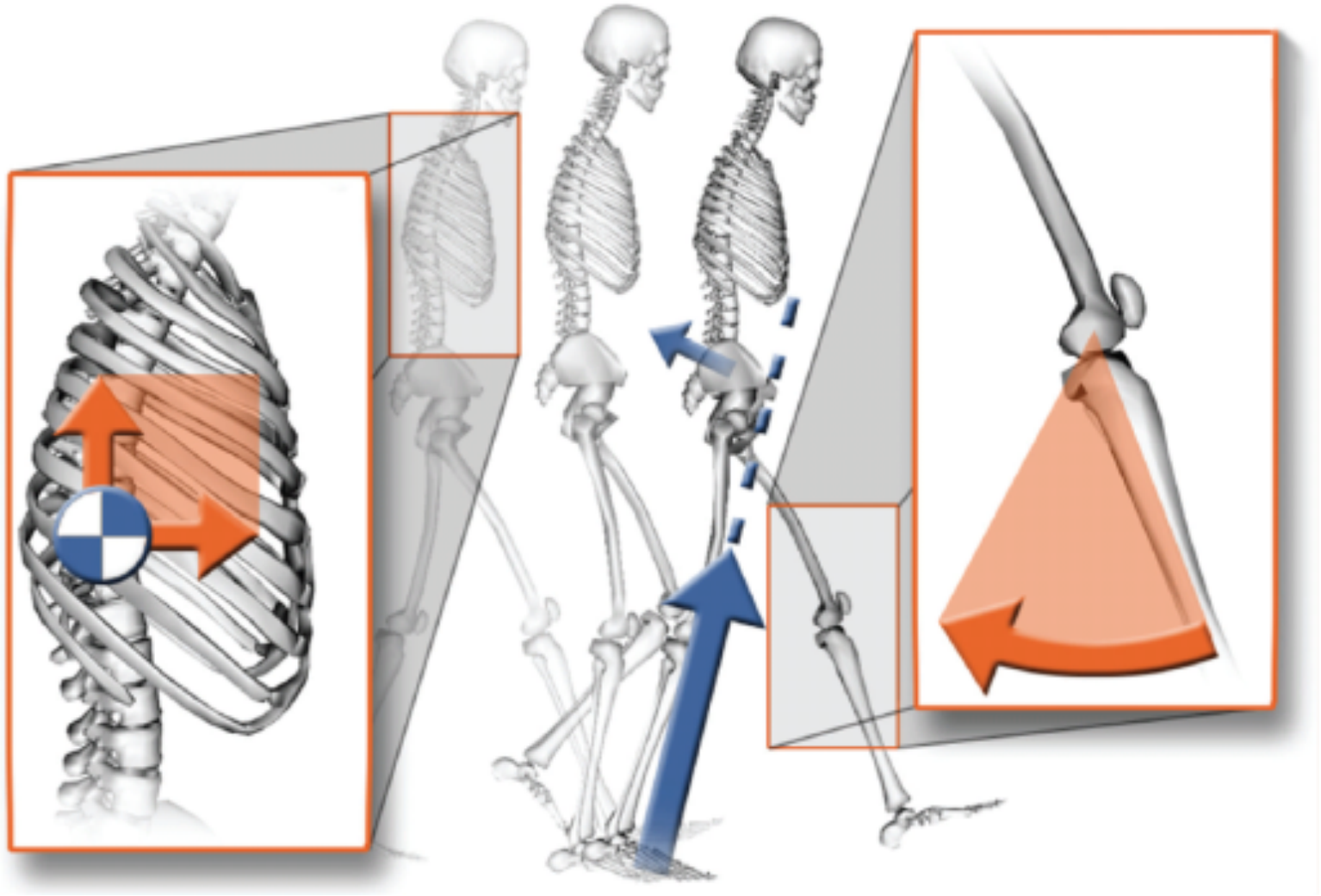


Reducing Residuals

What are residuals?

