Biomechanics and Computer-Aided Ergonomics

Inaugural lecture by
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Department of Mechanical Engineering
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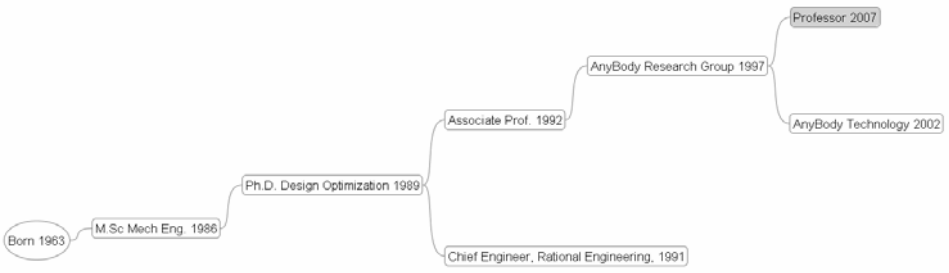
Career moves



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Career moves

Mechanical Engineering

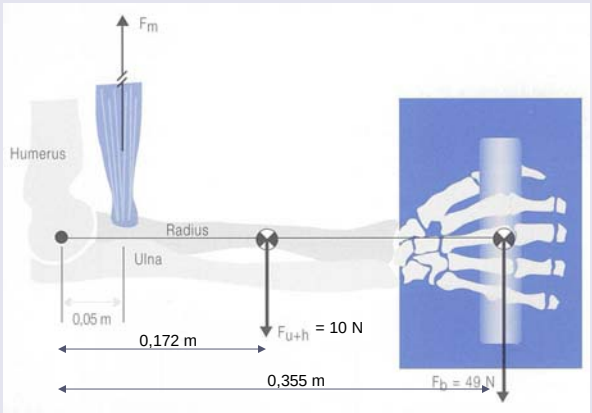
↓

Computational Mechanics

↓

Computational Biomechanics

AnyBody: The general Idea

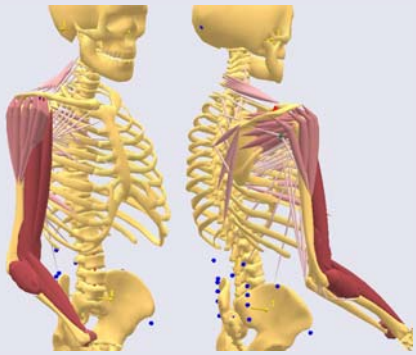


$$\sum M = 0{,}355 \cdot 49 + 0{,}172 \cdot 10 - F_m \cdot 0{,}05 = 0$$

$$F_m = \frac{19{,}1}{0{,}05} = 382 \;\; N$$

The same principle applies to more complex systems, except…

- The mechanics is too complicated to do by hand.
- We need software to handle the computational task.
- We need reliable models.
- When we have these, the potential is enormous.



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Point #1:

- Ergonomics and medicine are going computational
- This is a change of paradigm
  - from empirical to analytical
  - from qualitative to quantitative
- This opens many new opportunities

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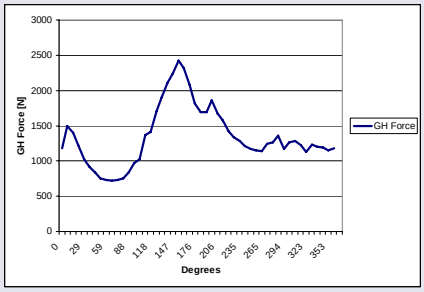
Computer-Aided Ergonomics in a nutshell



Shoulder joint forces

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Ergonomic example: Pushing

- Bed weight = 200 kg
- Acceleration = 0.3 m/s^2
- Time = 1.5 s
- Three handle heights:
  - 0,9 m
  - 1,1 m
  - 1,3 m

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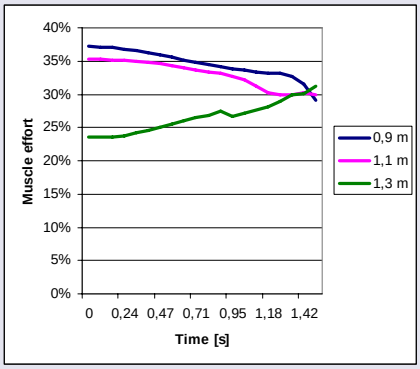
Muscle effort vs. handle position

- A high handle position preferable when the bed is close to the body.
- The difference wears off as the bed gets pushed away.



