

Analysis Of Human Gait Trails For Simulating Personalized Treatments

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Motivation

Need for Differentiated Gait Treatments

- Walking difficulties can be caused by various medical conditions such as Stroke, Osteoarthritis, Parkinson's and Cerebral Palsy
- Each person's gait/walk is unique and impacted by their medical condition
- Why are treatments for walking difficulties not individualized as well?

Objective

Improve Medical Device Treatments!

- Analyze human gait cycle using OpenSim
- Design passive improvements to be integrated into existing medical device treatments
- Simulate and analyze gait pattern of the model with a coordinate actuator (medical device treatment) in OpenSim



<http://opensim.stanford.edu/>

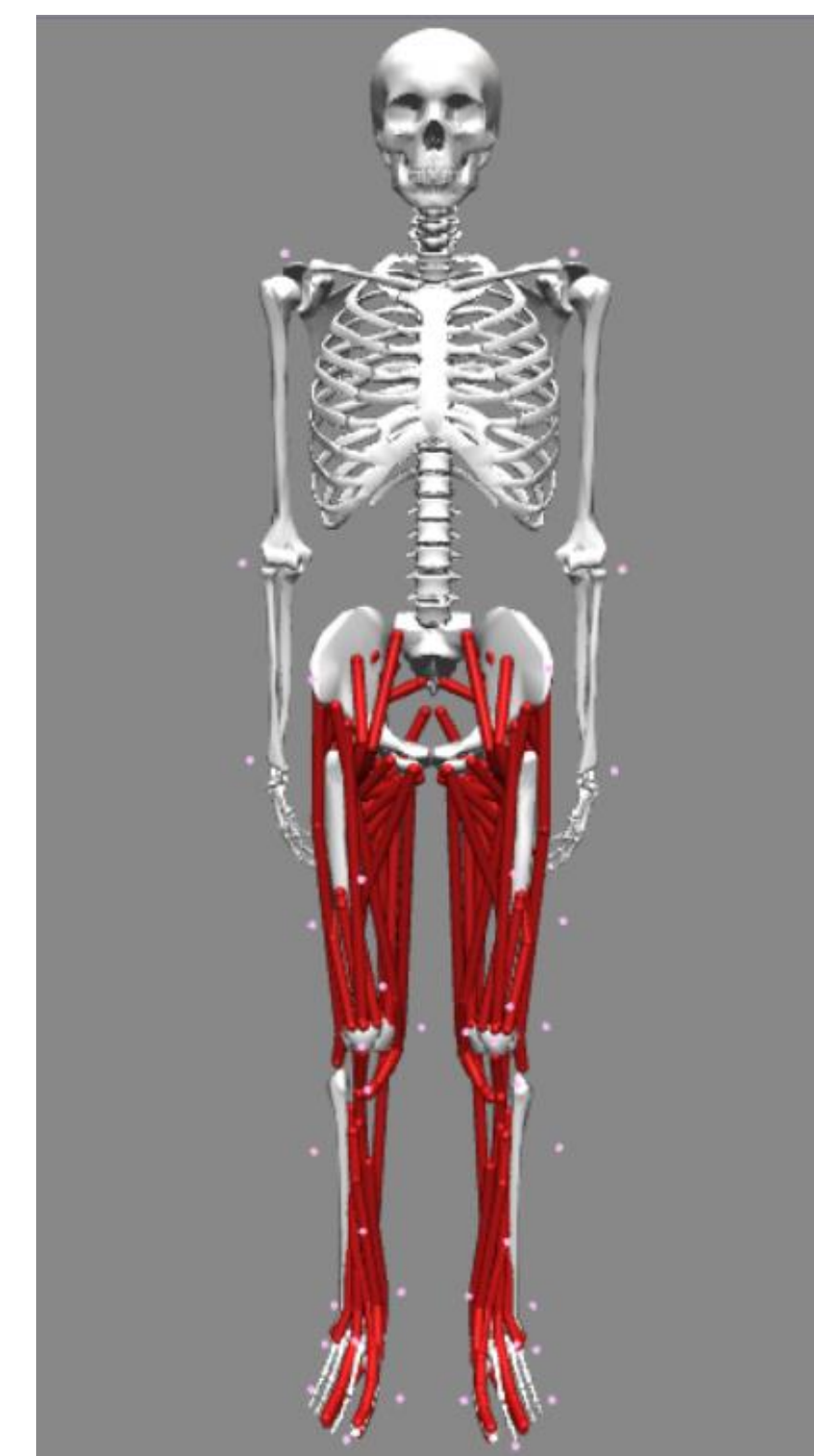
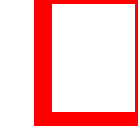