Non-physical forces that account for inconsistencies between experimental GRFs and joint accelerations estimated from experimental markers.

$$F = ma + R$$

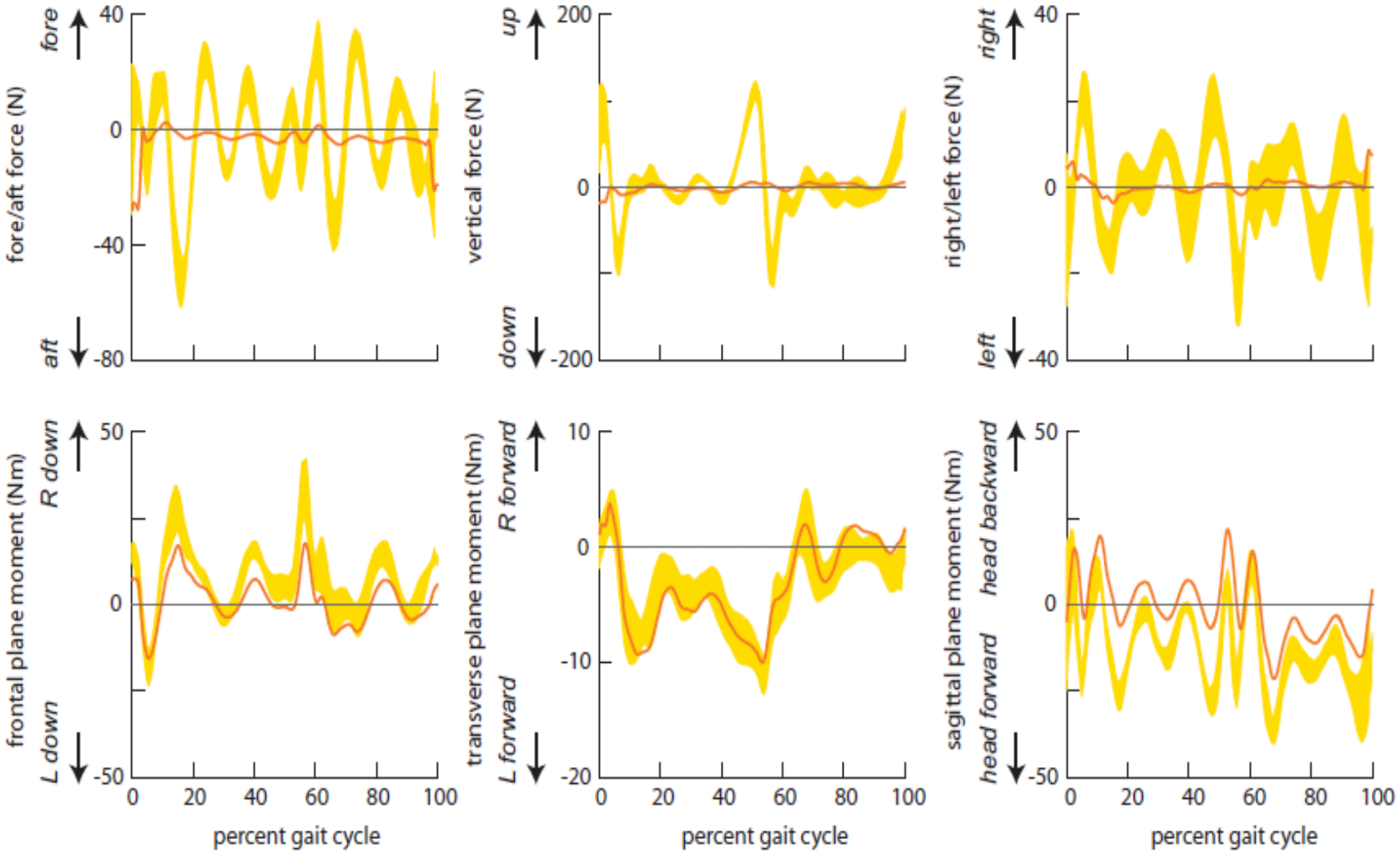
Inconsistencies due to:

1. noise in marker and joint angle data
   - differentiating angles for accelerations
2. inaccuracies in model geometry and mass distribution

Why reduce residuals?

