A REVIEW OF TRANSFEMORAL AND TRANSTIBIAL PROSTHESES

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Introduction

- Approximately 1.9 million people in the U.S alone are living with limb loss and expected do double by 2050 [1]
- Lower limb prosthetics offer a solution to increase amputees' quality of life
- Two kinds of prosthetic limbs, passive and active
- Passive prostheses are a bit inefficient, as they require more metabolic energy for movement and asymmetrical gait
- Active prosthesis are significantly more expensive than passive prosthesis, some can cost up to $50,000 [2]
- There is need to address design improvements to passive prostheses so they can both accessible and affordable

Transtibial or Below-Knee Passive Prosthesis

- Main purpose of prosthesis is to provide support, and store and return energy
- Comprised of socket, pylon tube, prosthetic foot and ankle, and springs
- Passive below-knee prosthesis produce net negative work during walking resulting in higher metabolic expenditure [2]
- Mechanical properties are fixed and cannot adapt to changes in gait speed or surface angles

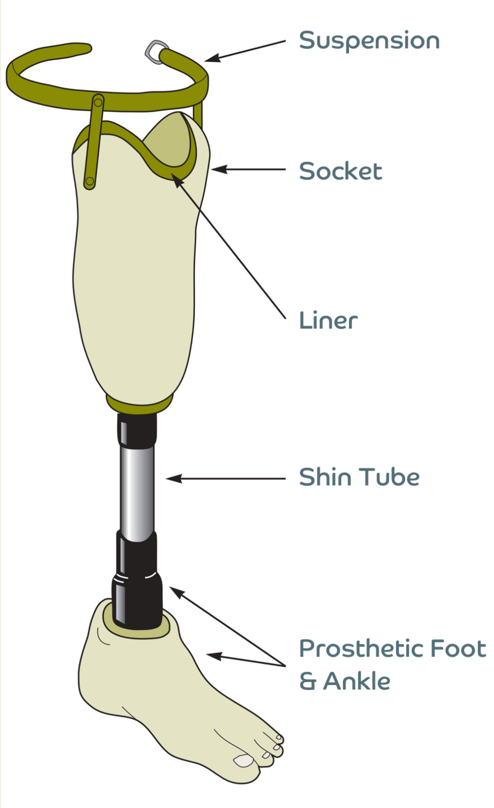

Figure 1: Passive Below-Knee Prosthesis

Transtibial Active Prosthesis

- Active below-knee prosthesis include motors used in conjunction with springs
- A motor can exert force
- As a result of energy from the motor, walking metabolic economy is improved [3]

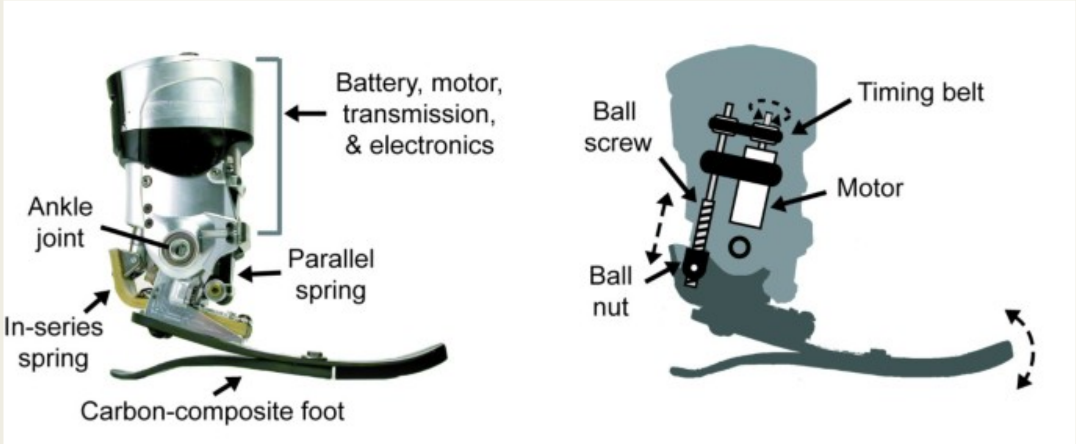

Figure 2: Active Below-Knee Prosthesis

Transfemoral Passive Prosthesis

- Transfemoral is more challenging prosthesis, as the hip becomes the primary mover
- Comprised of a prosthetic foot, ankle, pylon and artificial knee joint
- Comparable to passive below-knee prostheses, disadvantages include accidental knee flexion, overexertion of torque on hip joint, and higher metabolic cost of movement [4]

