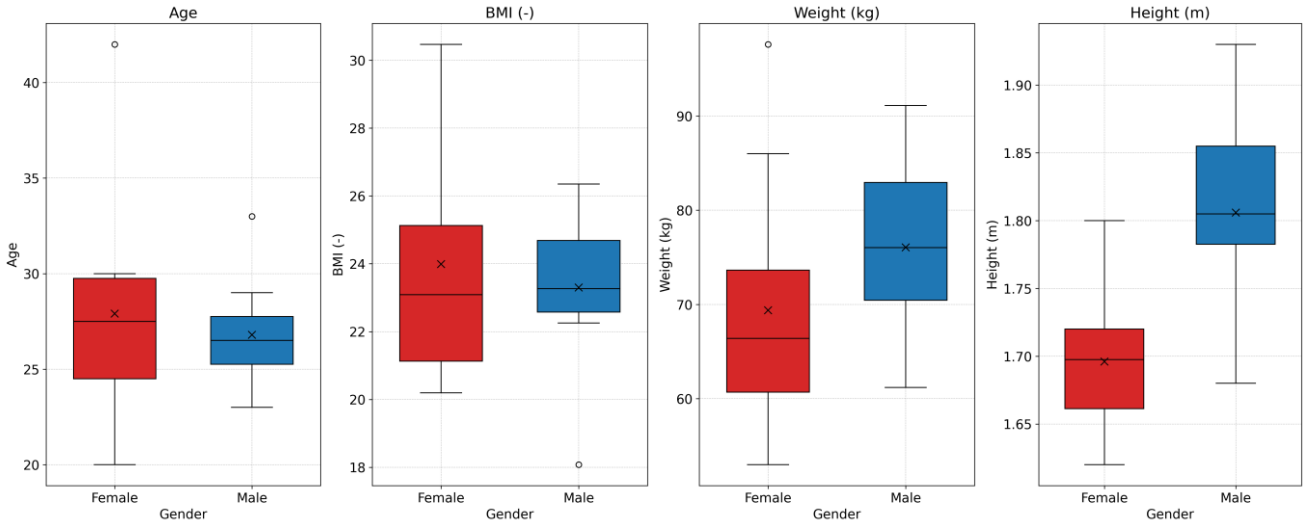
- Further
  - Foam compression
  - Pressure distribution seat pan





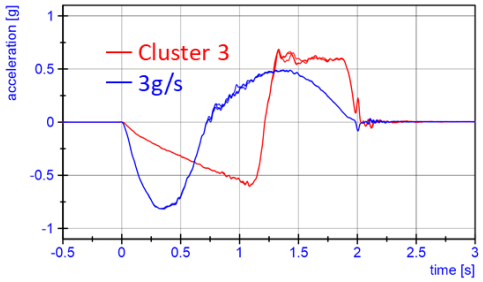
Volunteer tests

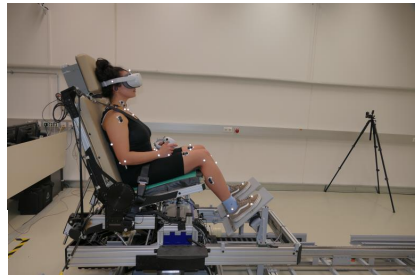
- 20 Volunteers tested
  - 10 female + 10 male
  - Median-Age: 27.5y (female), 26.5y (male)
  - Median-Height: 1.70m (female), 1.81m (male)
  - Median-Weight: 66.4kg (female), 76.0kg (male)
  - Median-BMI: 23.1 (female), 23.3 (male)

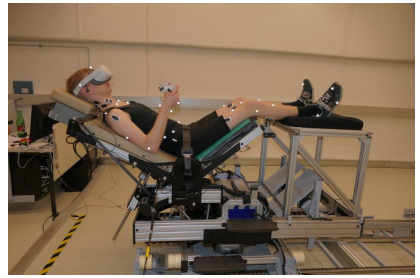


- Test Matrix
  - Familisarisation + 3 repetitions of each combination of seat position and AEB pulse → 14 tests

