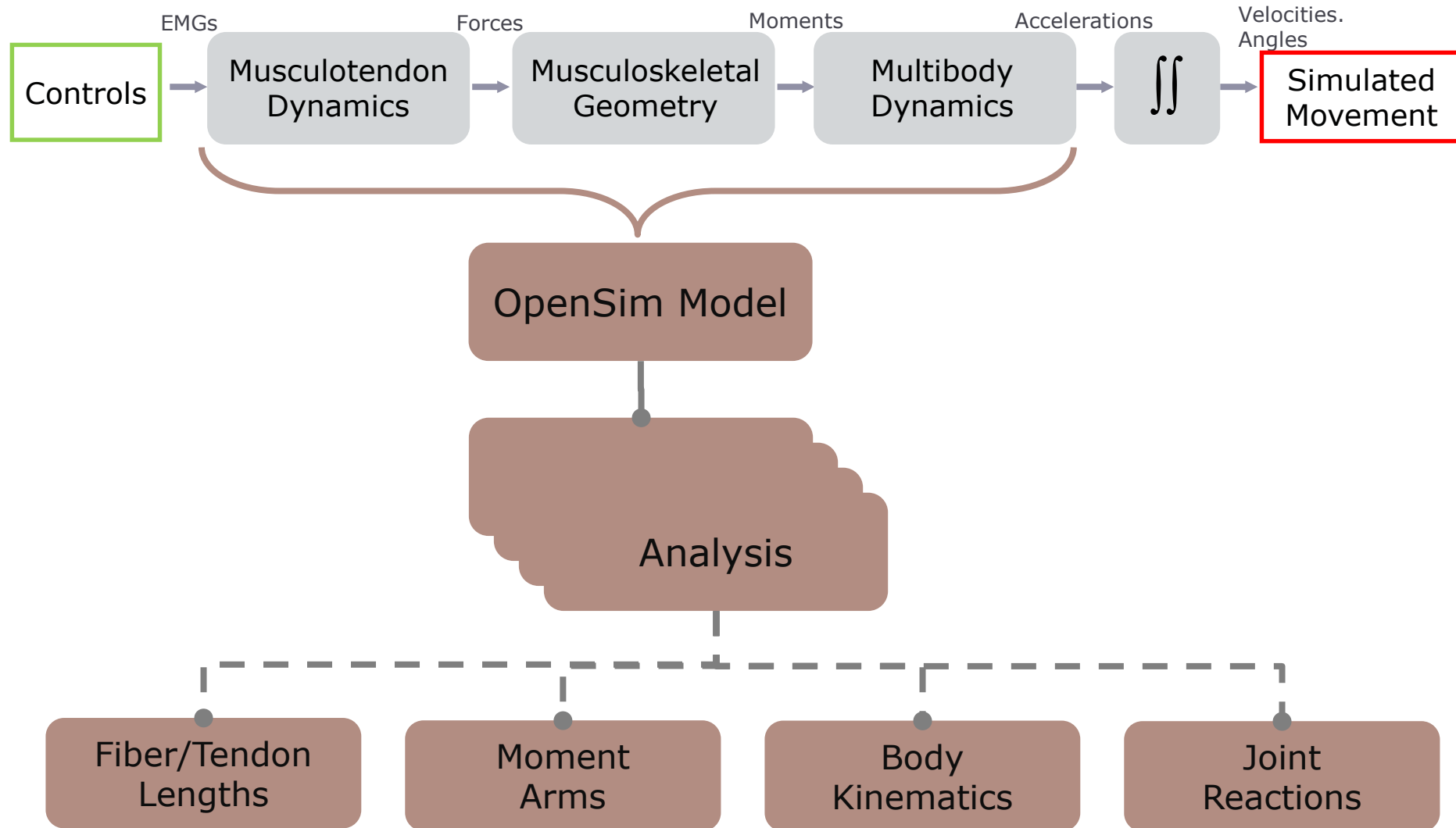


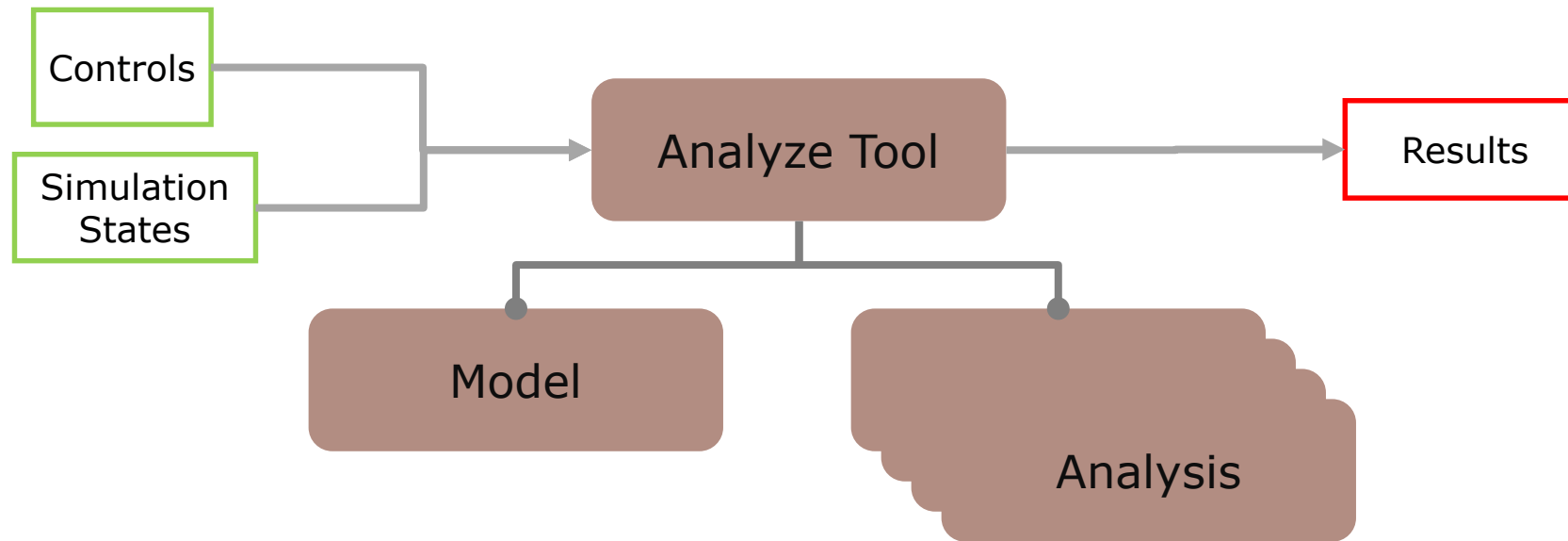
Simulation Analysis: Estimating Joint Loads