1. Residuals are non-physical and necessary only to account for errors
2. Want muscles to account for all movement
3. To have confidence in muscle contributions

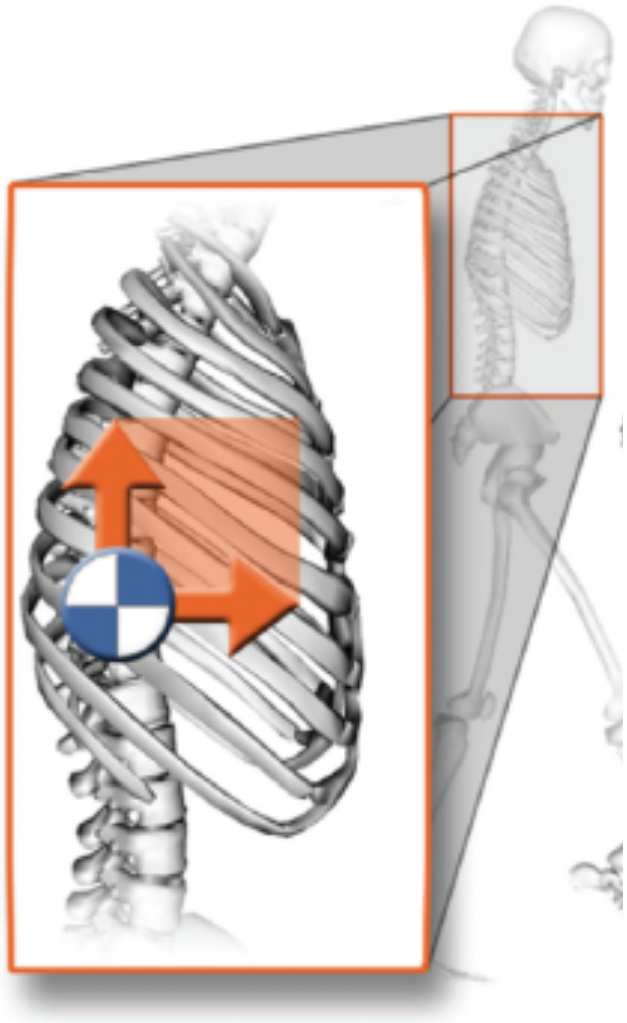
Sample residual reduction during gait



How can you reduce residuals?

- Torso is most massive and error prone to estimate
- Location of Torso mass center also difficult to estimate

1. Adjust mass distribution including Torso COM location



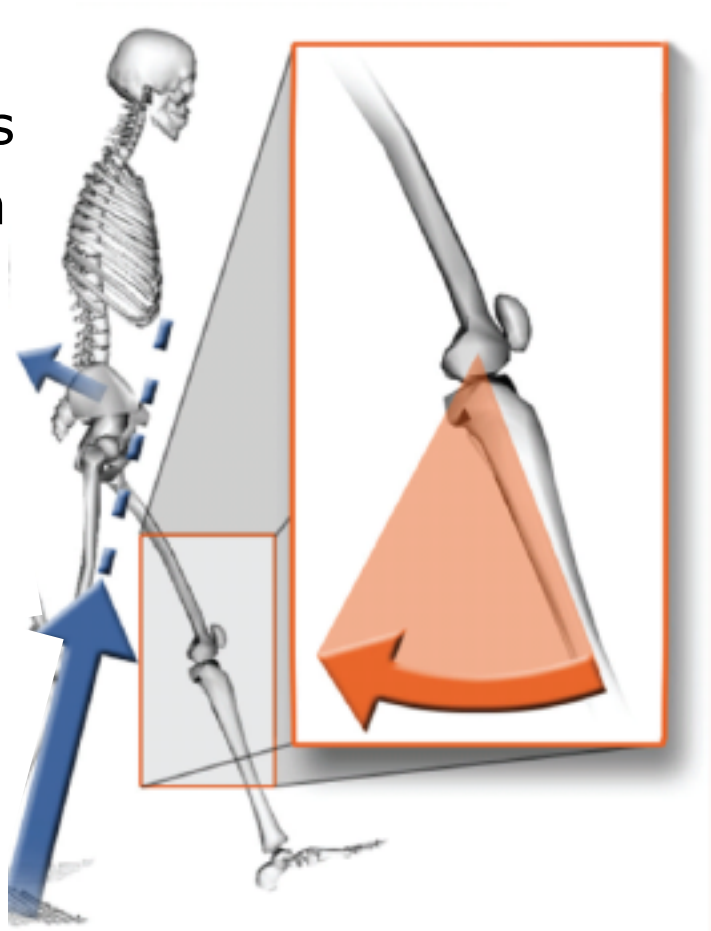
How can you reduce residuals?

