Scaling of musculoskeletal models

To fit your screen:
Sharing (upper right corner)->
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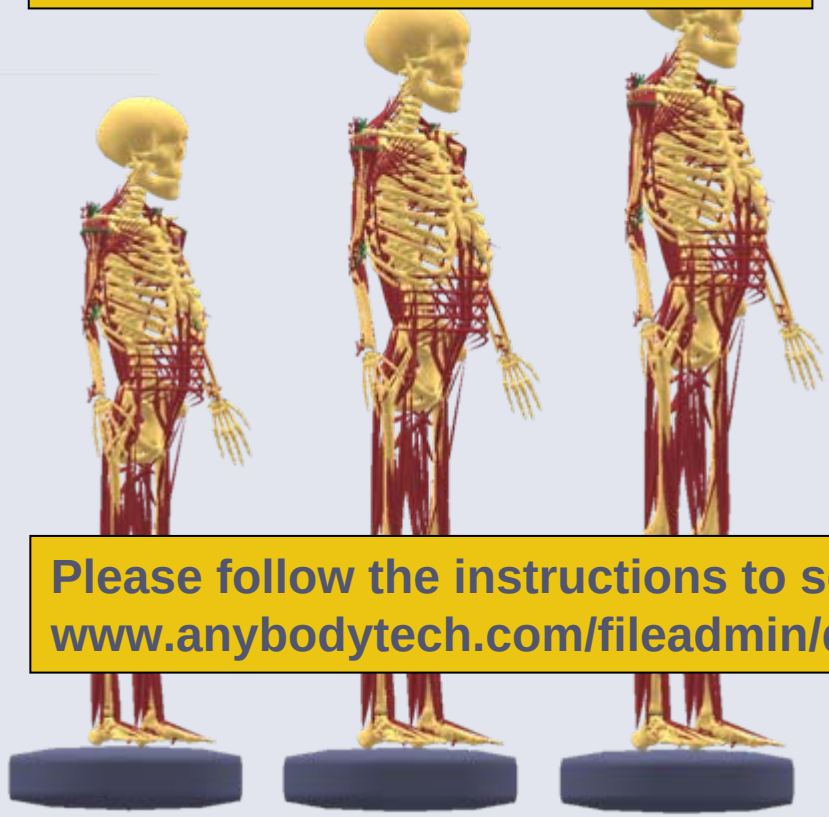

The web cast will start in a few minutes….

Introduction (~5 min)
Scaling methods (~15 min)
Demo (~15 min)
Q&A session (~10 min)

Please follow the instructions to set up the audio:
www.anybodytech.com/fileadmin/downloads/AudioInstructionsWebEx.pdf

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Presenters

John Rasmussen
(Presenter)

Arne Kiis
(Host)

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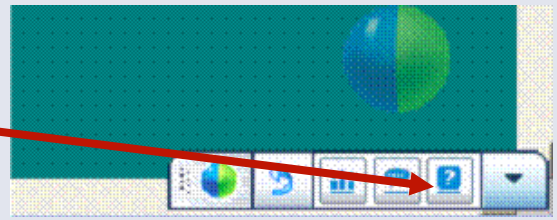
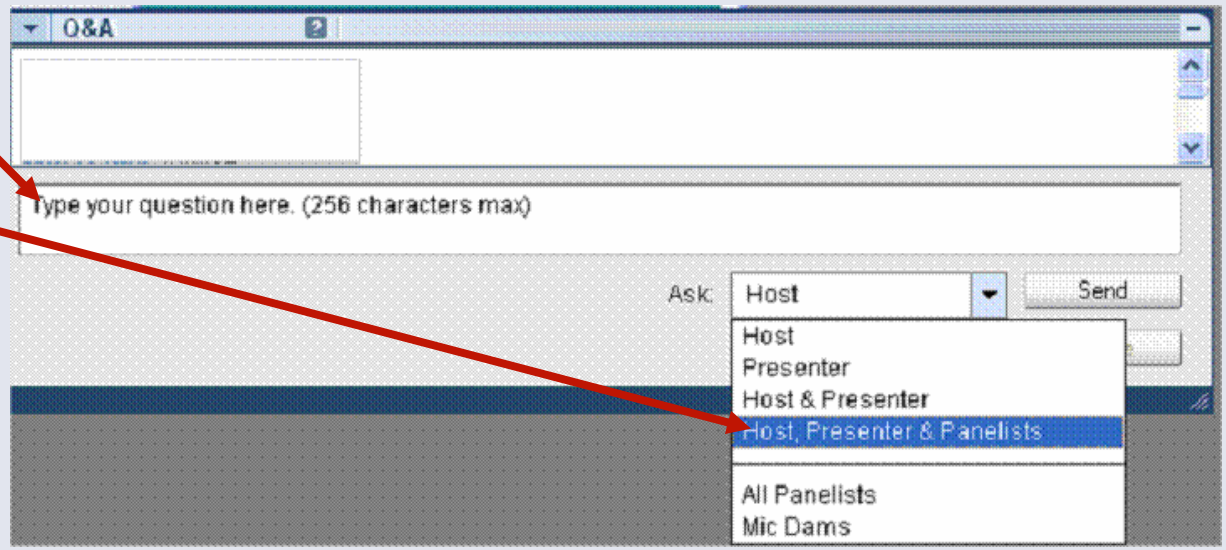
Q&A Panel