Figure 1: Mechanical Model created by OpenSim

How to Collect the Gait Data

Collect Coordinate data using Video Motion Capture System

- Marker Data  on the skin to track which joint had moved
- Ground Reaction Force Data  scales the force when/where foots pushed the plate
- EMG (Electromyography) Data  evaluates and records the electrical activity produced by muscles

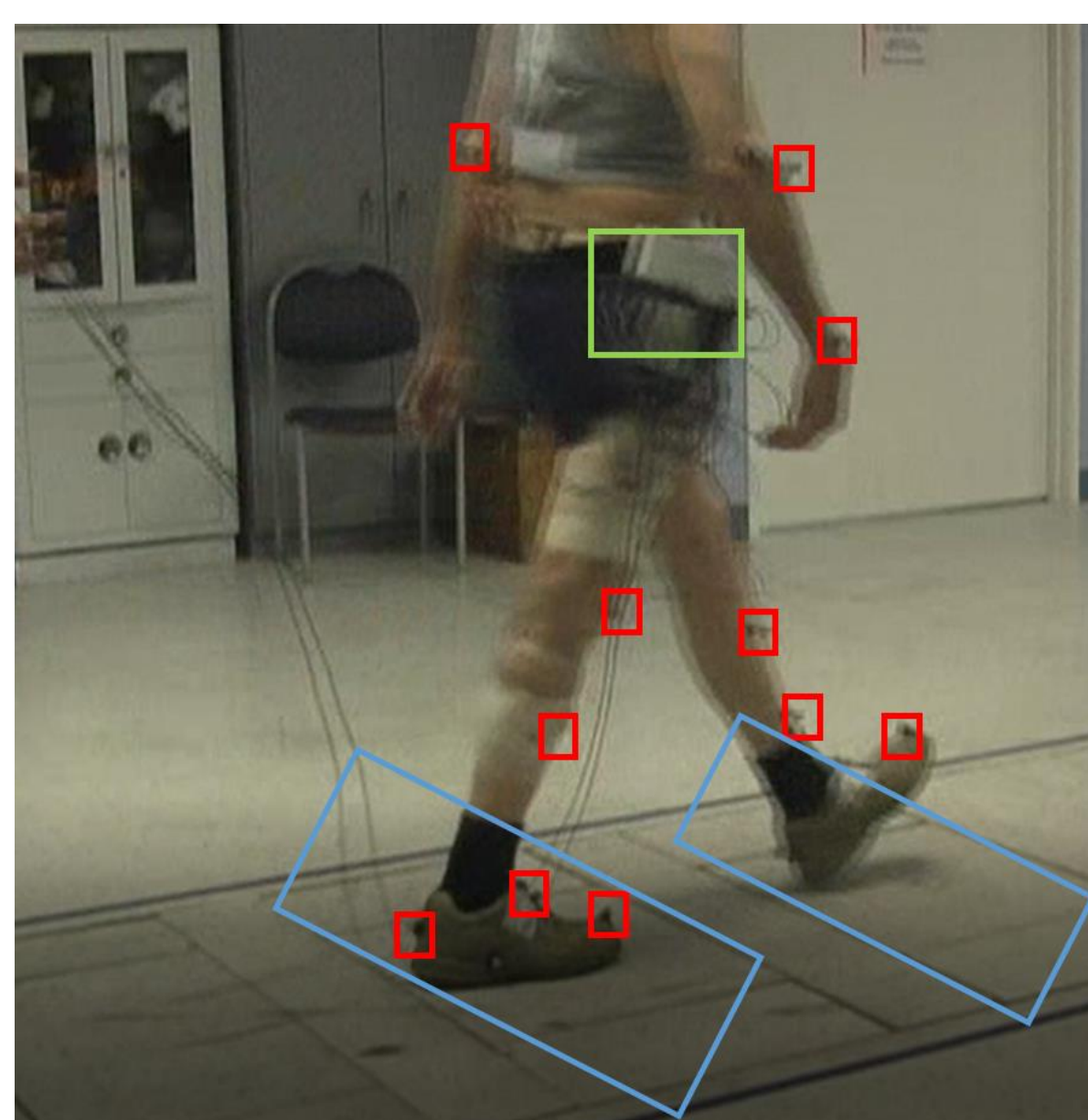


Figure 2: Scene from Experiment

Steps of Simulation

Scale Model

- Fit static marker coordinates on to the static OpenSim model

