Validation of the AnyBody version of the Dutch Shoulder Model

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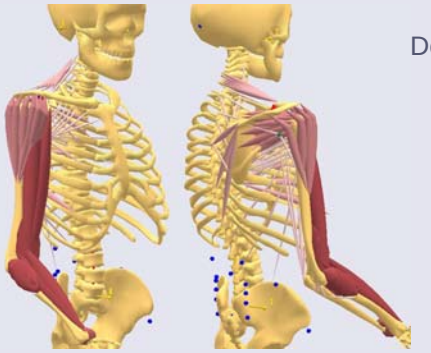

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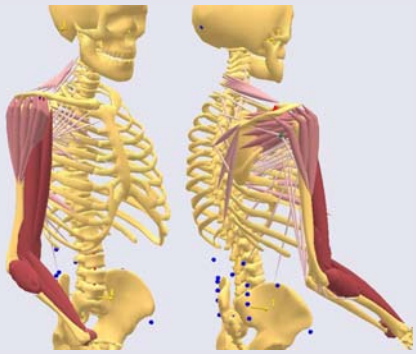
The shoulder model

- Based on data collected by the Dutch Shoulder Group.
- 118 muscles on each side.
- Wrapping of muscles by contact mechanics.
- Contact criterion in the GH joint.
- Part of the public domain model repository.



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The “entire” body model

- More than 500 muscles.
- A few parts missing:
  - Hands
  - Feet
  - Thoracic spine
  - Cervical spine

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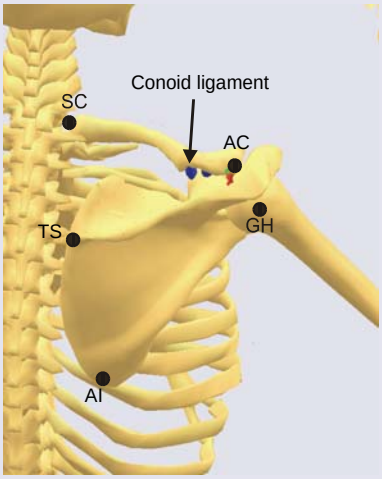
Shoulder Kinematics



AC	Spherical joint
GH	Spherical joint
SC	Spherical joint
TS	Scapula thoracic gliding plane, ellipsoid
AI	Scapula thoracic gliding plane, ellipsoid

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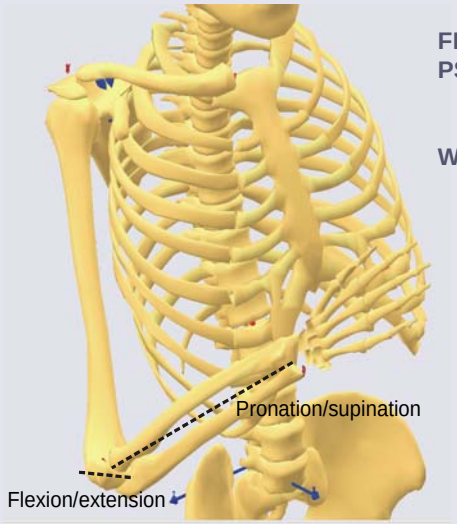
Arm Kinematics



FE	Flexion/estension, revolute joint
PS	Pronation/supination, combination of joints with one DOF
Wrist	Universal joint

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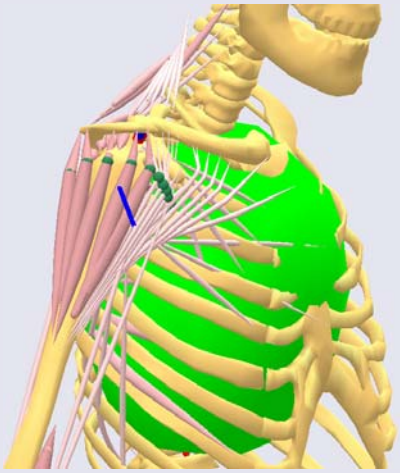
Muscle wrapping



- Most muscles wrap on analytical surfaces.
- Many muscles wrapping over several surfaces.
- Contact is engaged and released depending on posture.

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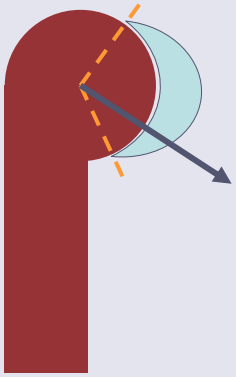
Gleno-humeral joint stability

- It is a common assumption that the GH joint is not unconditionally stable.
- Muscle recruitment must therefore honor the condition that the reaction force is directed into the glenoid fossa.