- Søren Tørholm
- Launch the Q&A panel here.
- Type your questions in the Q&A panel.
- Send the question to ”Host, Presenter & Panelists”
- Notice the answer displays next to the question in the Q&A box. You may have to scroll up to see it.





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Who is responsible?

The Research Group:

- Aalborg University, Denmark

This means that the scaling is implemented into the models and not into the system:

- **Accessible to all users**
- **Can be modified by the user**
- **New scaling methods can be defined by users**

Results are public domain

Models are in clear text

Documented on www

The company:

- AnyBody Technology A/S

Activities:

- The AnyBody Modeling System
- Training, support and consultancy

The software is proprietary

Free demo licenses

Host of this webcast

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Scaling Scenarios

- Detailed level
  - Purpose-specific modeling based on scans, ultrasound data, and similar.
  - Detailed data for each model element.
- Individual level
  - Sports biomechanics for a particular athlete
  - Gait analysis of a particular individual
- Overall population level
  - Investigate ergonomic compatibility for a broad range of the population
  - Based on anthropometric databases

This has always been possible because AnyBody models are fully accessible.

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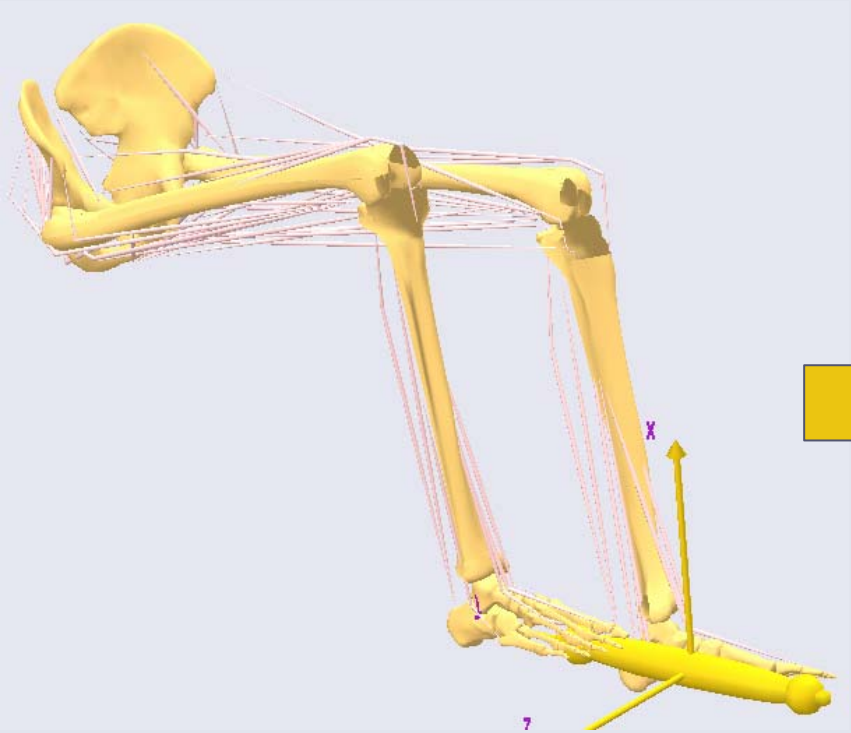
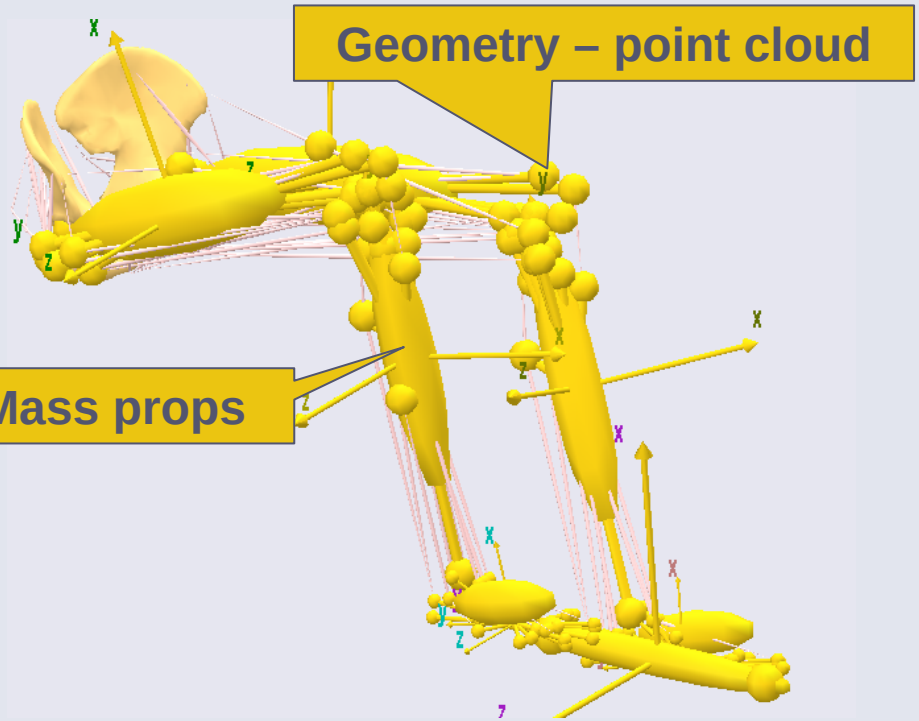
Scaling Methods

