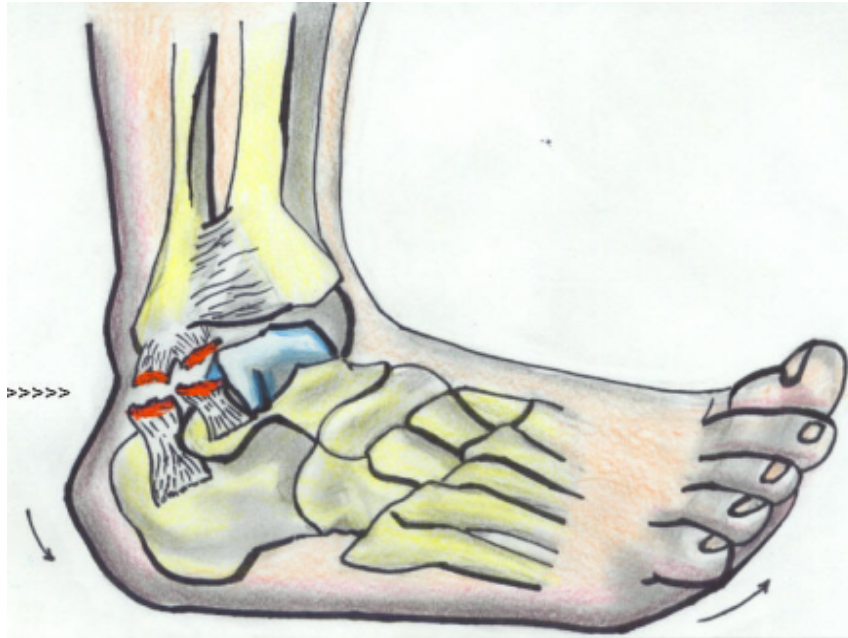


**Exercise: Simulation-based design
to prevent ankle injuries**

What is an ankle inversion sprain?

