Introduction

The number of amputations keeps increasing globally, and the cost of advanced prostheses is on the rise everywhere. The cost to American insurance agencies is approximated to be $12 billion annually [1]. As such, it has become very important to design prostheses that are not only performance focused but also affordable. The significant portion of the costs lie in the industry and manufacturing of the prosthetics, even when the design is made of relatively less expensive materials. The costs can be reduced significantly through the process of 3D printing. In fact, in addition to reducing the cost of manufacturing and resources, it will also allow an easy adaptation (fitting) of the model through the Computer Aided Design software (SolidWorks).

Methods and Materials

A detailed research was conducted specifically on Polycentric Knee (Four bar joint design) to evaluate and analyse the pros and cons of the designs on patients. The chosen design was inspired by two knee designs that were closely studied and analysed:

1. The Jaipur knee [3] designed by a team of students at Stanford University. The knee prosthesis currently being fitted on amputees in India, was improved by the company D-Rev that renamed the design as the ReMotion Knee.
   - Characteristics: Maximum flexion degree 165°
   - Component Weight: 400g
   - Material: Nylon
   - Maximum user weight: not specified

2. The ROADRUNNERFOOT POLYCENTRIC KNEE [4] (Code 6.002.01)
   - Characteristics: Maximum flexion degree 165°
   - Component Weight: 520 g
   - Material: Alluminium alloy
   - Maximum user weight: 130 kg

Results-Design

This research focuses on designing a 4 bar linkage knee joint that can be simple enough to be 3D printed, while also being
- durable
- reliable
- affordable

<table>
<thead>
<tr>
<th>Activities</th>
<th>Knee Flexion</th>
<th>Compressive load (Body weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal gait/level</td>
<td>60°</td>
<td>1 BW</td>
</tr>
<tr>
<td>Stair climbing</td>
<td>80°</td>
<td>3.8 BW</td>
</tr>
<tr>
<td>Sitting/ rising from most chairs</td>
<td>90°</td>
<td>-</td>
</tr>
<tr>
<td>Sitting/ rising from toilet seat</td>
<td>115°</td>
<td>-</td>
</tr>
<tr>
<td>Cycling</td>
<td>60°-100°</td>
<td>1.2 BW</td>
</tr>
<tr>
<td>Walking</td>
<td>15°</td>
<td>3.0 BW</td>
</tr>
</tbody>
</table>

Acknowledgments

This project was funded by the Undergraduate Research Opportunity Program. I would like to express my gratitude to Marc Doumit, Daniel Benoit, Ahmed A. Faraz, Omar Sahrarri, Nacer Abdellouali, Yasmine Elgaraway and the Neuromuscular Rehabilitation Research Unit (NRU) for their support, mentorship and involvement in this project.

Reeham Hammouda, rhammo37@uottawa.ca

References


Conclusion

Although this new prototype may result in the absence of some features present in the high end prosthetic knee joints, the overall performance was optimised in the proposed innovative design. This design can be used globally, but perhaps its impact will be felt greatly in third world countries.