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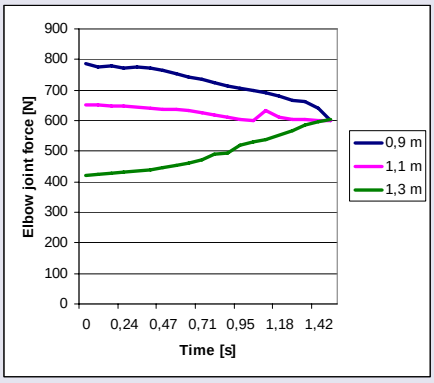
Elbow joint forces

- Same tendency for the elbow joint forces.
- Joint forces are created by muscle actions.



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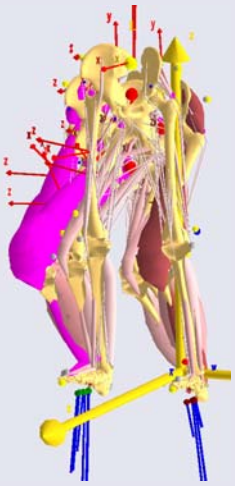
Example: Patella tendon rehab

- Example thanks to Kjartan Halvorsen, Stockholm.
- Model driven by mocap data.
- Experimental knowledge: Tendon rehab is accelerated by eccentric loading.
- How can we design exercises to maximize this effect?



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Point #2

Separate models from software

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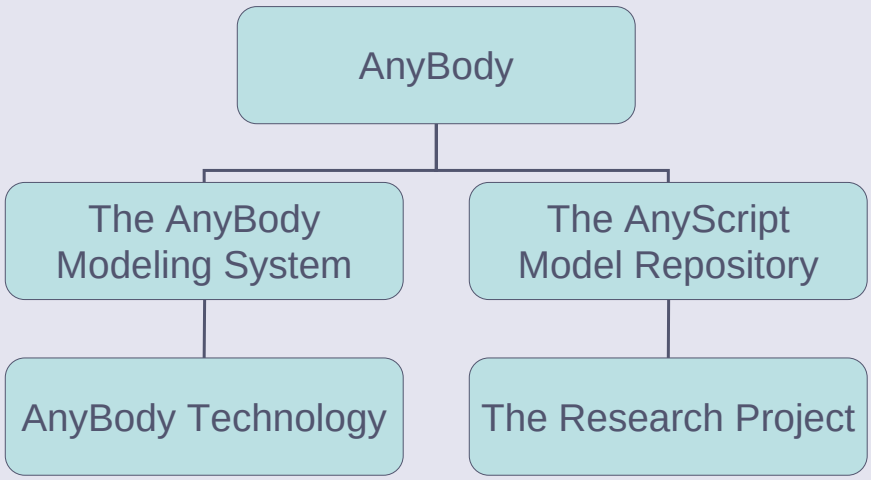
Why?

- We need good software.
  - Universities are not good places to develop software.
- We need good and validated models.
  - Companies are not good places to develop and validate models.
- CAE style
  - How could we foresee all the models people would want to make?

Our solution



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The Model Repository
- a musculoskeletal physiome

- An almost complete collection of human body parts.
- Different animal models in the works.
- Scaleable.
- Open source and public domain.
- Structure!
- Only partially validated.

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Point #3

Science (internationally) and industry must work together to realize this potential.

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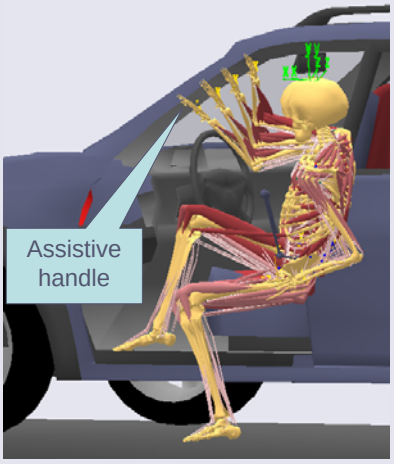
The automotive industry

- Ageing population.
- Limited muscle strength.
- Arthritis in the knees.
- Investigation of handle position.