OpenSim Workshop

Investigating a Simulation:

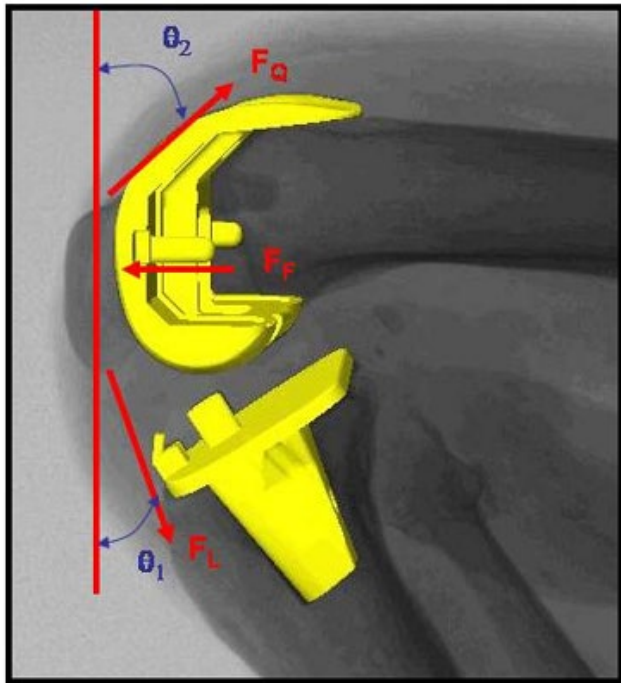


The Analyze Tool:



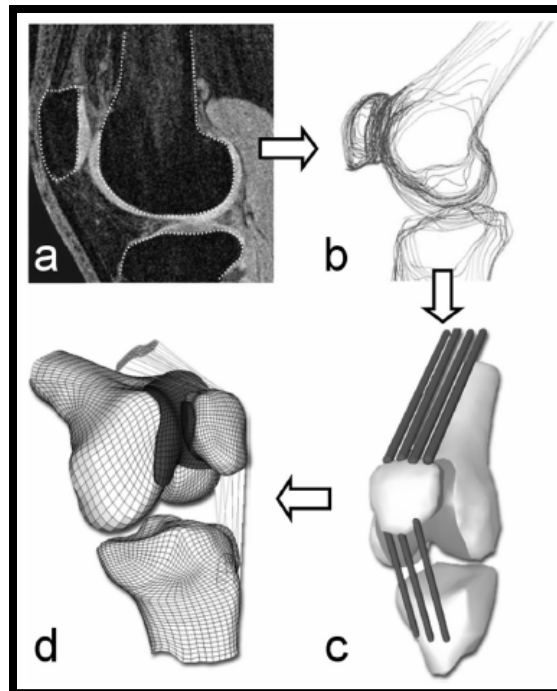
Example: Quantifying Joint Loads

Design Biomedical Devices



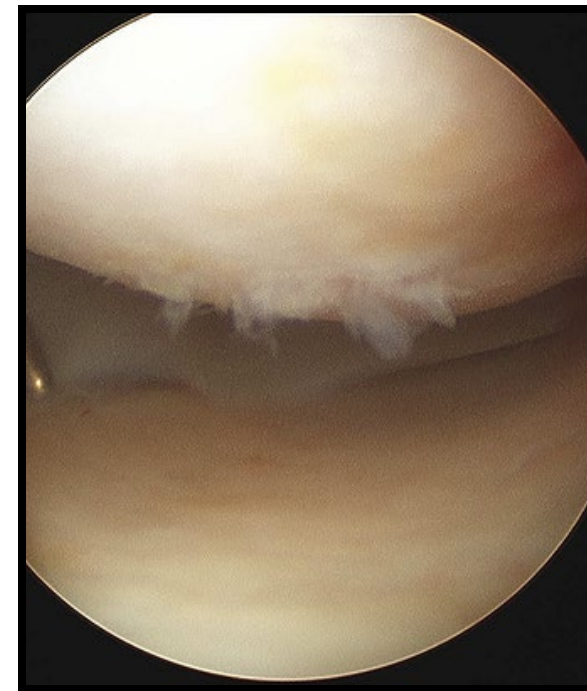
Argenson et al, J. Biomech 2005

Predict Tissue Stress



Besier et al, MED. SCI. SP & EXERCISE, 2006

Study degradation

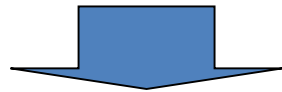


USC2000, 2009,
<http://www.flickr.com/photos/usc2000/3189533413/>