Damage to the ligaments that restrain ankle inversion

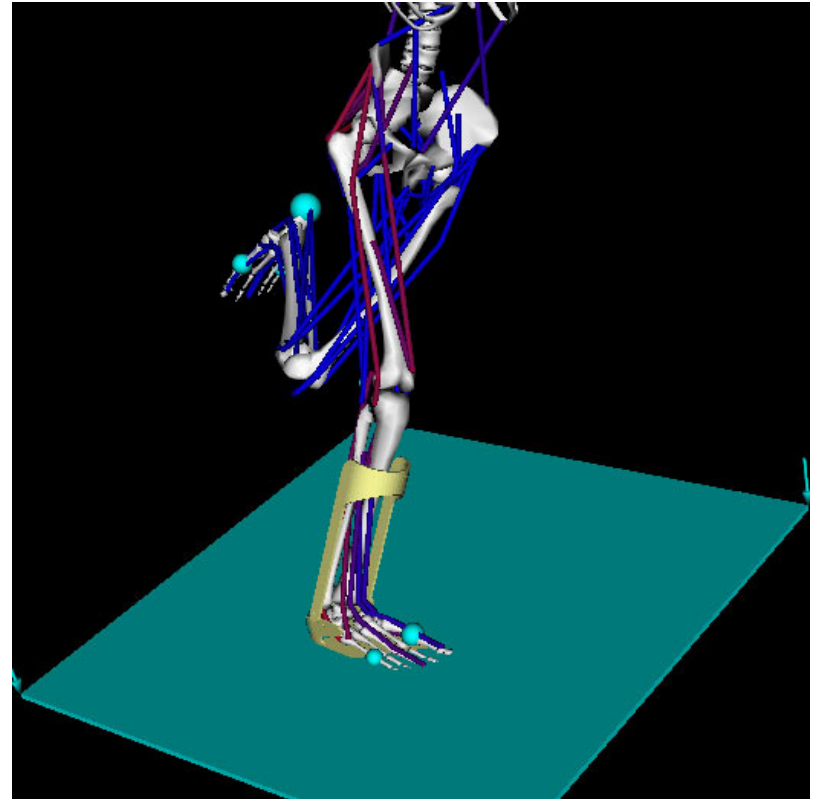


Ankle inversion angle indicates ligament strains

> **25°** correlates with injury

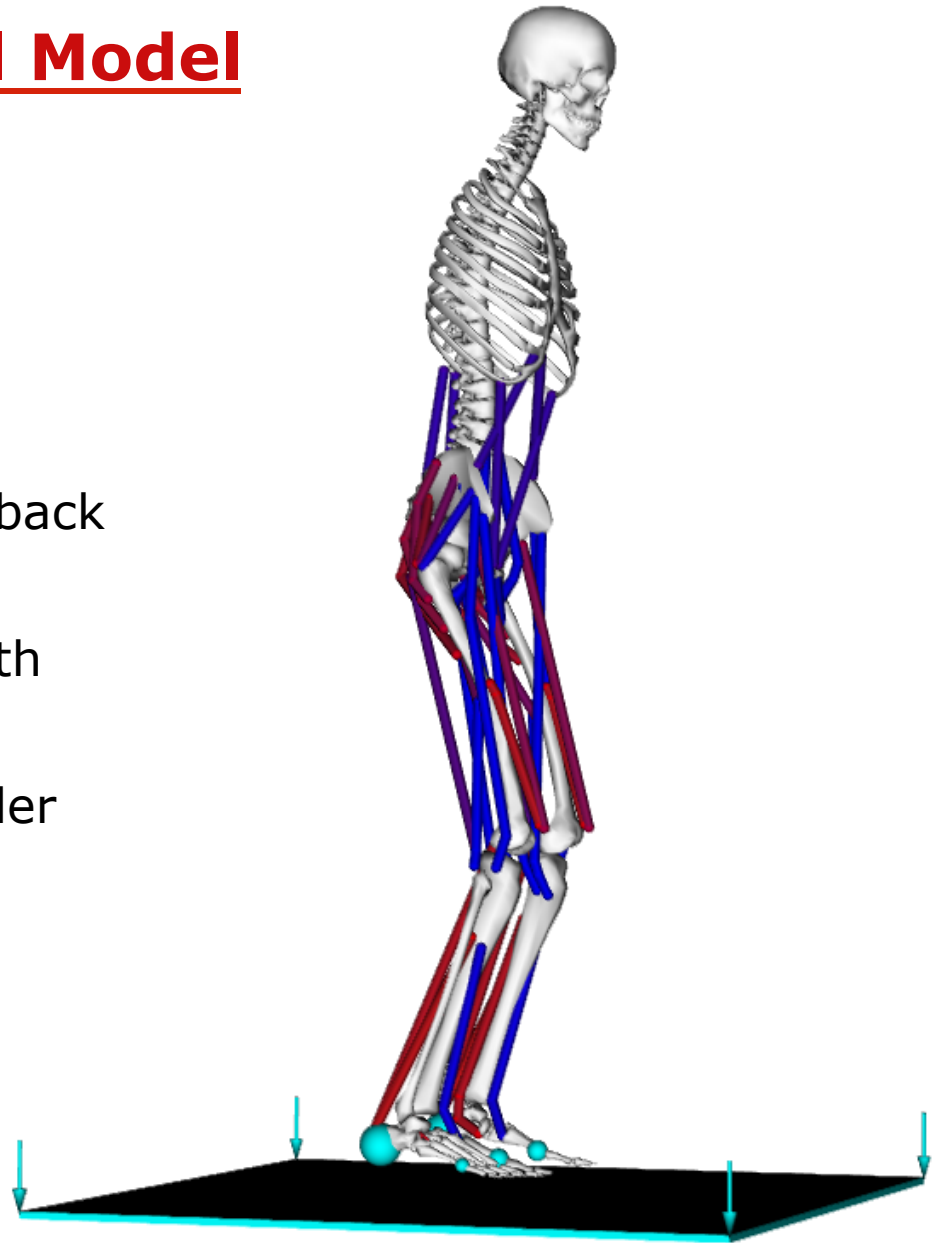
Overview of Exercise

1. Explore the model
2. Evaluate ankle inversion injury risk in a simulated drop landing
3. Design Challenge

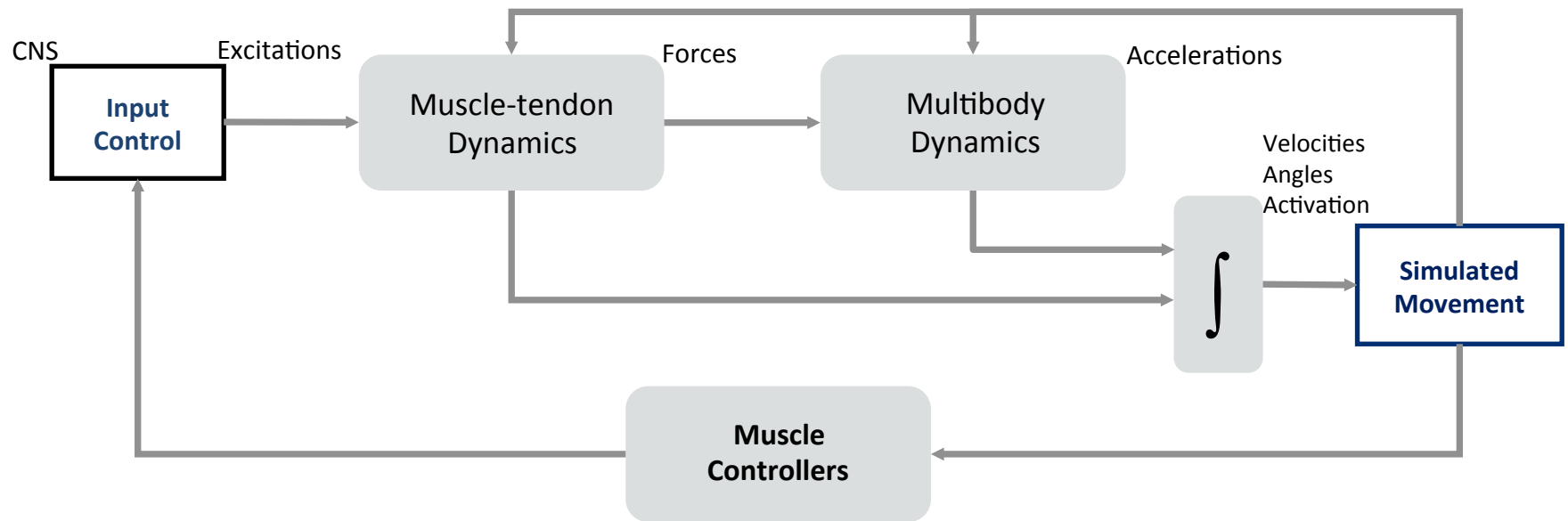


DEMO Musculoskeletal Model

1. Degrees of Freedom = 23
 - Subtalar joint enables inversion/eversion
2. Muscles = 70
3. Passive joint stiffness at the back and ankle
4. Compliant contact (Hertz) with friction (Hunt-Crossley)
5. Stretch reflex muscle controller
6. Ankle muscle controllers to simulate co-activation
7. Ankle Foot Orthosis



Forward Dynamics Simulation



Part I: Launch OpenSim and Explore the Model

10 minutes

1. Which degrees of freedom enable ankle inversion/eversion?
 2. To tilt the platform in the sagittal plane would you change platform_ry or platform_rz?
 3. Why do you think the mtp_angle_r coordinate in the model is locked?
-

Part I: Launch OpenSim and Explore the Model

10 minutes

1. Which degrees of freedom enable ankle inversion/eversion? *subtalar_angle_r*
2. To tilt the platform in the sagittal plane would you change platform_ry or platform_rz? *platform_rz*
3. Why do you think the mtp_angle_r coordinate in the model is locked?