Inverse Kinematics

- Add marker motion coordinates from gait trail
- Body Joints Motion

Inverse Dynamics

- Body Joints Motion + Ground Reaction Force
- Joint Moments

Static Optimization

- IK result + GRF + Actuators
- Find the best possible solution of Joint Moments

Add Simulated Ankle Spring on the model

- Run SO again with ankle spring
- Plot and compare SO results

Simulated Spring Reduces Force!

Force gets smaller, Object can walk with less power!

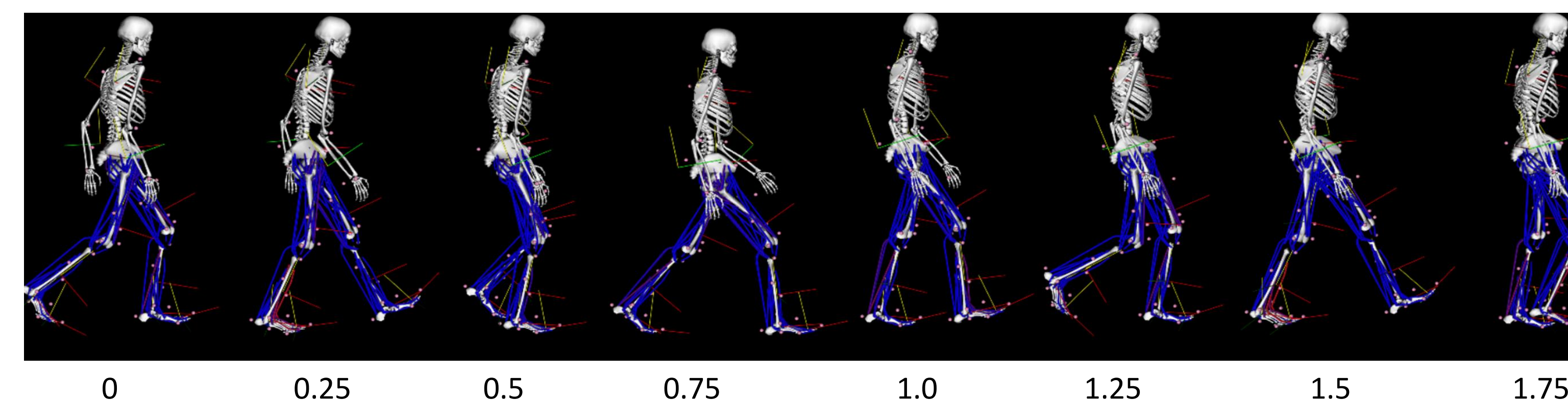


Figure 3: Normal Gait Cycle (t= 0 to 1.75 second)