	Seat	Pulse
T0.1	upright	0.5g sinus
T0.2	upright	0.5g sinus
T1.1	upright	Cluster 3
T1.2	upright	Cluster 3
T1.3	upright	Cluster 3
T2.1	upright	3g/s
T2.2	upright	3g/s
T2.3	upright	3g/s
T3.1	0g	Cluster 3
T3.2	0g	Cluster 3
T3.3	0g	Cluster 3
T4.1	0g	3g/s
T4.2	0g	3g/s
T4.3	0g	3g/s







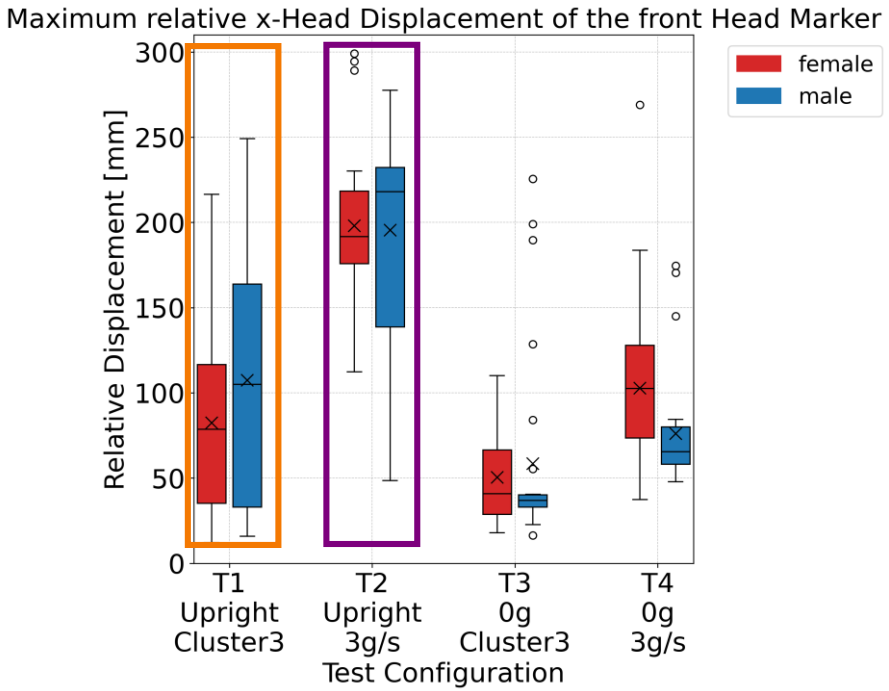
- Distraction
  - VR-Set + music

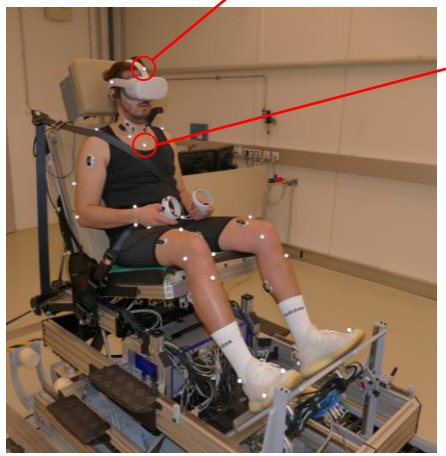
[1] https://matplotlib.org/stable/api/_as_gen/matplotlib.pyplot.boxplot.html