Joint Reaction Analysis

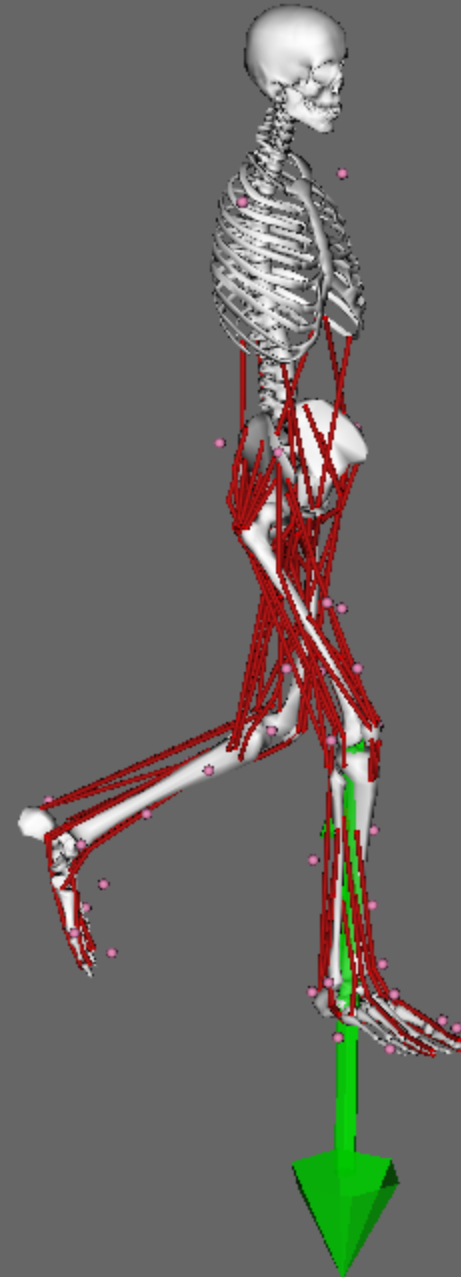
Joint reaction forces and moments

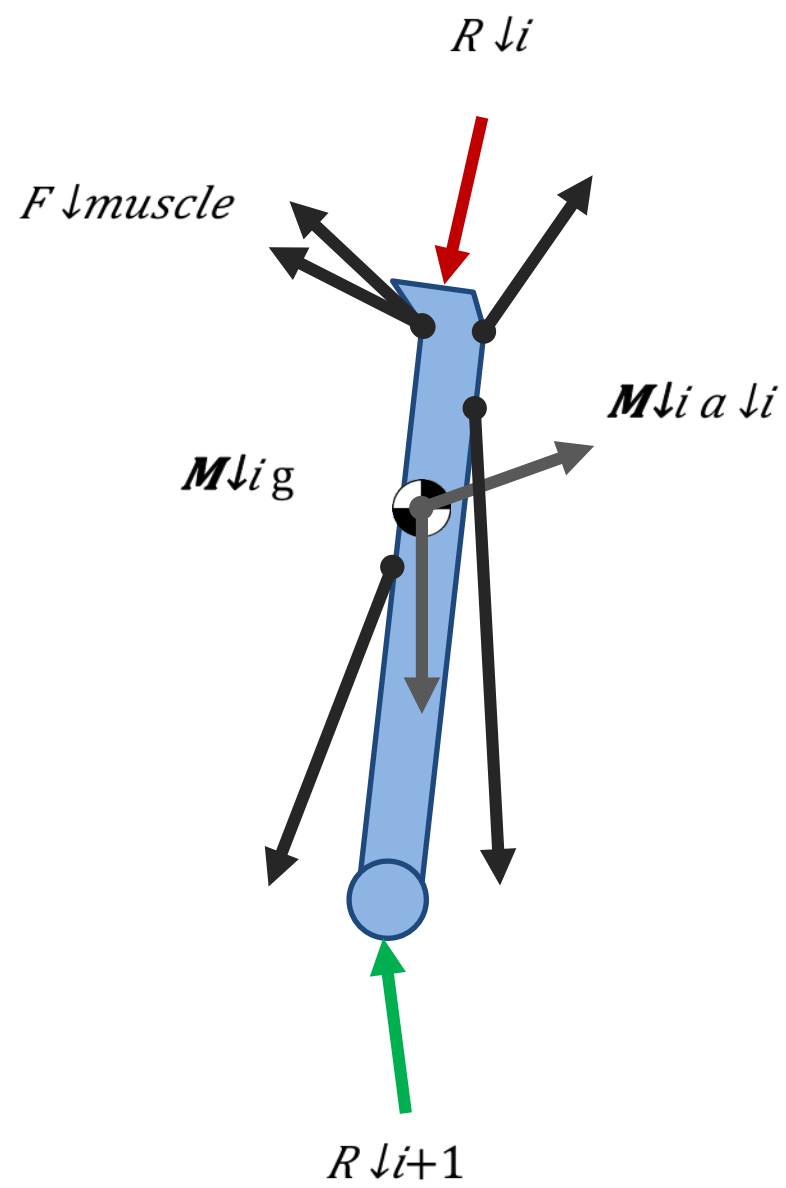
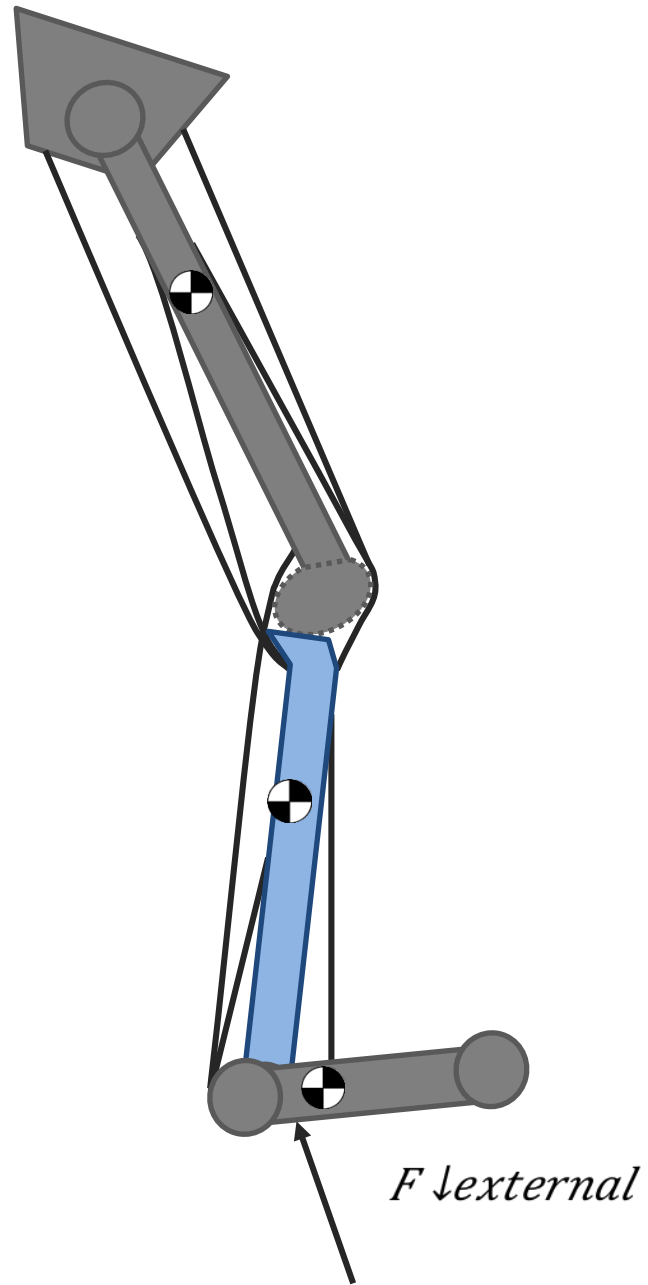
- **satisfy joint constraints**
- **represent internal loads carried by the joint structure**
- **result from all loads acting on the model**