Forces on Left Leg and Right Leg

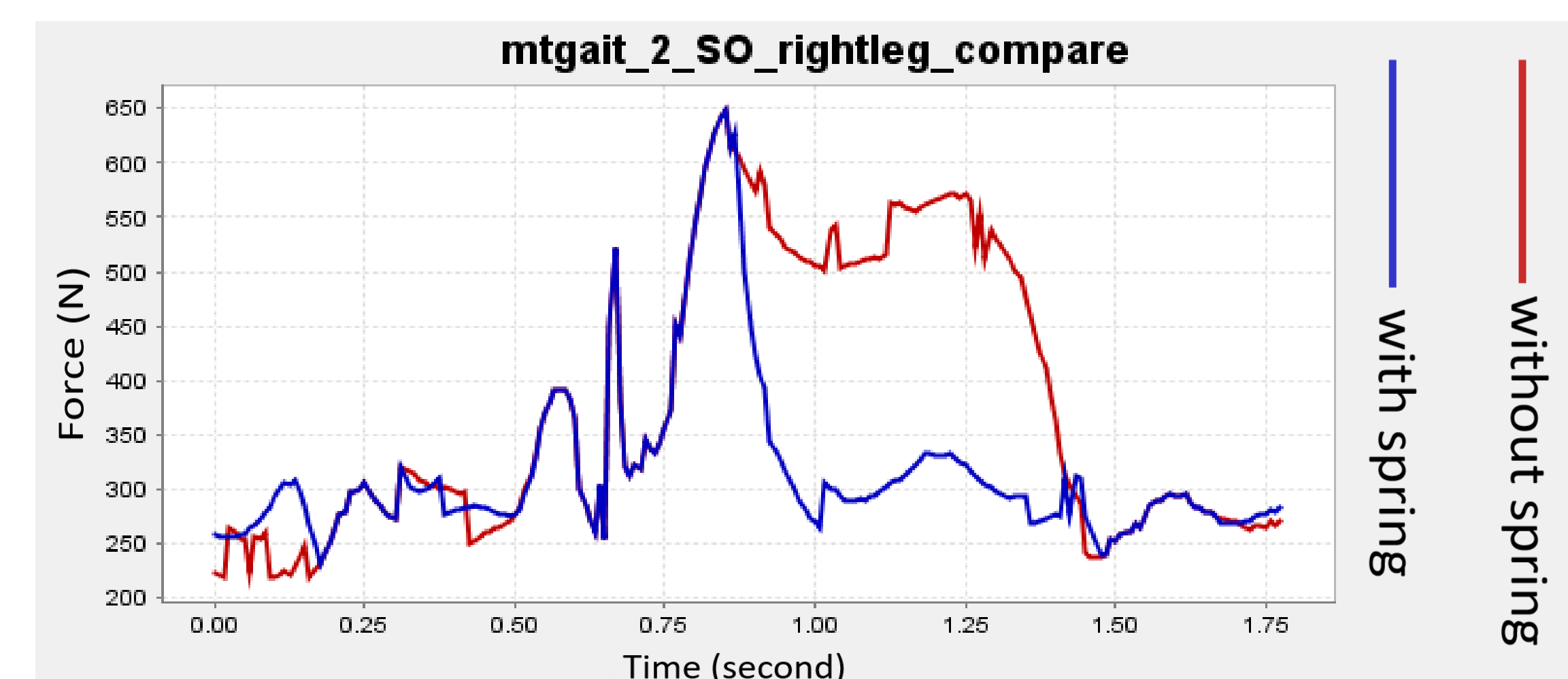


Figure 4: SO Result of Right Leg Muscle Group

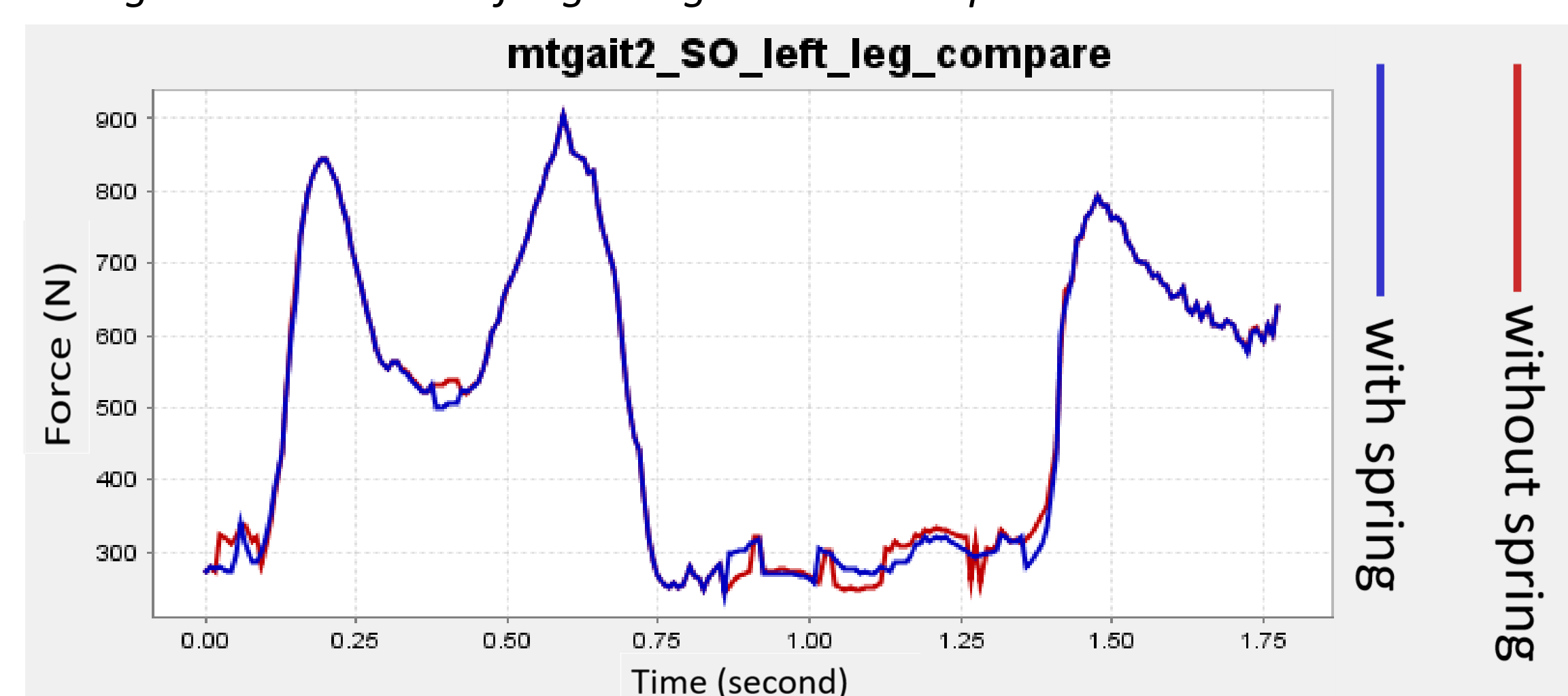


Figure 5: SO Result of Left Leg Muscle Group

- Comparing these two, left leg force didn't reduced as much as right leg force does
- Right leg force incredibly decreased when subject is stepping out the right leg
- Forces on each leg perfectly matches when subject was moving each leg

