Symmetrical Movement Assistance in Cycling Rehabilitation for Transtibial Amputees

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What is a transtibial amputation (TTA)?

- A surgical procedure performed to remove the lower limb below the knee when the limb has been severely damaged or diseased
- Often referred to as below-knee amputation [1]
Causes of Transtibial Amputation

- Peripheral artery disease (PAD)
- Diabetes
- Infection
- Foot Ulcers
- Trauma
- Cancer
Transtibial Amputation Statistics

- 28.2% of all lower-limb amputations [4]
- representing 71% of all dysvascular amputations [2]
- 47% increase expected in below knee amputations from 1995-2020 [2]
Diabetes Amputation Statistics

- Persons with diabetes are anywhere from 8-24 times more likely to undergo a lower limb amputation than non-diabetics [5]
- American Diabetes Association (ADA) states 60% percent of non-traumatic lower-limb amputations for people over 20 are in diabetics [6]
- The number of amputations caused by diabetes increased by 24% from 1988 to 2009 [2]
- International Diabetes Federation (IDF) predicts that current global prevalence of diabetes will burgeon from 285 million to reach 435 million by 2030.1 [2]
Rehabilitation Problem

- Prolonged immobility
- Risk of loss of contralateral leg amputation:
  - 15%-20% after 2 years [7]
  - 20% to 50% after 4 years [8]
- Risks of falling during rehabilitation
Cycling with Transtibial Amputation

- Issues:
  - Asymmetric movement with regard to kinematics and kinetics while cycling
  - A prosthesis limits the motion of the limb
  - Increased range of motion of the hip and knee joint
    - Compensation for lack of ankle motion
  - Increased work asymmetry between limbs
- Solution:
  - Shortened crank arm for the amputated leg produces more symmetrical limb kinematics (Childers)
TTA Cycle Motion
The Effect of Crank Shortening

- Creates a similar range of motion demand for the affected side
- Reduces the geometric asymmetries between the two lower limbs
- Reduction of work asymmetry
# Childers’ Crank Arm Study

<table>
<thead>
<tr>
<th>Condition</th>
<th>Hip angle (degrees)</th>
<th>Knee angle (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>Sound limb</td>
<td>14</td>
<td>57</td>
</tr>
<tr>
<td>Amputated limb with symmetrical crank arms</td>
<td>10</td>
<td>56</td>
</tr>
<tr>
<td>Amputated limb with 15 mm shorter crank arm</td>
<td>12</td>
<td>53</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subject number</th>
<th>Work asymmetry with symmetrical crank arms (%)</th>
<th>Work asymmetry with 15 mm shorter crank arm on the amputated side (%)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>15.0</td>
<td>7.0</td>
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<tr>
<td>2</td>
<td>30.0</td>
<td>20.8</td>
</tr>
<tr>
<td>3</td>
<td>20.8</td>
<td>20.8</td>
</tr>
</tbody>
</table>
Define the Optimal Crank Asymmetry

- For larger range of subjects
- Develop adjustable crank
- Look at how saddle height further affects this asymmetry
Funding Uses

• Fund further research of the limb kinematics
  • Pay graduate students
  • Lab equipment – motion capture system, markers and stationary bike
  • Lab space

• Design an adjustable crank prototype
  • Materials & Manufacturing
  • Patent fees
Summary

• Growing elderly population and an increase in diabetes and PAD
• Cycling is one of the best ways to rehabilitate amputees
• Design adjustable crank for transtibial amputees
References


Questions?