Selected Results

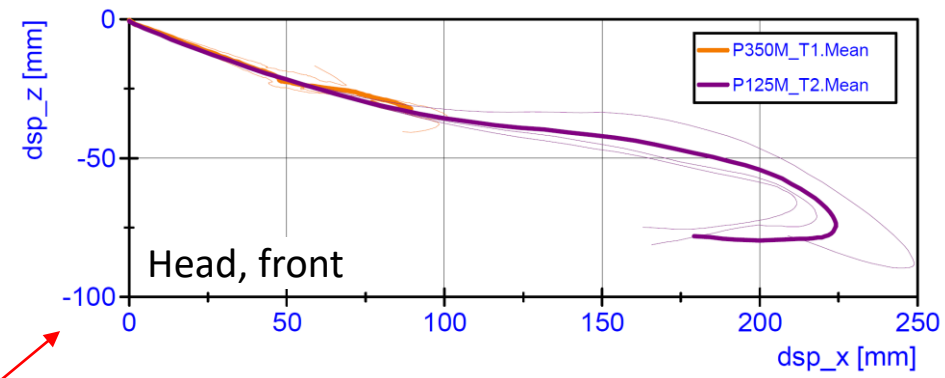
Head displacement, Neck angle

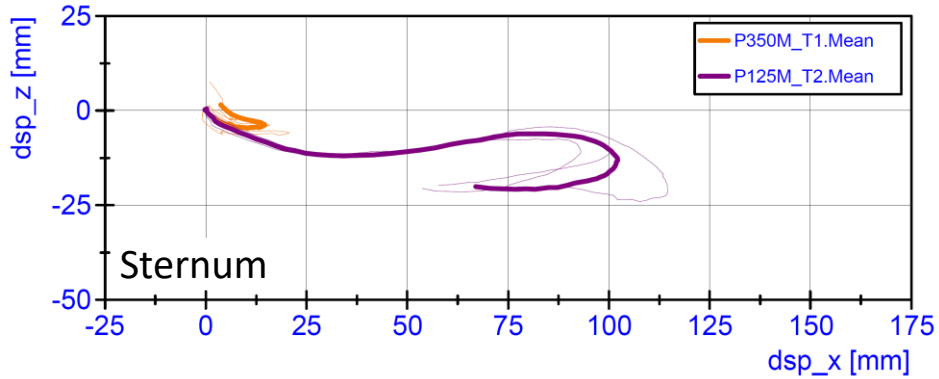
- Pulse influence
  - Similar initial head trajectory for both pulses
  - Neglectable torso rotation for Cluster 3 AEB-Pulse
  - Significant influence of AEB characteristic on head excursion, torso rotation and neck angle

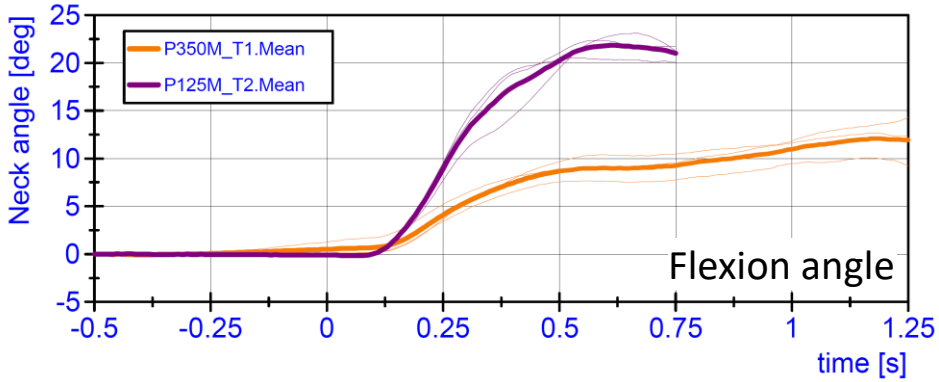




Selected exemplary test data:

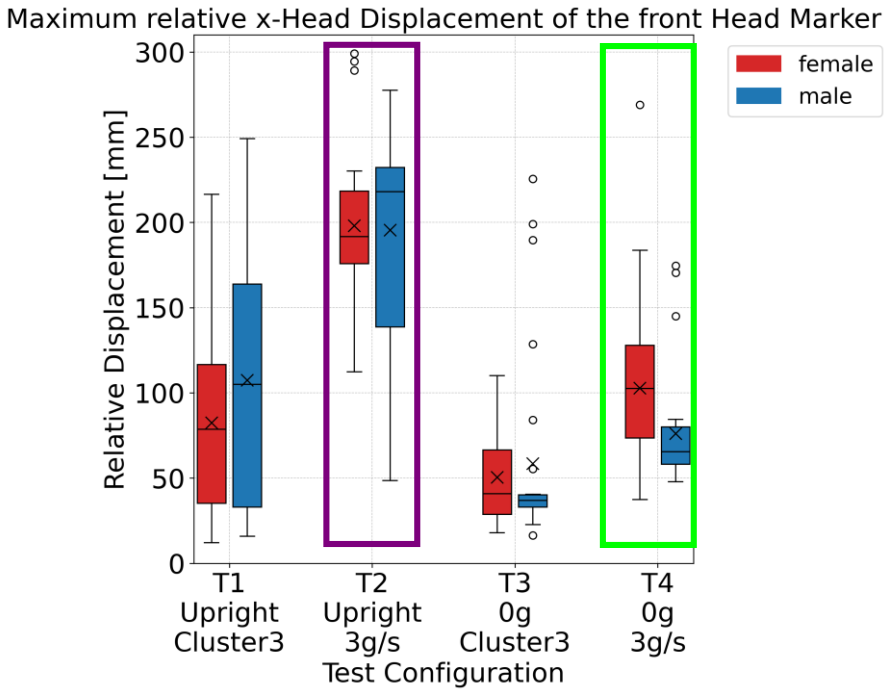


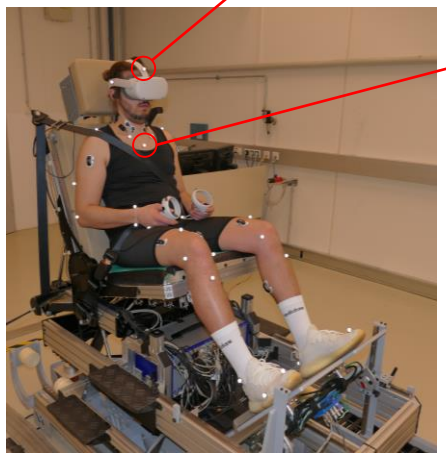




Head displacement, Neck angle

- Influence of seat position
  - Different initial trajectory of head motion for different seating positions
  - Torso „slides down“ seatback w/o significant rotation
  - Similar peak neck angle but earlier neck rotation for 0g seating