Other Reduced Muscle Forces

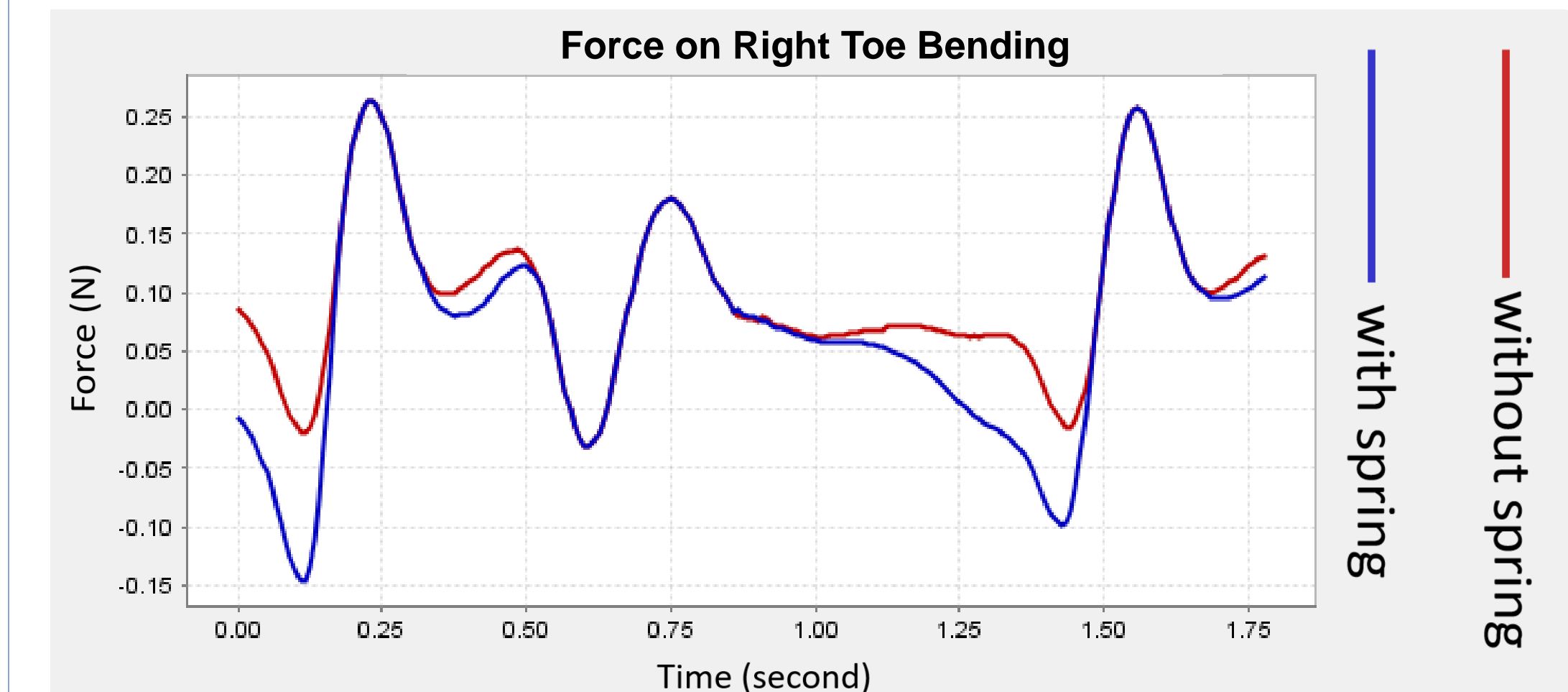


Figure 6: SO Result of Right Toe Force to Bend
mtgait2_Gastrocnemius_right_compare