How a segment is defined





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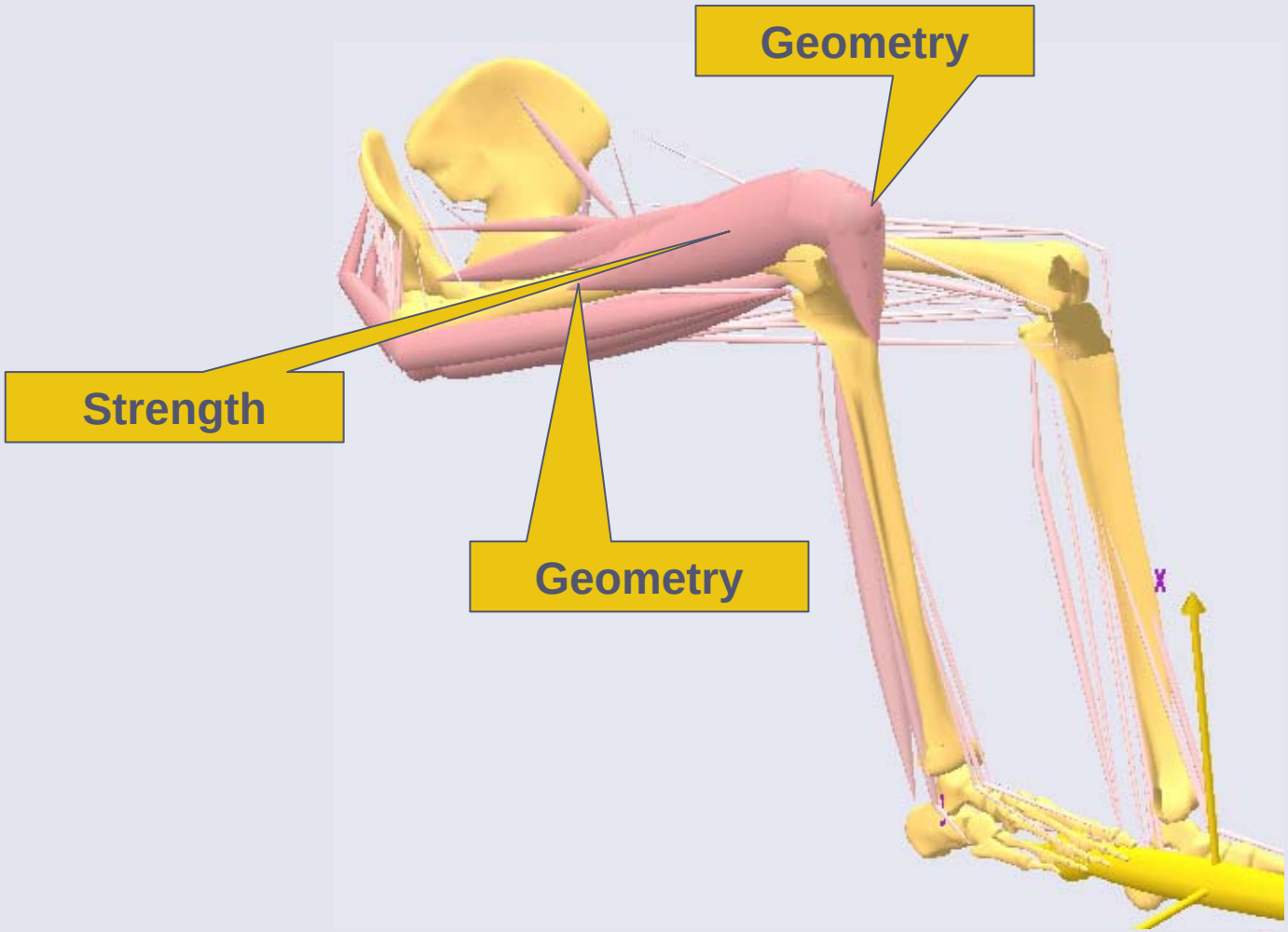
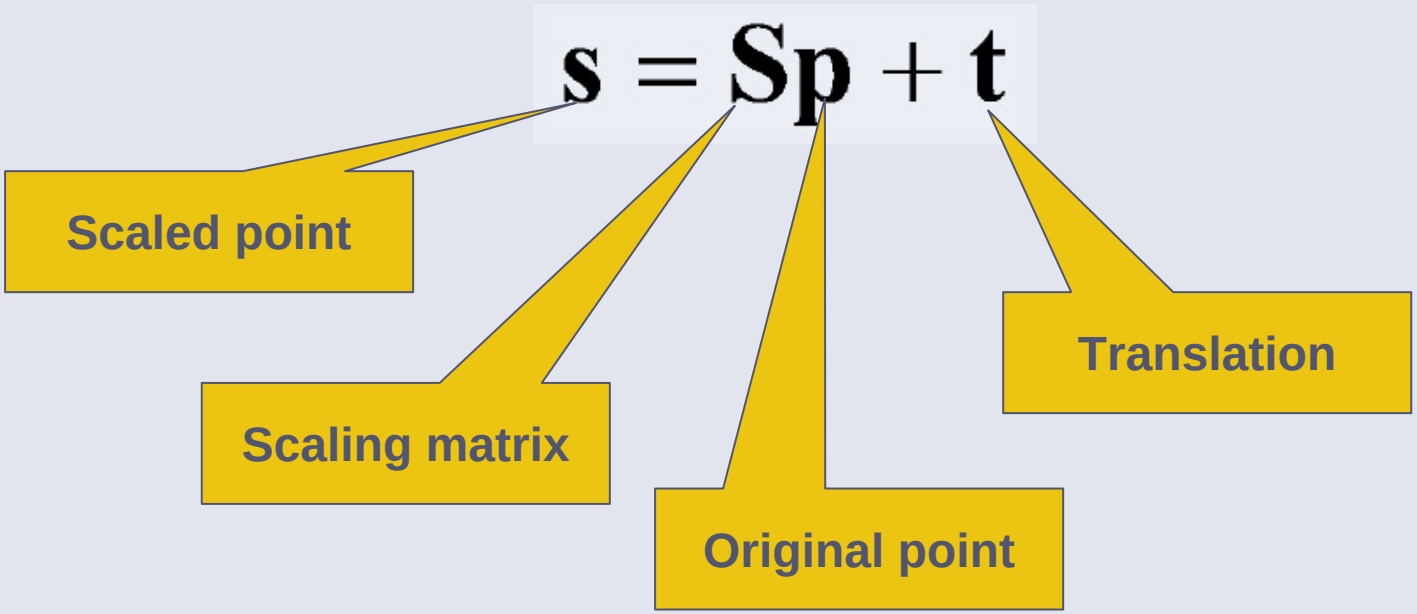
How a muscle is defined