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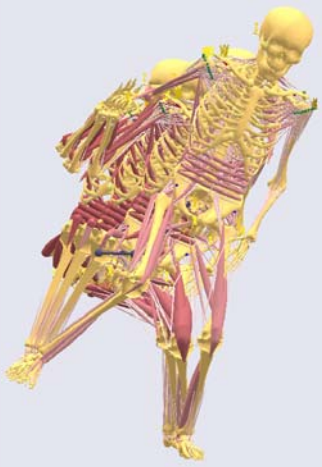
The Movement



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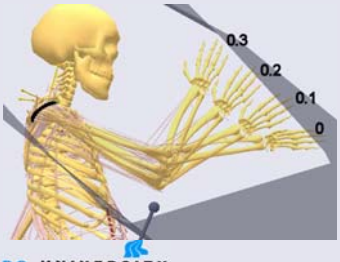
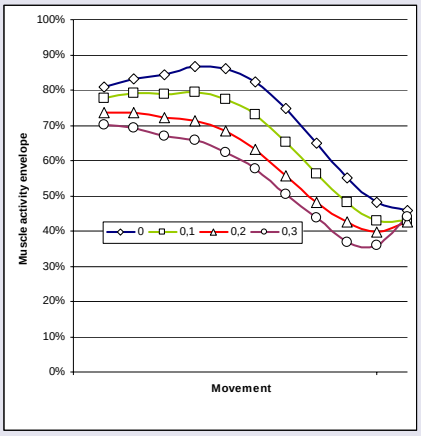
Muscle effort

- High handle position preferable
- Near-standing positions less strenuous





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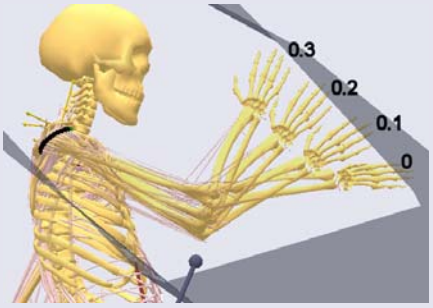
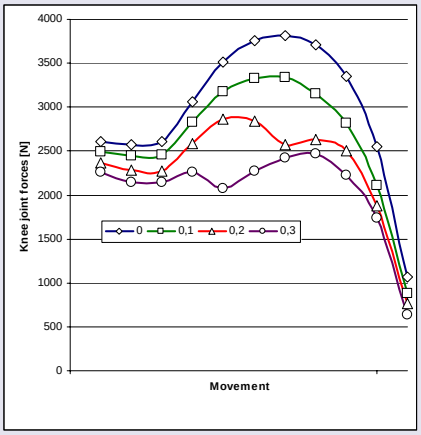
Knee joint forces





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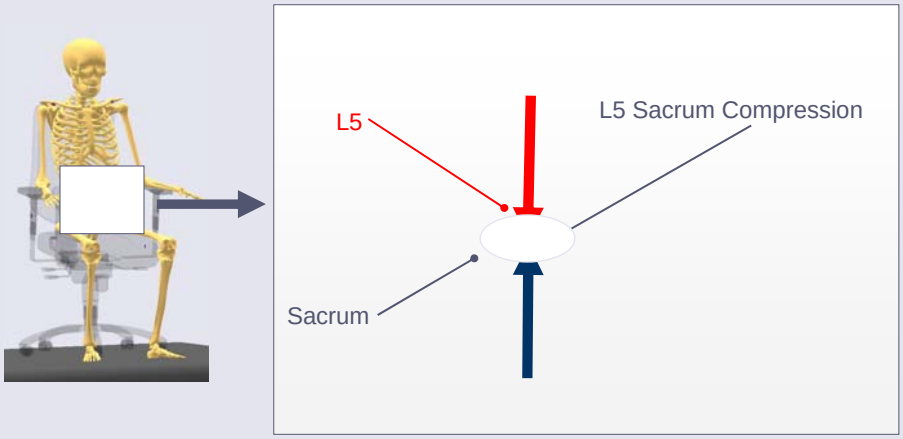
The furniture industry: RBM



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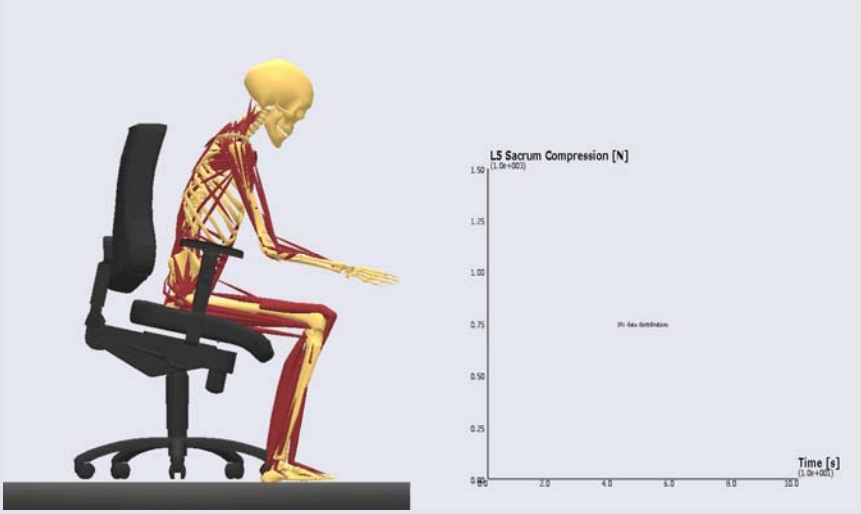
Backrest Support and Spinal Loads