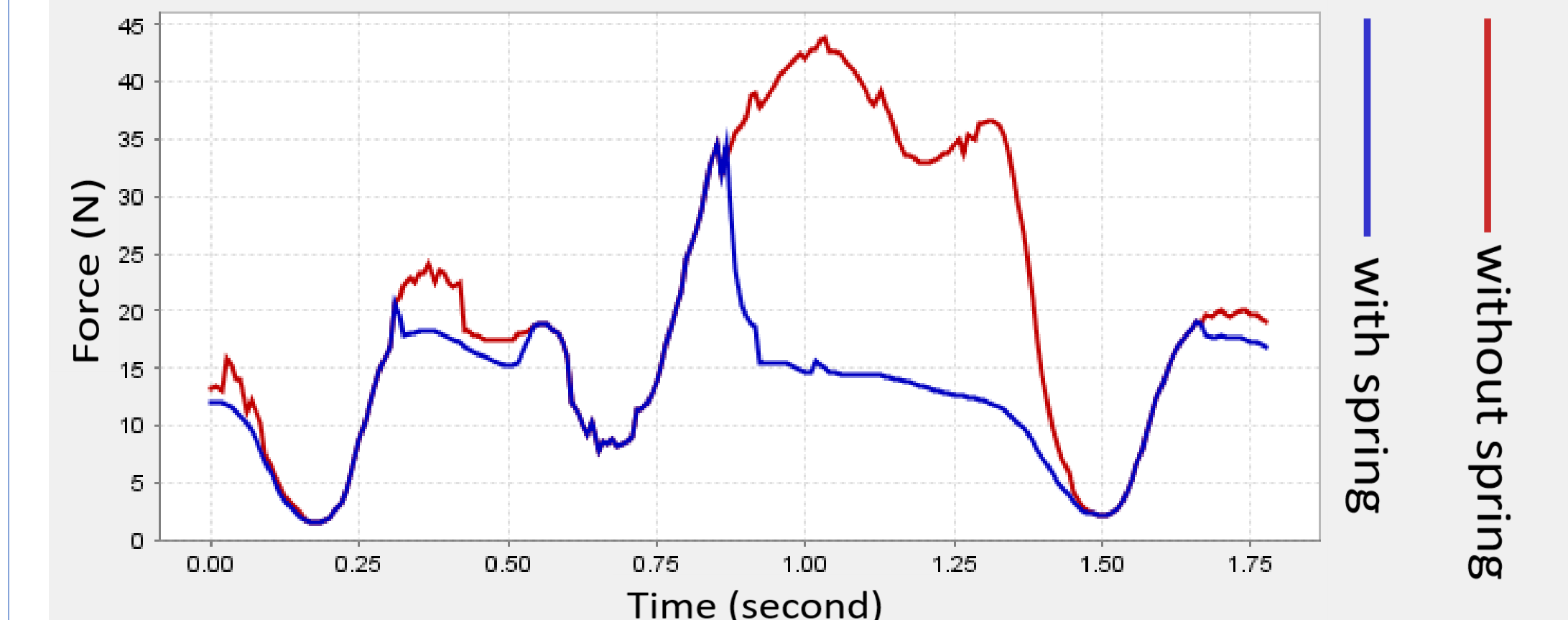


Figure 7: SO Result of Right Gastrocnemius

- Force to bend the toes decreased during the period of toe-off
- Force on Right Gastrocnemius (the muscle which flexes foot at the ankle joint and the leg at the knee joint) improved when the subject stepped on the ground

Conclusion

- Compared the Static Optimization result between the ankle spring added model and experimental model
- Force is a quantity of power the subject need to use to reach that position
- In many muscle groups, the force became less and improved when spring was added which means it helped subject to walk
- Most forces improved in Right side more than Left side, which means this subject's center of mass is slightly leaned on right

Future Developments

- To build a personalized mechanical model of each patient including women and children
- Test the treatments on the model instead of doing experiments
- Predict how treatments going to work to each patients
- Leads efficient and low-risk personalized treatments in future

References

1. Benjamin J Fregly, Jeffrey A Reinbolt, Kelly L Rooney, Kim H Mitchell, Terese L Chmielewski. (2007). Design of patient-specific gait modifications for knee osteoarthritis rehabilitation, IEEE Trans Biomed Eng. 2007 Sep; 54(9): 1687–1695.
2. OpenSim Confluence
<https://simtk-confluence.stanford.edu:8443/display/OpenSim/User%27s+Guide>

Acknowledgements

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