In summary...

- Geometry
- Mass properties
- Muscle strength

Linear geometry scaling



Different choices of $\mathbf{S}$ ant $\mathbf{t}$ lead to different scaling laws

Uniform Scaling

- Same scaling factor in all directions.
- Does not seem to fit well with imperical data.
- Does not intuitively correspond to the idea of longitudinal extremities and their mass and strength properties.

$$\mathbf{S} = \begin{bmatrix} k_L & & \\ & k_L & \\ & & k_L \end{bmatrix}$$

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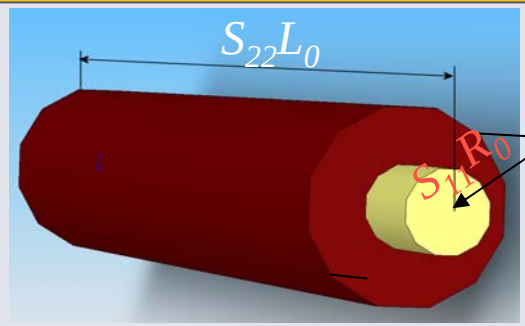
Length-mass scaling

- Idea: Scale the length
- longit
- dimension.
- Scale the width to obtain the specified mass

This method tends to over-estimate the strength of short and heavy bodies

$$k_L = \frac{L_1}{L_0}$$

$$k_m = \frac{m_1}{m_0}$$



$$S_{22} = k_L = \frac{L_1}{L_0} \qquad S_{11} = S_{33} = \sqrt{\frac{k_m}{k_L}} \qquad F = F_0 k_m^{2/3}$$

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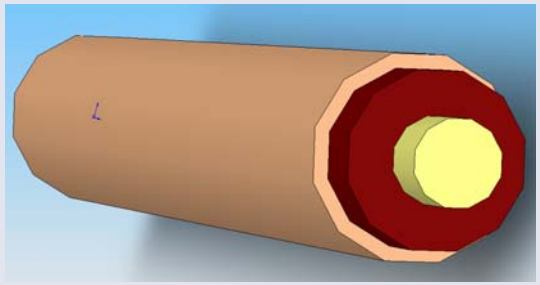
Length-mass-fat scaling

- Idea: Take the fat percentage into account.
- The fat percentage can be estimated from the BMI
- - or it can be measured directly.
- R_{other} = 50%



$$R_{muscle} = 1 - R_{fat} - R_{other}$$

$$F = F_0 \frac{k_m}{k_L} \frac{R_{muscle,1}}{R_{muscle,0}} = F_0 \frac{k_m}{k_L} \frac{1 - R_{other} - R_{fat,1}}{1 - R_{other} - R_{fat,0}}$$