Prevent movements that cannot be produced

Available from the Analyze Tool

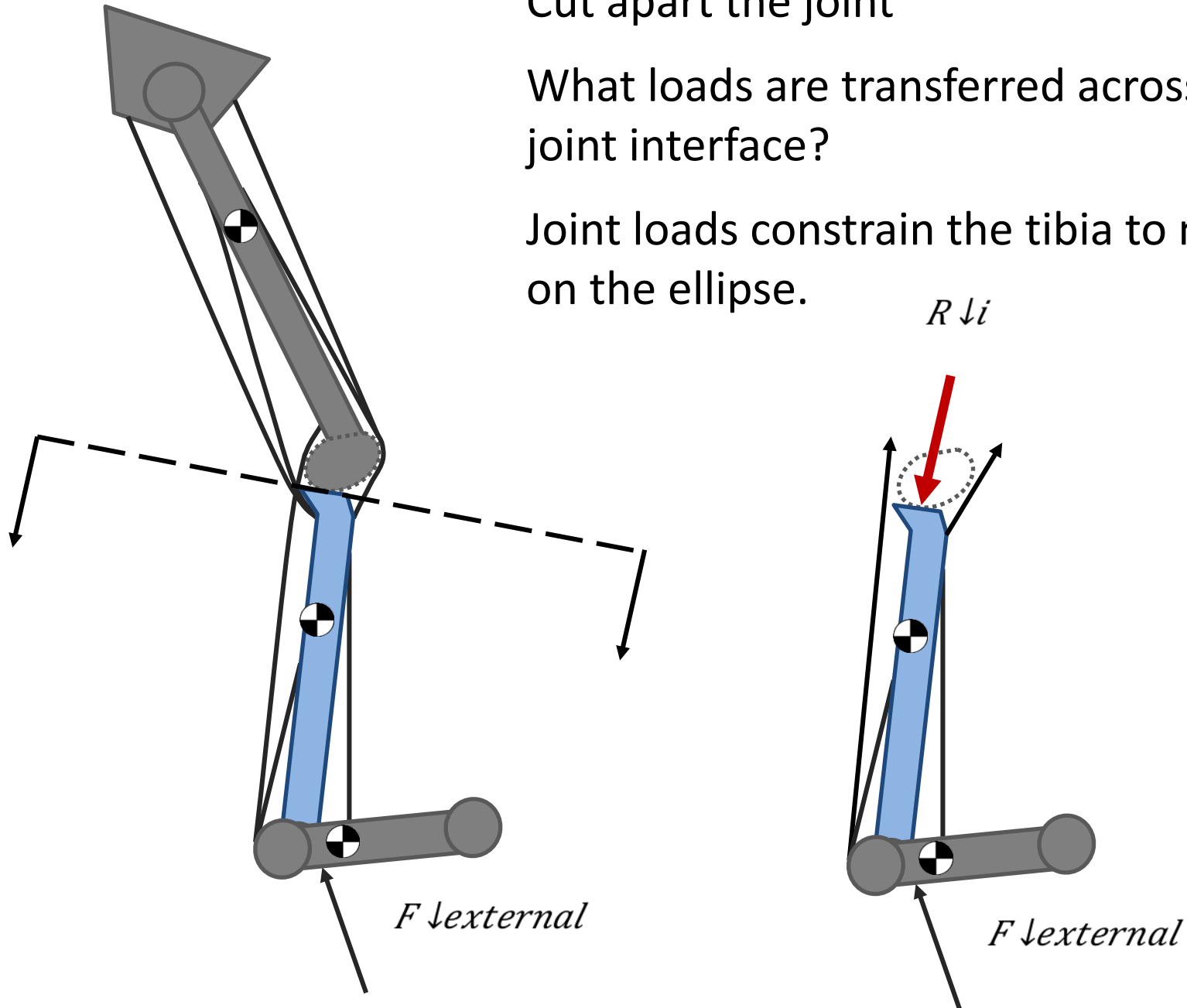




Cut apart the joint

What loads are transferred across the joint interface?