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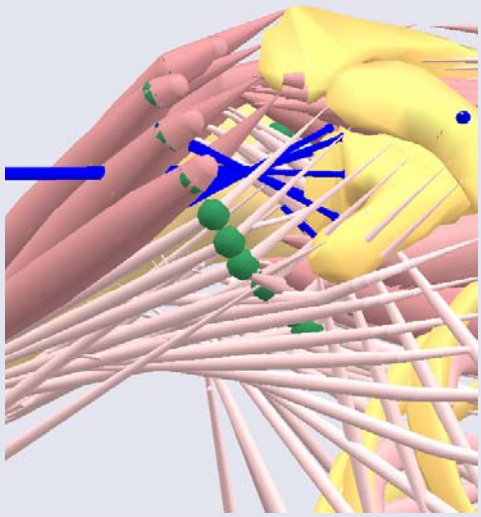
Stability in AnyBody

- Contact elements.
- They can only carry pressure.
- Directed from the edge of the glenoid to the center of the joint.
- Linear combinations can only generate resulting forces inside the glenoid.



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Validation against joint forces

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In vivo glenohumeral contact forces—Measurements in the first patient 7 months postoperatively

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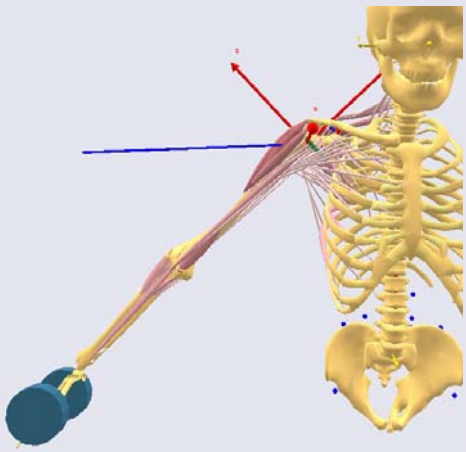
Demo: Abduction with dumbbell



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Two recruitment criteria:

Minimum fatigue

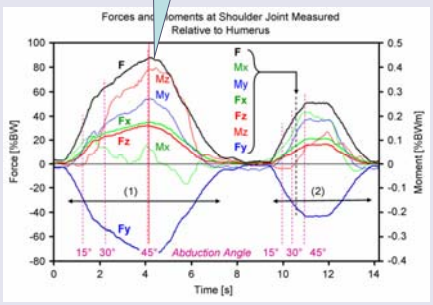
$$\min \max_i \left(\frac{f_i^{(M)}}{N_i} \right)$$

or

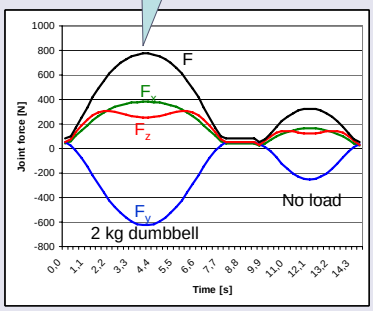
$$\min \sum \left(\frac{f_i^{(M)}}{N_i} \right)^2$$

Results - abduction

880 N



774 N
QP criterion



Bergmann et al

(With min/max criterion: 1118 N)

Discussion

- Force profiles indicate that the basic mechanics of the model mimic the real shoulder.
- Accuracy:
  - QP criterion: 12% below Bergmann.
  - Minimum fatigue criterion: 27% above Bergmann.
- Anthropometrical data not adjusted.
  - Segment lengths
  - Segment masses
- Posture uncertainties:
  - Humerus rotation.
  - Scapular-thoracic posture

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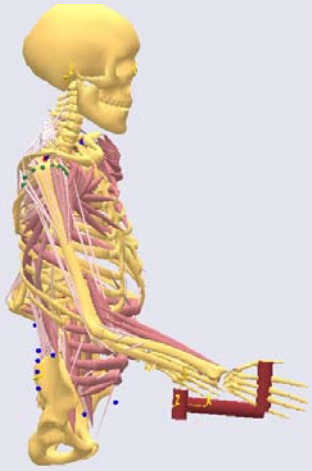
Further information

- 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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