Two kinds of numerical models of occupants:

1. Crash test dummy models
2. Human body models

Other crash FE models

- Barrier models
  - FTSS
  - LSTC
- Moose model
  - ERAB
• Don’t make the model more complicated than what is required for its application(s)

Human Body Models (HBM)

Multi Body Dynamics  Finite Element Method
Multi body dynamics

Give examples of when you would choose MBD!

Finite element method

Give examples of when you would choose FEM!
Full Body FE Models

THUMS  GM Model  HUMOS  GHBMC Model

50th percentile male
175 cm, 78 kg

HOW ABOUT THE REST OF THE POPULATION?
Recent HBM activities at Chalmers University

Karin Brolin, Johan Iraeus, Johan Davidsson
Chalmers University of Technology
Gothenburg, Sweden
Improved injury prediction using HBM, step 3

HBM:
- Total Human Model for Safety (THUMS) version 3.0

Finite Element Code:
- LS-DYNA v. 970/971

Pre- and post-processing:
- Hyperworks, LS-PREPOST, MatLab, Primer

Previous research (steps 1-2) Model and methods

Previous research (I-HBM, steps 1-2)

- Construction of AIS2+ risk curves based on simulations 23 PMHS tests


Previous research
(RLSI, Umeå Univ.)

Accident reconstructions


Previous research
(I-HBM, steps 1-2)

The HBM was over predicting rib fracture injury risk in real world accidents

How can we improve the biofidelity of injury predictions?

Improved injury prediction using HBM, step 3 – Focus on thorax, brain and lumbar spine injuries
Improved rib fracture risk prediction using HBMs

- **Hypothesis**
  - Rib fracture is strain controlled

- **Method**
  - Develop a generic rib cage
  - Evaluate rib strain as indicator of rib fracture
  - Evaluate how PMHS results relates to real world accident data

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Hypothesis

- Rib fracture is strain controlled

Method

- Develop a generic rib cage
- Evaluate rib strain as indicator of rib fracture
- Evaluate how PMHS results relates to real world accident data

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**IHBM, step 3**

Model and methods

- **HBM:**
  - Total Human Model for Safety (THUMS) version 3.0

- **Finite Element Code:**
  - LS-DYNA R9.2.0

- **Pre- and post-processing:**
  - Ansa, LS-PREPOST, MatLab

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Development of a generic ribcage

1. Each rib defined using:
   - Rib chord length
   - 11 elliptic cross sections

2. Each cross section defined using:
   - 16 cortical thickness measurements

3. Create surface and mesh:
   - First all solid mesh
   - Convert outer solids to thin shells

4. Fit to 3-D shape using morphing:
   - Both curvature and twist assigned

5. Assemble all ribs:
   - Ribs location given by Shi study

6. Adapt boundaries to THUMS:
   - Adapt costal cartilage
   - Reshape ribs locally at spine

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Rib strain validation

1. Single rib tests
2a. Table top tests
2b. Impactor tests


Rib strain validation / Injury criteria evaluation

3. Sled tests
4. Accident reconstructions


SAFER Active Human Body Model – A-HBM step 3

AIM

- Biofidelic HBM for simulation of sequences of events:
  - combined emergency and crash events
  - run off road events
  - other long duration crash events
Model and methods

- **HBM:**
  - Total Human Model for Safety (THUMS) version 3.0

- Finite Element Code:
  - LS-DYNA v. 970/971

- Pre- and post-processing:
  - Hyperworks, LS-PREPOST, MatLab, Primer

Previous work

- Implemented muscle control for braking events using feedback control of body angles.
- Provided validation data for autonomous and driver braking.
- Validated the SAFER A-HBM for braking events.
Previous work

**Autonomous braking**


**Driver braking**


Schematic of HBM validation
Ongoing work

- Implemented muscle control for omnidirectional events using feedback control of
  - Body angles, and
  - Muscle length
- Experimental study on autonomous and driver
  - Braking, and
  - Steering.
- Validate the omnidirectional SAFER A-HBM.

Model validation - ongoing

- New experimental volunteer tests series:
  - Drivers and passengers in test vehicle
  - Muscle activity, vehicle data and 3-D kinematics
  - Autonomous events and driving:
    - Lane change w/o braking and with braking
    - Braking
    - U-turns
- All data collected and data analyses ongoing
Omnidirectional SAFER A-HBM

ViVA II
Virtual Vehicle Safety Assessment Step 2: Open Source Human Body Models and Crash Testing
AIM

- To reduce transport gender inequality.
- Create an open source virtual HBM of an average female.
- Propose a virtual test method protocol seat assessment.

Detailed neck

- Cortical and trabecular bone
- Intervertebral discs
- Ligaments
• Multi-modal surface data from 50th female (161.6 cm, 60.8 kg).
• Skeletal structures modeled as rigid with compliant kinematic joints.
• Open access: https://www.chalmers.se/en/projects/Pages/OpenHBM.aspx

Simulation of PMHS test (Yoganandan et al. 2000): \( \Delta V = 6.7 \text{ m/s}, \quad a_{\text{mean}} = 45 \text{ m/s}^2 \)
Another example

- The problem of obesity …

Will obesity be beneficial or harmful in a crash?

Questions?

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