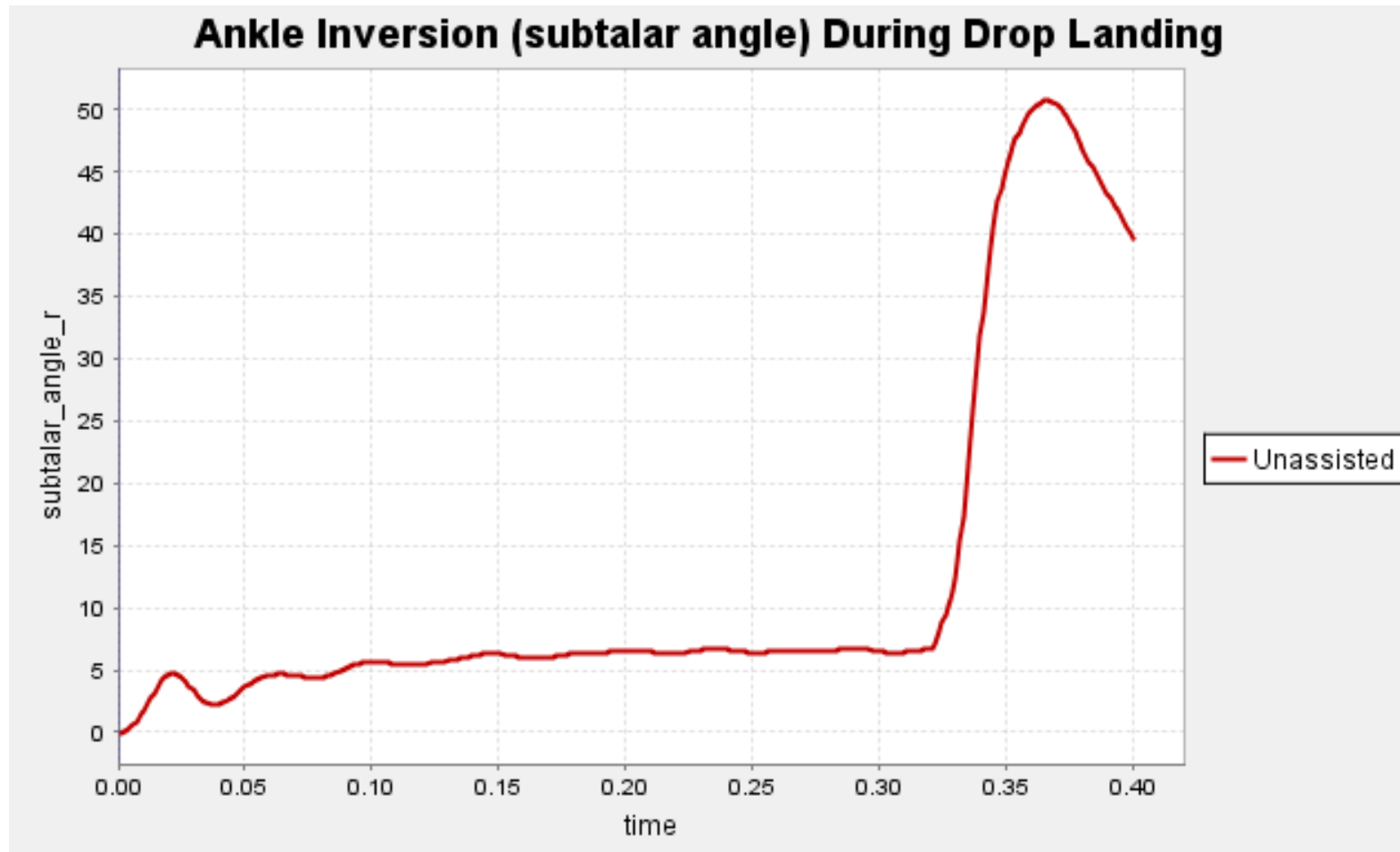
The joint is under actuated

Part II: Simulate a drop landing and analyze ankle inversion injury risk

10 minutes

1. What is the maximum subtalar angle during the drop landing?
 2. Would an ankle inversion injury have occurred during this landing?
-