Joint loads constrain the tibia to move on the ellipse.



Estimating Joint Loads

Know

Model

Joint Kinematics

External Loads

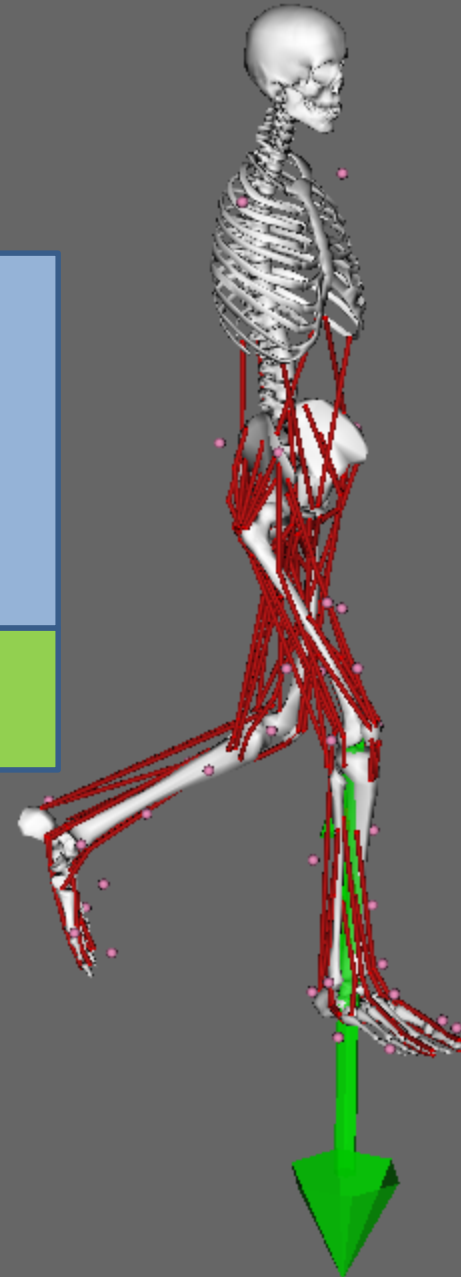
*Fit to
measurements*

Muscle Forces

Estimate

Calculate

Joint Reaction Forces and
Moments



Static Optimization

Input

Model

Joint Kinematics

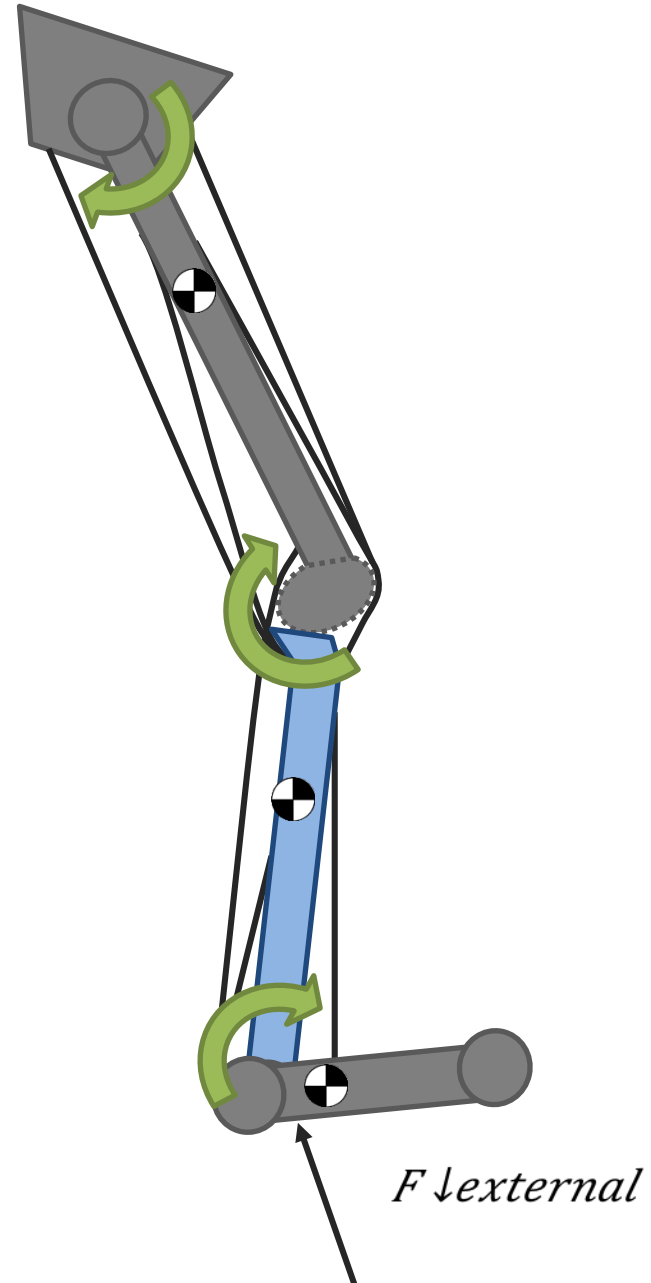
External Loads

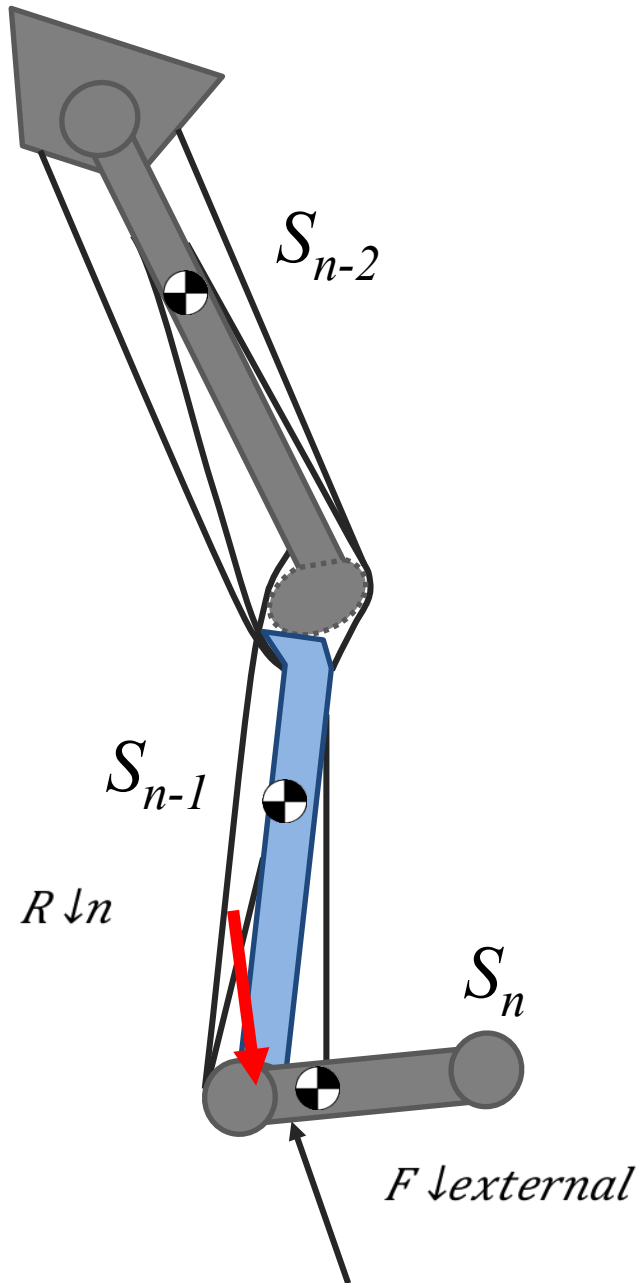
Output

Muscle Forces

