THUMS (Total Human Model for Safety) in der Fußgängerschutz-Simulation

Using THUMS (Total Human Model for Safety) for Pedestrian Safety Simulation

Tsuyoshi Yasuki
Toyota Motor Corporation, Japan

yasuki@giga.tec.toyota.co.jp
What is THUMS?

THUMS: Total Human Model for Safety

#1 Base model: pedestrian and passenger since 1997 and provided OEMs and ETC.

#2 Size and Age

#3 Pregnant

#4 Brain and internal organ: under development

#5 Muscle: under development

Fig. 2

Motivation of the Study #1
Traffic Accident Fatalities in Japan

Total 7702 in 2003

By ITARDA, 2003

Fig. 3
Motivation of the Study #2
Age and Body Region of Pedestrian Accidents

Fatalities & serious injuries / 10 Mil. Accidents

By ITARDA in 1999

Fig. 4

Motivation of the Study #3
Necessity of Human FE Model as a Design Tool

Is the countermeasure for the impactor effective for AM50, AF05, and child?

Fig. 5
Bio-fidelity of THUMS

Fig. 6

Knee Structure

Fig. 7
Knee Bending Stiffness

![Graph showing knee bending stiffness with data points and lines indicating different test conditions.]

- Dynamic test (16km/h)
- Dynamic test (20km/h)
- Dynamic test (10km/h)

PMHS data:
- Triangle: Dynamic test (16km/h)
- Diamond: Dynamic test (20km/h)
- Square: Dynamic test (10km/h)

※Shearing and bending human knee joint tests in quasi-static lateral load, 1995, IRCOBI

Fig. 8

Tibia Structure

![Diagram showing the structure of the tibia with labels for spongy bone, cortical bone, fibula, and tibia.]

Fig. 9
Bending Stiffness of Bones
Three point bending

Tibia

Fibula


Fig. 10

THUMS as a Design Tool

Fig. 11
Design Steps

Step 1

Lower leg foam impactor

40km/h

Step 2

THUMS

40km/h

Fig. 12

Lower Leg Foam Impactor Model (Step 1)

Time = 0

Fig. 13
THUMS 6 years Old Model (Step2)

Mechanism of Ligament Rupture
Comparison of Lower Leg Motions

![Comparison of Lower Leg Motions](image)

**Fig. 18**

Knee Bending and Tibia Deformation

![Knee Bending and Tibia Deformation](image)

**Fig. 19**
**Contact Force**

![Graph showing contact force over time for different materials]

- **Lower leg foam**
- **THUMS**

**Definition of contact area**

---

**Pros and Cons of the Method**

Full scale dummy is good for accident reconstruction. Impactor is good for car assessment. Human FE model is good for accident reconstructions and vehicle development.

<table>
<thead>
<tr>
<th></th>
<th>Full scale dummy</th>
<th>Impactor</th>
<th>Human FE model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio-fidelity</td>
<td>Good</td>
<td>Marginal</td>
<td>Good</td>
</tr>
<tr>
<td>Injury mechanism</td>
<td>Marginal</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>research</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td>Poor</td>
<td>Marginal</td>
<td>Good</td>
</tr>
<tr>
<td>Vehicle development</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

*Fig. 20*

*Fig. 21*
**Outlook**

*Fig. 22*

**Cyclist safety simulation**

**Detailed brain model**

---

**Conclusion**

THUMS has been provided to universities, parts suppliers, and OEMs.

Actually, THUMS is a design tool for pedestrian safety. A lower leg impactor simulation FE model can be replaced by THUMS.

By using THUMS for pedestrian safety simulation, knee ligament rupture and bone fracture can be estimated at design stage of vehicle development.

*Fig. 23*
Thank you for your attention

Fig. 24