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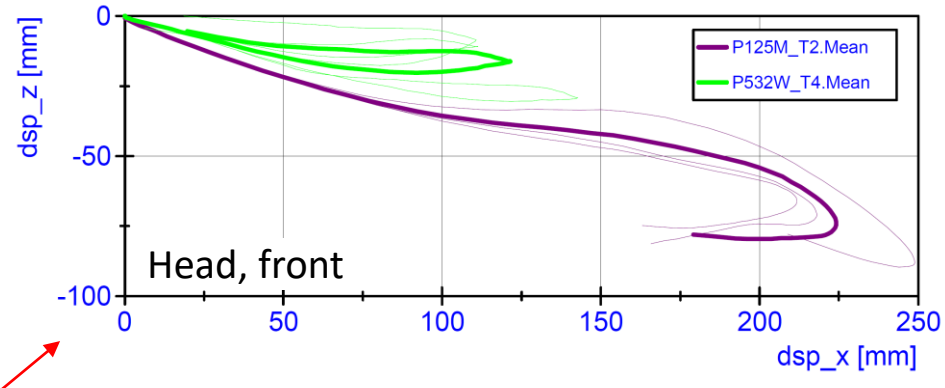
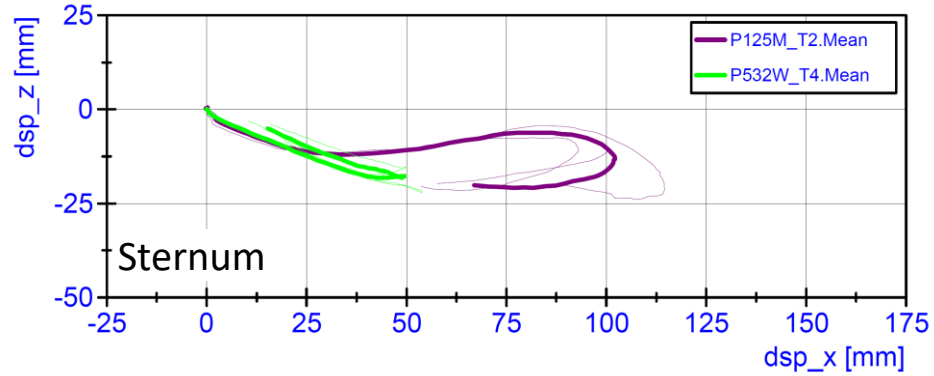
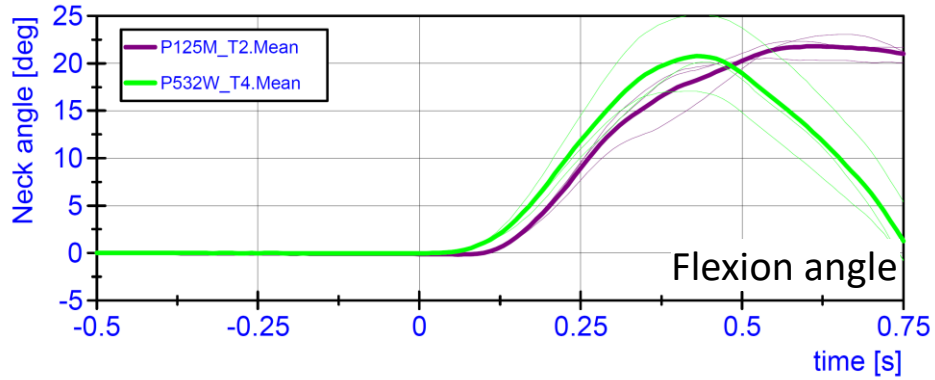