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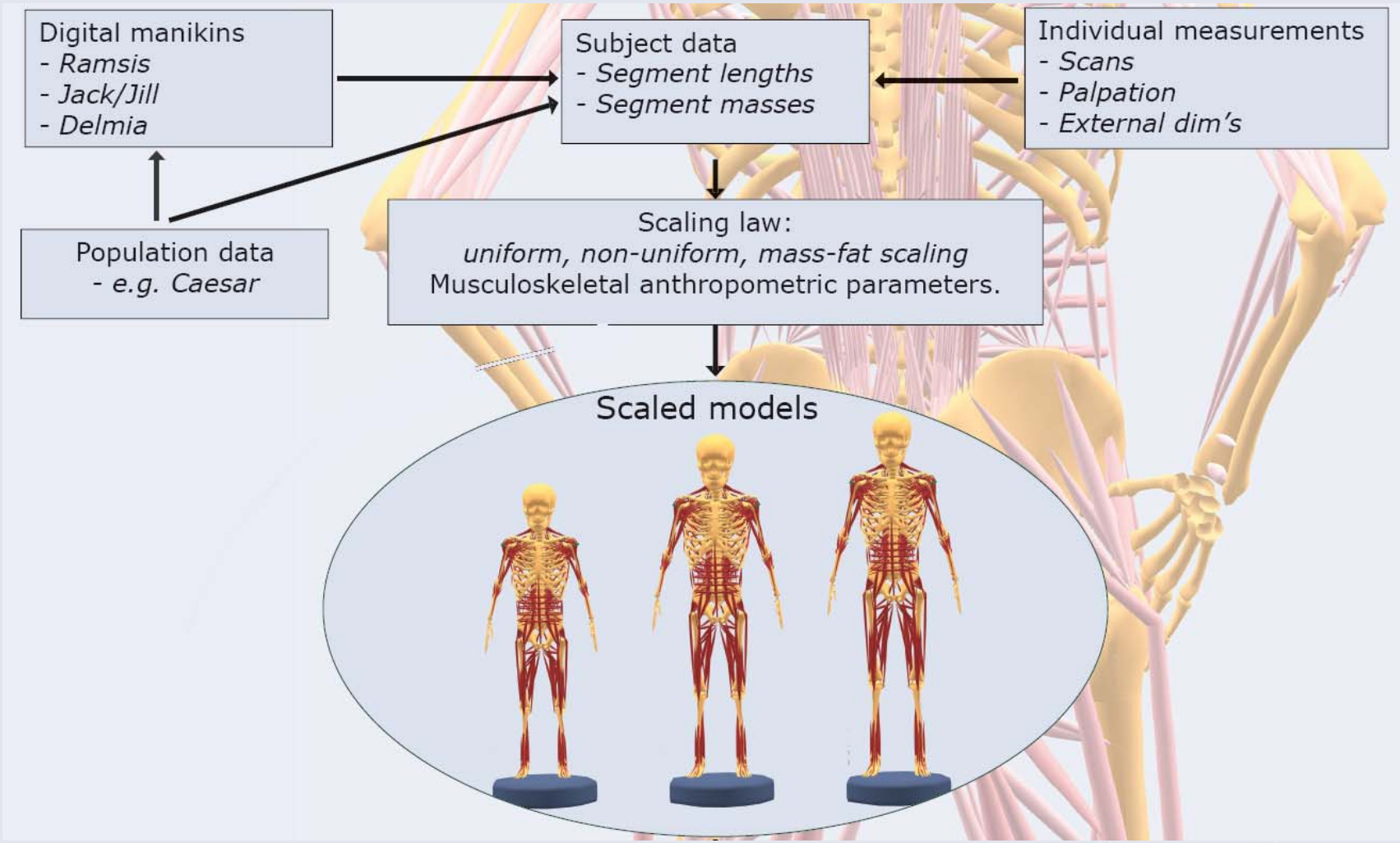
Scaling Pipeline



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Implementation - demo

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Discussion

- Scaling has been implemented as simple formulas in directly in the models.
- The formulas are based on reasonable physical and physiological properties.
- Uniform scaling is not a good idea.
- Longitudinal and cross-sectional directions must be distinguished.
- It seems to be necessary to take fat percentage into account.
- Population data or individual data can easily be used.
- Alternative scaling methods can be implemented by users.

Online resources

- The AnyBody Modeling System
  - Free demo license
    www.anybodytech.com
  - Email: anybody@anybodytech.com
- The AnyBody Research Project
  www.anybody.aau.dk
  - Public domain library of body models and applications
  - Publications, for instance about scaling.

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Thank you!
Q & A

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