Part II: Simulate a drop landing and analyze ankle inversion injury risk

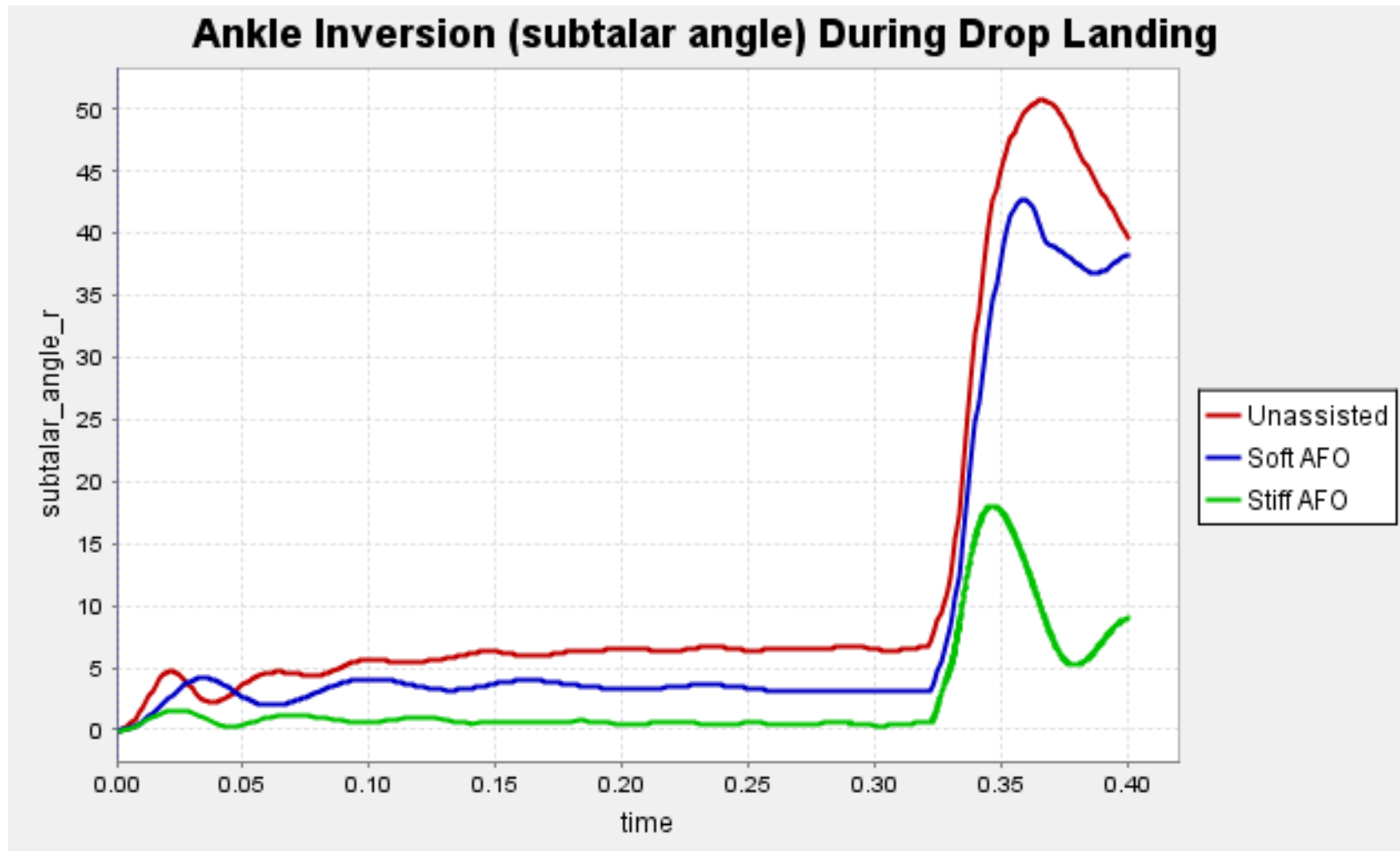


Part III: Analyze the effects of an ankle-foot orthosis

10 minutes

1. What differences in peak ankle inversion do you observe between the simulations (Unassisted vs. AFOs)?
 2. Could this AFO mitigate ankle inversion injuries?
-