- Joint kinematics estimated from marker position has inaccuracies
- Differentiation of kinematics can yield non-physical accelerations

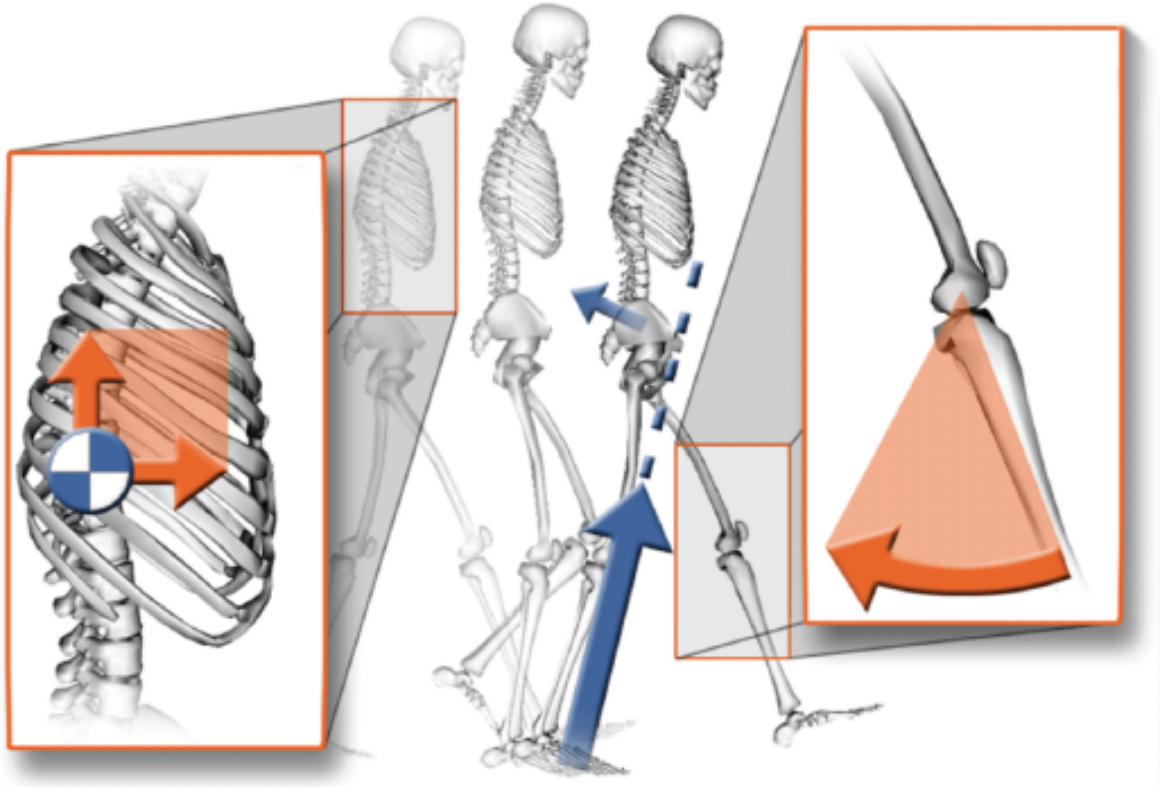
1. Adjust mass distribution including Torso COM location

2. Adjust kinematics slightly while satisfying equations of motion

RRA tracks kinematics in a forward dynamics simulation



Residual Reduction Algorithm (RRA)



TIPS & TRICKS
Keep optimal forces for residuals low (increase control bounds if necessary)
Lower weight on kinematics that track closely or have low confidence in measurement
Make mass adjustments and run RRA again - repeat until residuals no longer change