Kinematic and Kinetic Analysis of a Transtibial Biarticular Prosthesis

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BP Prototype

- Thigh Cuff
- Socket
- Pylon Strain Gauge
- Variflex foot
- Ratcheted Clutch
- String Potentiometer
- Spring
- Load Cell
Specific Aims

1. Validate OpenSim methodology

2. Analyze how the BP affects one amputee’s gait
Methods

Walking trials:

1. Prescribed Prosthesis
2. BP with increasing spring stiffness
   - 1.85 N/mm
   - 3.7 N/mm
   - 10 N/mm
   - Stiff
3. Unpowered BP

Vicon
Marker trajectories
Ground reaction forces
Matlab
Processing and formatting

OpenSim
Scale
Inverse Kinematics
Inverse Dynamics
Matlab $\tau_{BP}$ Calculation

$F$ – measured from load cell

$r$ – Calculated in OpenSim using preset points of application

$$\tau_{BP} = r \times F$$
Dual Inverse Dynamics

\[ \tau_{GRF} + \tau_{other} + \tau_{unknown} = I\alpha \]
Methods Comparison

Comparison of BP contribution calculation methods

Knee Moment Contribution (Nm)

Percent Gait Cycle (%)
BP Ankle Contribution

Ankle Moment N·m/kg

Plantar

Dorsi

Average: 33%

Unpowered BP
1.9 N/mm BP
3.7 N/mm BP
10.5 N/mm BP
Stiff BP
Knee Kinematics

Graph showing the knee angle in degrees over time for different conditions:
- Unpowered BP
- 1.9 N/mm BP
- 3.7 N/mm BP
- 10.5 N/mm BP
- Stiff BP

Flex point indicated on the graph.
Discussion

- Dual ID method is an accurate and valid method to compute the BP contribution to joint torques

- BP contribution to ankle plantar flexion torque increased as stiffness increased

- More analysis and additional subjects needed to delineate the BP effects at the knee
Acknowledgments

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Contralateral Knee Moment
Ipsilateral Knee Moment

The graph shows the knee moment in Newton-meters per kilogram (N-m/kg) as a function of flexion angle. The graph includes curves for different conditions, with labels for 'Ext' and 'Flex' indicating extension and flexion, respectively. The x-axis represents the flexion angle in degrees, ranging from 0 to 100. The y-axis represents the knee moment in N-m/kg, ranging from -0.4 to 0.6.