Muscle Activations

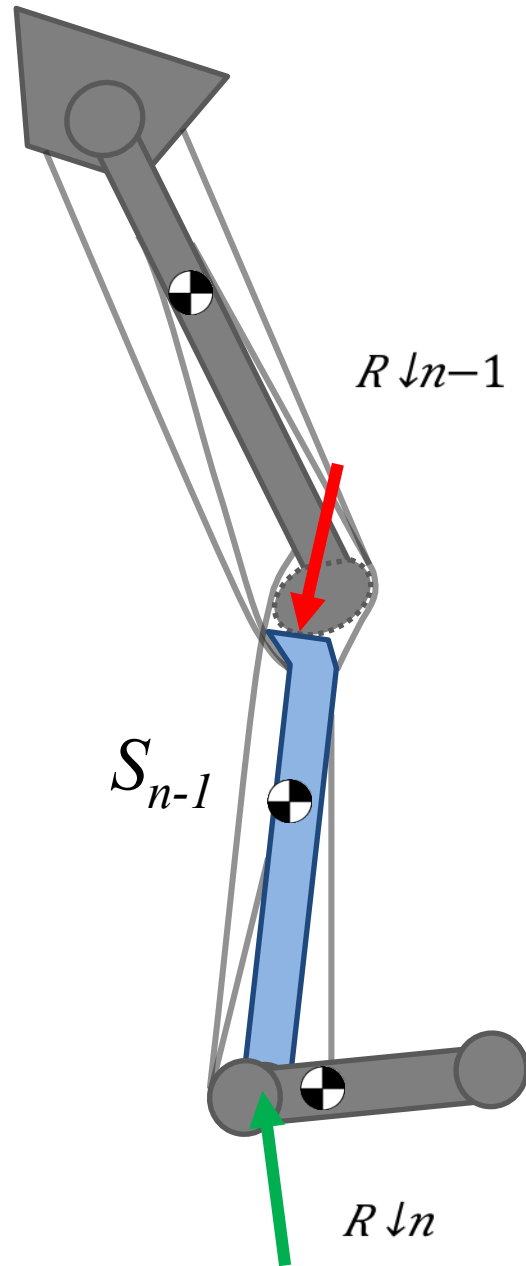
Complete dynamic description





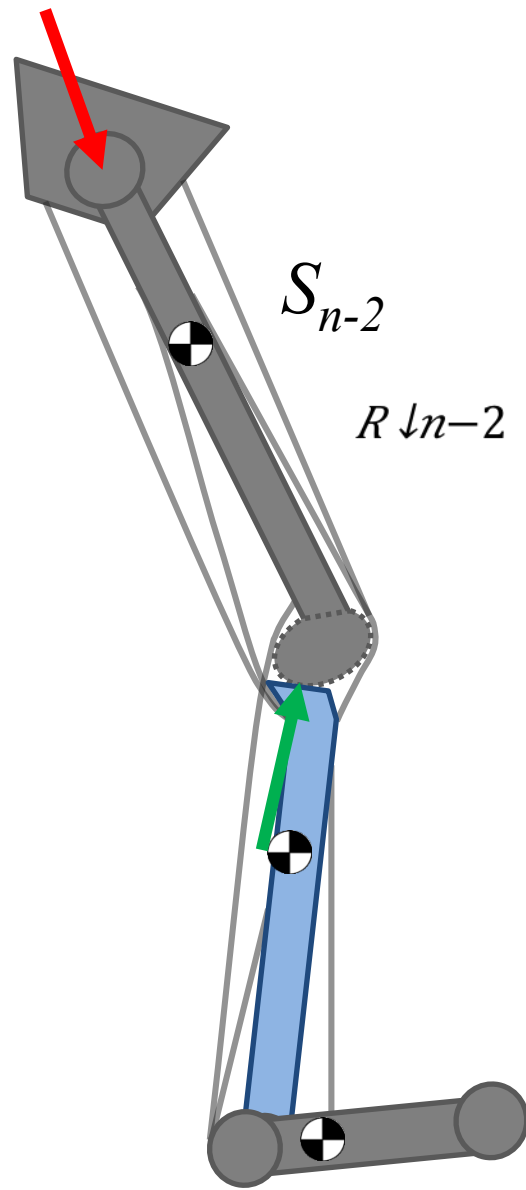
Joint Reaction analysis
calculates joint loads in a post
processing step.

This step traverses all joints in
the musculoskeletal model.



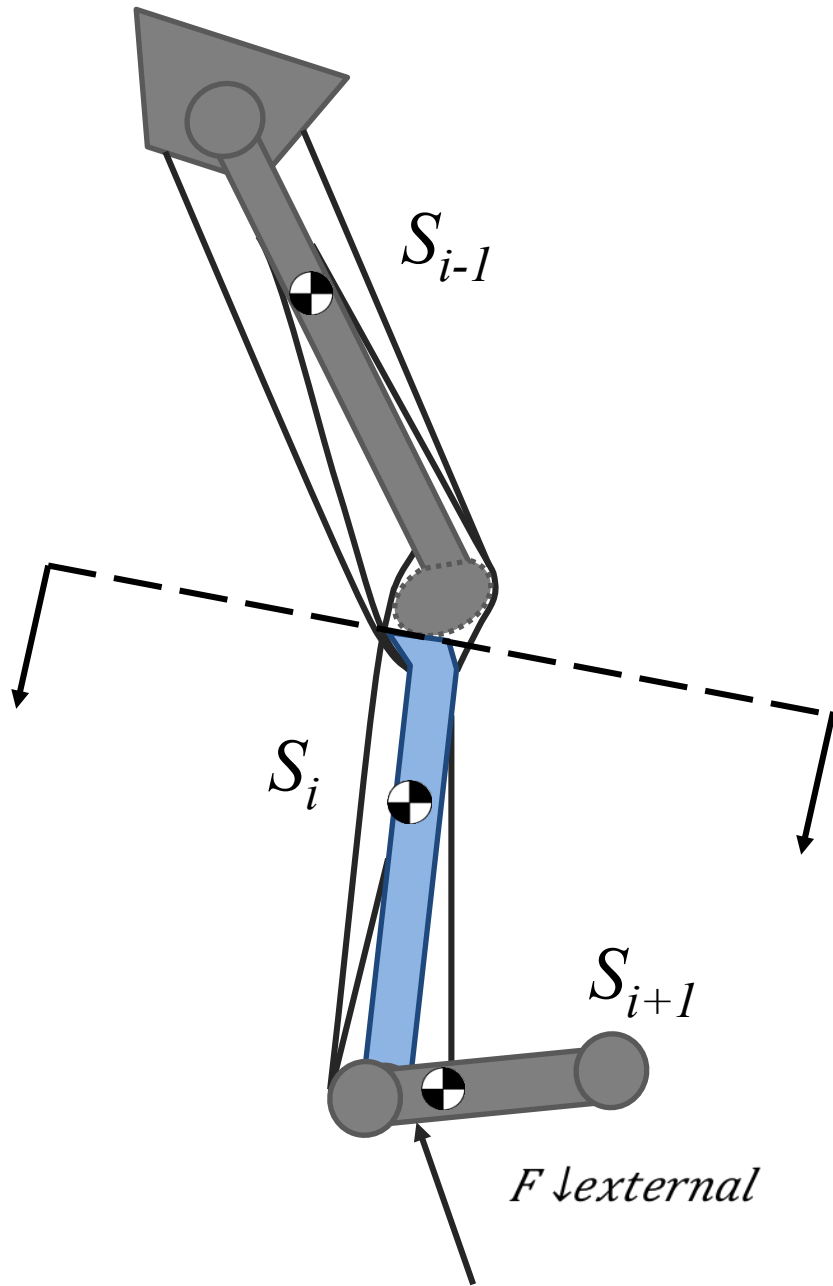
Joint Reaction analysis
calculates joint loads in a post
processing step.

This step traverses all joints in
the musculoskeletal model.