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Courtesy RBM

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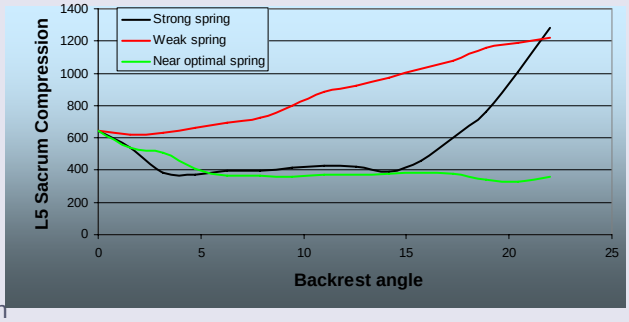
Model 625 : Spinal load



Initial position

End position

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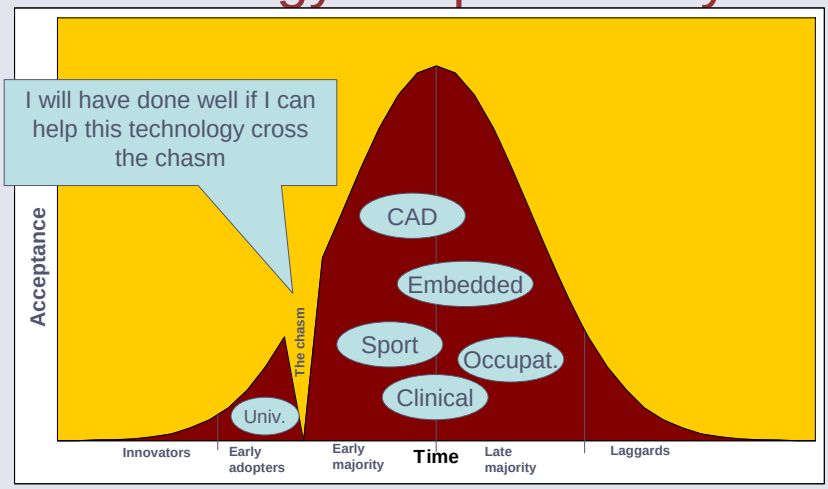
Technology adoption lifecycle



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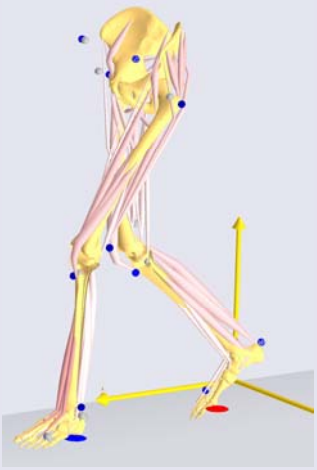
Gait lab application

- Diagnostics.
- Surgical planning.
- Prescription of orthoses.
- Footwear.



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Bicycle fitting

- Internet application.
- Insert your individual body dimensions.
- The system optimizes the dimensions of a bicycle for you.

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Take-home messages

1. Ergonomics is going computational.
2. It is a good idea to separate models from software.
3. Science and industry must work together.

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One man can do very little

- The Any Buddies:
  - Michael Skipper Andersen
  - Johan Dahlquist
  - Michael Damsgaard
  - Jens Lübeck Johansen
  - Ulrik Jørring
  - Steen Kibsgaard
  - Arne Kiis
  - Kim Lehmann
  - Per Sondrup
  - Egidijus Surma
  - Søren Tørholm
  - Mark de Zee
- People who believe enough in us to spend time and money on the technology.
- The entire ME dept. but especially
  - Niels Olhoff
  - Erik Lund
  - Line Nesgaard
  - Tina Holst Nielsen
  - Hans Jørgen Brodersen
- Management
  - Ole Thybo Thomsen
  - Frede Blåbjerg
- Enthusiastic industrial supporters
  - Karl Siebertz
  - Lars Ole Rærup
- My patient family
- A large number of co-authors

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Thanks!

- The AnyBody group is open to scientific cooperation.
  - Purpose: Do science, write papers.
  - Methods: Complementary contributions.
- Modeling discussions and support: tech.groups.yahoo.com/group/anyscript
- Papers, references and models: www.anybody.aau.dk
- Software downloads, documentation, newsletter: www.anybodytech.com

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