Part III: Analyze the effects of an ankle-foot orthosis



Part IV: Analyze the effects of muscle co-activation

10 minutes

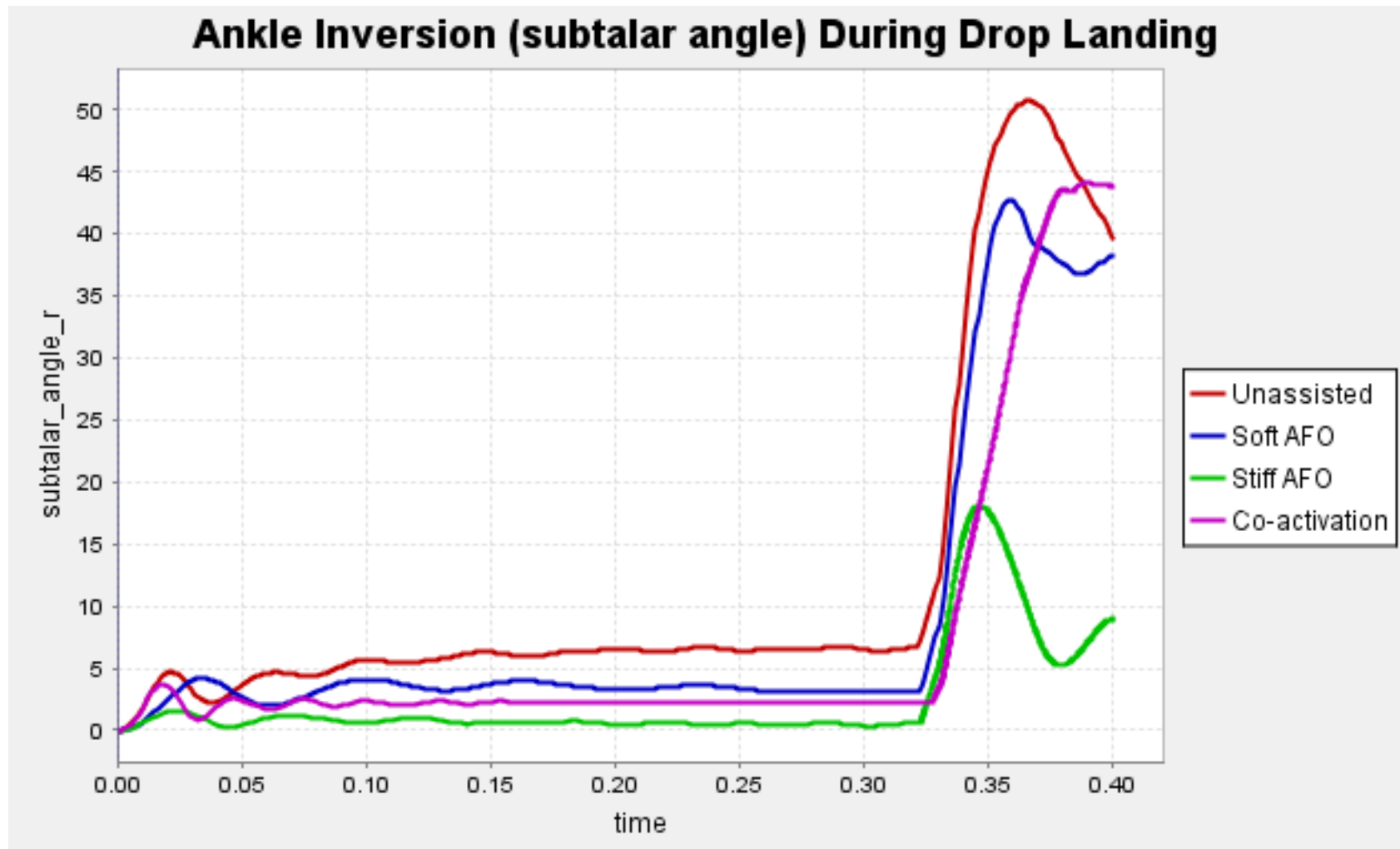
1. What is the constant control value for the inverters and everters when the co-activation controllers are enabled?

Inverters = 0.1

Everters = 0.3

2. Does co-activity of the inverters and everters mitigate ankle inversion injury?
-

Part IV: Analyze the effects of muscle co-activation



Part IV: Design Challenge

15 minutes

Design an "optimal" device and training program to prevent ankle injury:

- Increasing stiffness adds cost
 - Training programs add cost
 - Versatile scenarios reduce cost
 - Goal = neutral subtalar angle at landing
-

Example Design

Translation Stiffness in AFO = 50,000

Co-activation = 0.4 for Inverters, 0.8 for Everters