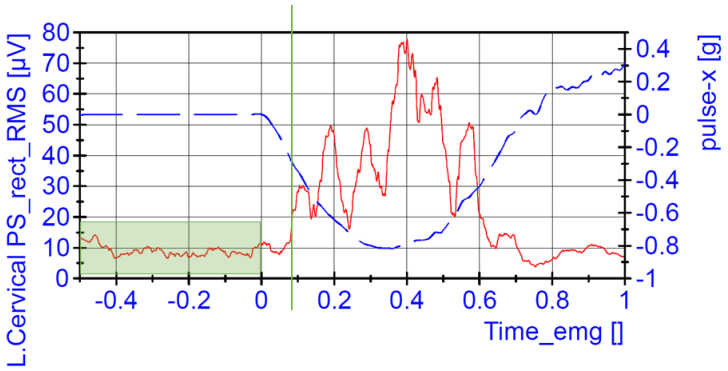


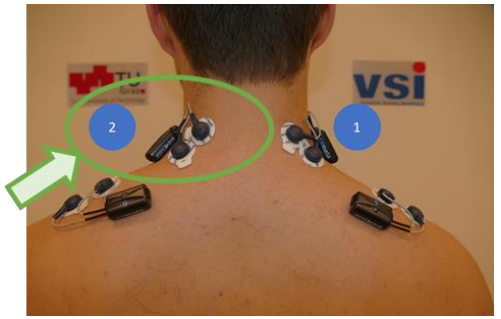
Muscle Activation

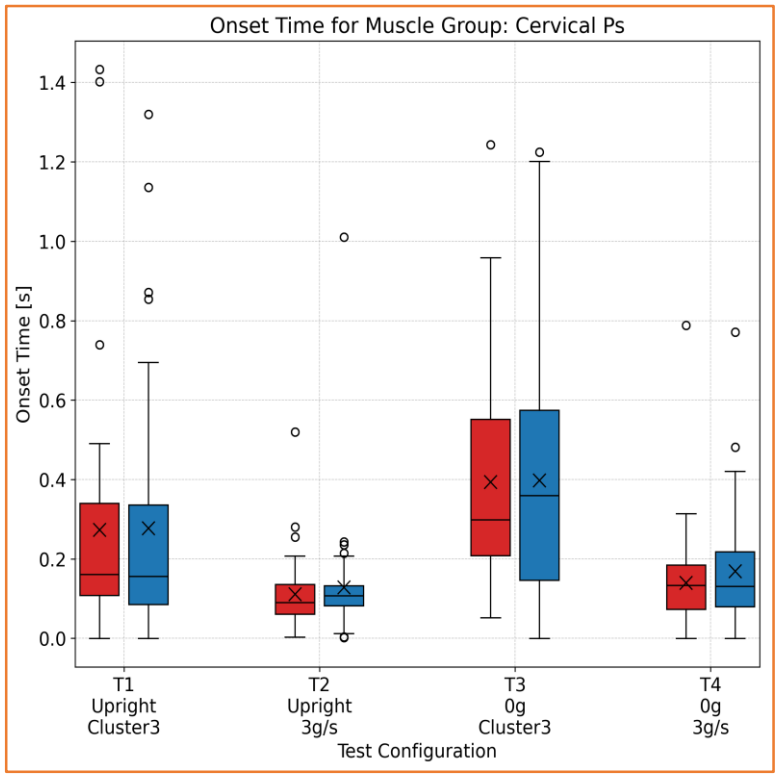
- Analysis of onset time (based on Ghaffari et al. 2019) and monitoring of amplitude (MVC)

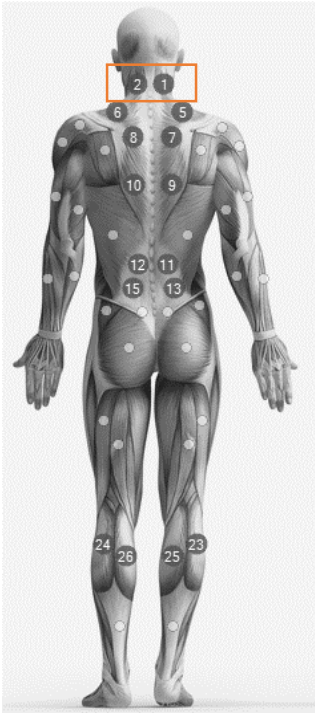
- Generally small spread in timing for 3g/s pulse
- Partly very wide time windows for Cluster3 → muscles are partly not activated at all (~50/5200)
- Tendency to bigger time spread for 0g seat position compared to upright
- ~0.2s later onset times on average for Cluster 3 compared to 3g/s

Selected exemplary test data:









Conclusions

Conclusions / follow up items

Conclusions

- Difference observed between male and female volunteers
- Different moving patterns in 0g posture compared to upright seating
  - Downward sliding and small head excursion for 0g posture
- Braking characteristics showed large effect on observed kinematics and muscle activity:
  - belt interaction mainly observed in the tests with 3g/s pulse
  - smaller variation within and in between volunteers for 3g/s tests

Next Steps

- Analysis of the effect of initial postrues from volunteer tests on injury risk within in-crash phase with Human Body Models
- Publish tests as dataset for validation of muscle models of active female and male HBMs
- Investigation of different anthropometries (present study: „normal“ BMI) and age groups (present study: 20-40yrs)?

