ViVA Open Access Female Human Body Model

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Open Access Mission Statement

The aims for this Open Source human body model project are to:

• Establish a quality platform for development of human body models, within the traffic safety research community, in order to enable access to models for
  — double checking of research results, and
  — novel applications.

• Broaden human body models beyond the average male.

The first steps of this Open Source human body model project are to develop:

1. A plug-in LS-DYNA model of the average female,
   a) with biofidelic kinematics for omnidirectional acceleration loading typical of pre- and crash situations, and
   b) structured in such a way that body parts can easily be exchanged for more detailed/enhanced models.

2. An anatomically detailed model of the cervical spine, with biofidelic response in rear end impacts.
Open Source License

• GPL v3 used for the HBM developed in VIVA
  — + Most widely used OS license
  — + Stops derivatives from being made proprietary
  — +/− All derivatives should be available as source code – no encrypted keywords
  — +/− No restrictions on redistribution of model – Forking possible
  — Added exemption to allow for linking with proprietary models
Modeling Strategy

- **Plug-in HBM**
  - Kinematic whole body model of MB type
  - Fast to run (timestep > 1-10 µs (TBD))
  - Skeletal structure (rigid bodies) and simplified soft tissues to interact with seat
  - Possibly some deformation of chest for seat belt interaction
  - Boundaries to *plug-in* detailed models of body parts
  - A framework for detailed body parts (not developed in ViVA)
Plug-in HBM

- Based on 50th percentile female anthropometry acquired with multimodality approach (Gayzik et al. 2009) at Wake Forrest University
  - 31 years old, 162 cm, 61 kg
  - Average deviation for 15 anthropometric measurements 3.3%

Gayzik et al. 2009
Detailed Cervical Spine Model
Detailed Cervical Spine Model

• Geometry from trauma CT of 167 cm/59 kg female/26 years old (Gonzales-Carcedo and Brolin 2012)
  – Female vertebrae are smaller than male (depth and width)
  – Neck is more slender (circumference to neck)
  – Seated spinal curvature with less lordosis than for seated males

• Repositioned to slight lordosis posture (from supine) w.r.t Sato et al. (2015)

• Ligament dimensions governed by vertebral geometry
Some key features

- Cortical and trabecular bone
  - Isotropic elastic-plastic material
  - Tria and tetra elements

- Intervertebral discs based on concept by Panzer and Cronin (2009)
  - Orthotropic anulus fibrous fiber layers
  - Non-linear elastic anulus bulk
  - Visco-elastic nucleus
  - Tied contact
Some key features

• Ligaments
  — Quad membrane elements
  — Orthotropic, non-linear elastic material

• Material data based on Mattucci et al. (2012; 2013; 2015)
  — 8 M, 8 F PMHS
  — Average age 41 years
  — Rate dependent properties found (LCS)
Whole spine simulation

- Stemper et al. (2003)
  - 1.83 m/s forward translation of T1
  - Including gravity

- For visualization - Only ligamentous spine
Next steps

• Publish results from development and validation of ligamentous cervical spine

• Release alpha version including ligamentous cervical spine
  — Preliminary platform for model (webpage)
  — Target is mid fall 2015
Next steps

• Cervical model need hyoid bone, additional soft tissues and **muscles**
  — Muscle model concept needs to be developed
  — Ideally, muscle activation by modeling postural and reflexive responses (feedback)

• Plug-in model
  — Interface with detailed model
Thank you for listening


Head form

- Two ellipsoids with length and height according to anthropometric data
- Mass of head 3.58 kg (EvaRID, Carlsson et al. 2014)
- Mass elements positioned so that
  - Principal axes of inertia correspond to Beier et al. (1981)
  - Inertia matching regression by Plaga et al. (2005)
Principal axes of inertia