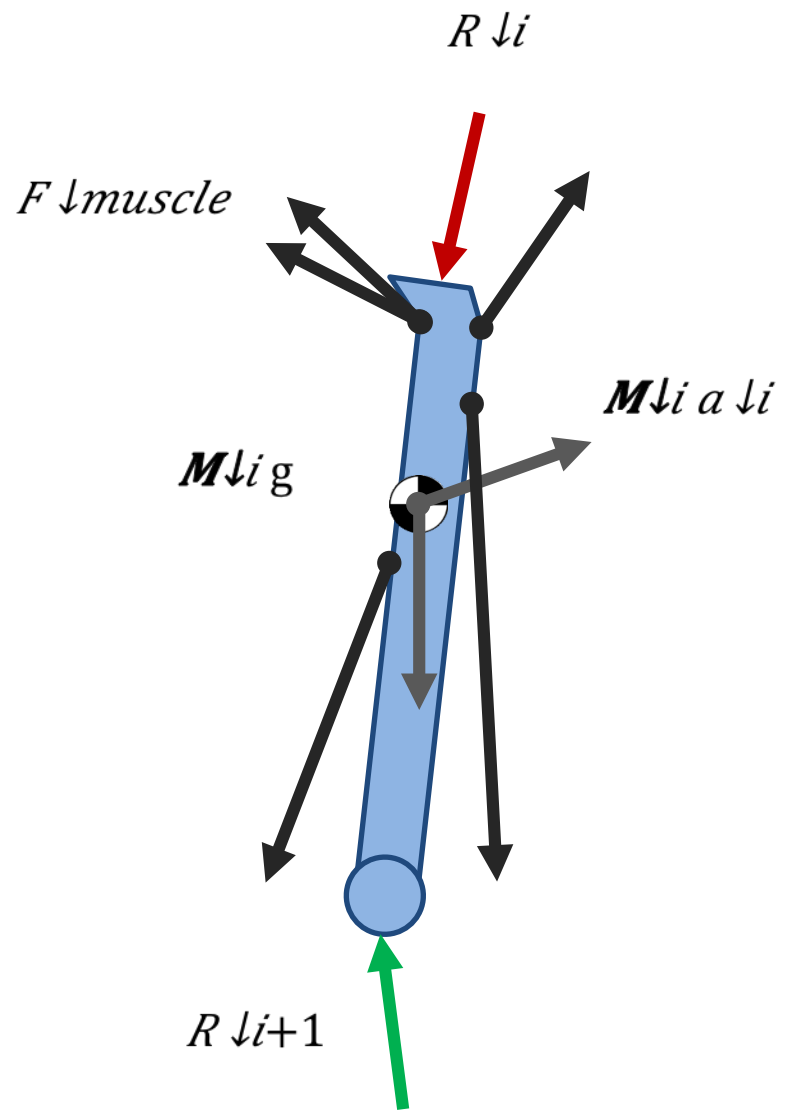


Joint Reaction analysis
calculates joint loads in a post
processing step.

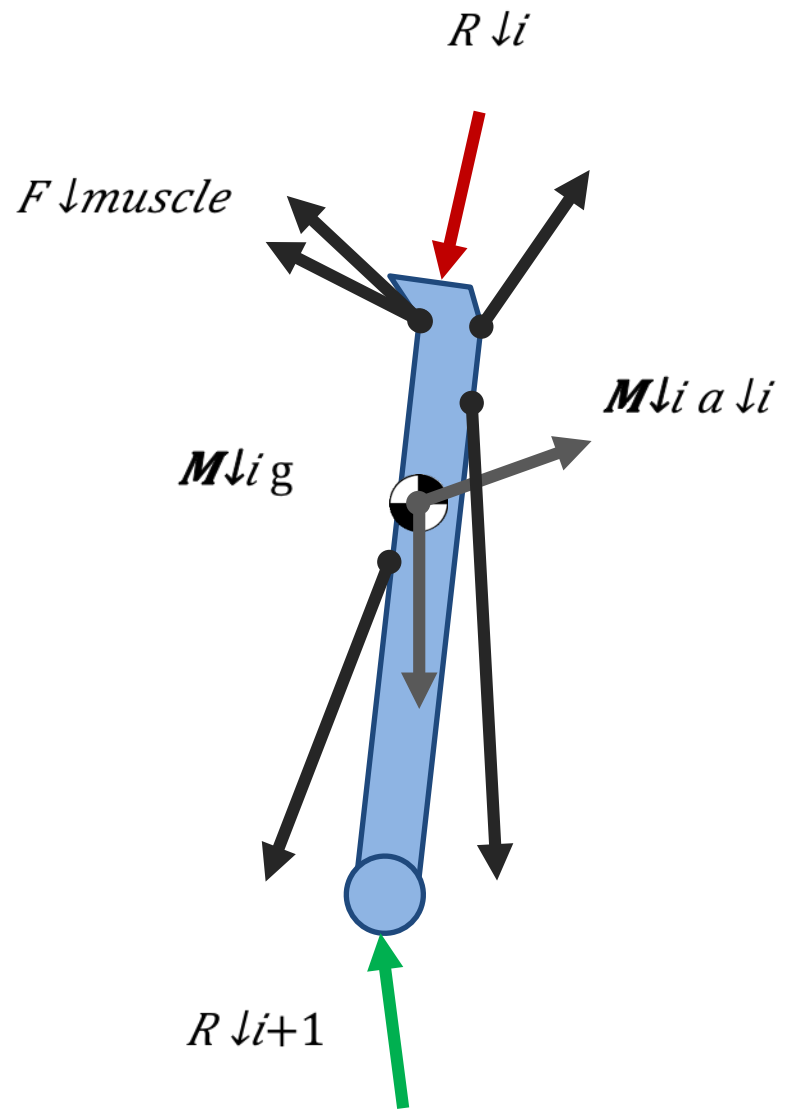
This step traverses all joints in
the musculoskeletal model.



Calculation of the joint reaction forces on S_i



$$\sum F_{external} + \sum F_{muscles} + R_{i+1} + R_i = M_i a_i$$



$$R_i = M_i a_i - \left(\sum F_{external} + \sum F_{muscles} + R_{i+1} \right)$$

Joint Reaction Analysis: Setting It Up

Inputs from Static Optimization

- Model
- Kinematics
- External Loads data
- Residual Actuators

Inputs specific to JointReaction

- Muscle force data
- Joints of interest
- Bodies of interest
- Coordinate reference frames

Output

*_JointReaction_ReactionLoads.sto