References

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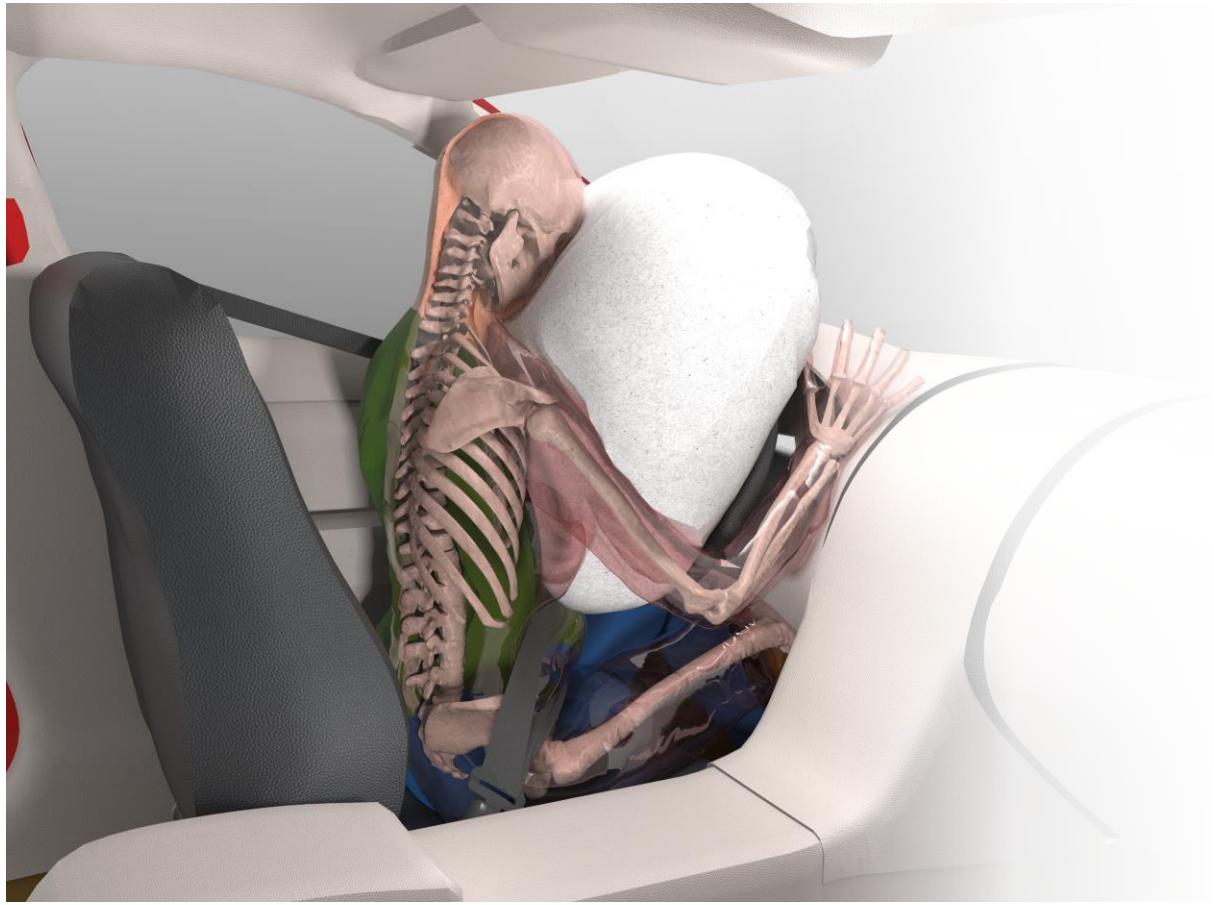
- Ghazaleh Ghaffari, Karin Brolin, Bengt Pipkorn, Lotta Jakobsson & Johan Davidsson (2019) Passenger muscle responses in lane change and lane change with braking maneuvers using two belt configurations: Standard and reversible pre-pretensioner, Traffic Injury Prevention, 20:sup1, S43-S51, DOI: 10.1080/15389588.2019.1634265



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