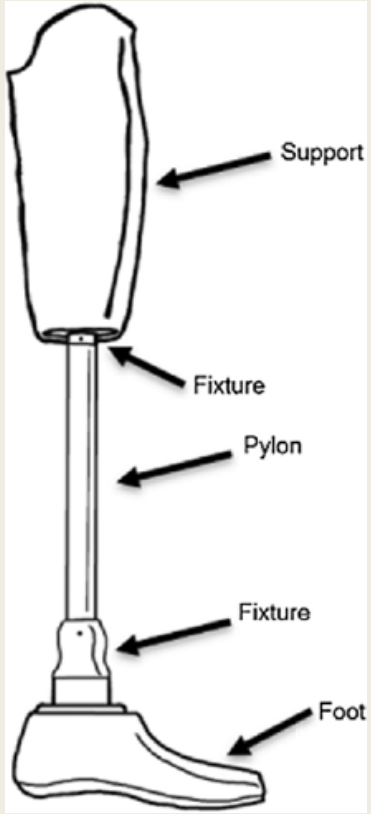

Figure 3: Transfemoral Passive Prosthesis

Transfemoral Active Prosthesis

- A powered above-knee prosthesis is used to address issues and duplicate the human gait as much as possible
- In a prototype produced by Geng *et al. [4]* a linear motor is introduced and connected to a four-bar linkage such that it can rotate to provide knee flexion and extension

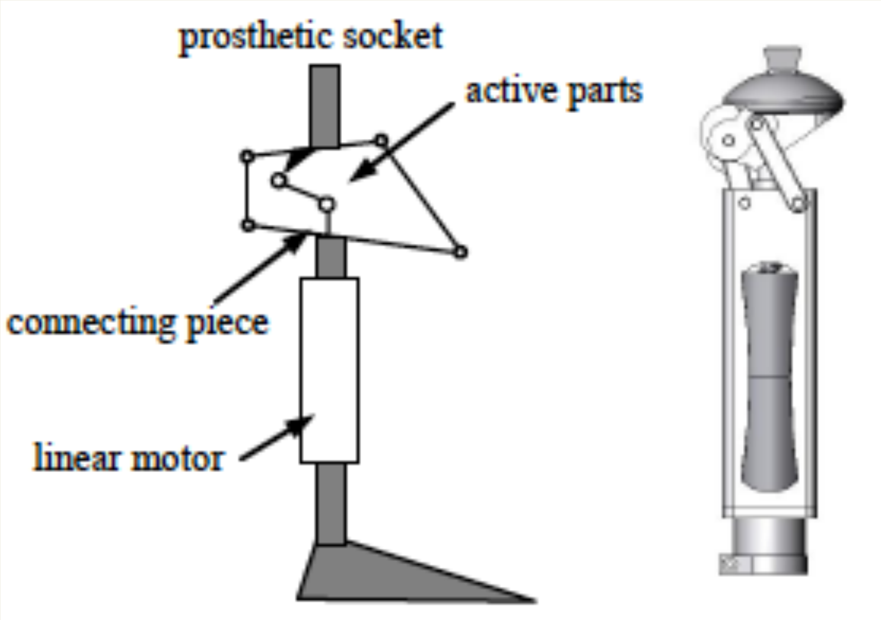

Figure 4: Active Above-Knee Prosthesis

Current State of the Art

- Figure 5 displays the patent for a prosthetic foot from Ossur and covers different embodiments
- One such embodiment can be fitted with a fluid damper that can function as a variable spring
- The fluid would need a variable storage modulus G’
- At slow walking speeds, the fluid would have higher damping and energy absorption while having fewer rebound properties. While walking at high speeds, the fluid would have less damping and energy absorption but more rebound [5]

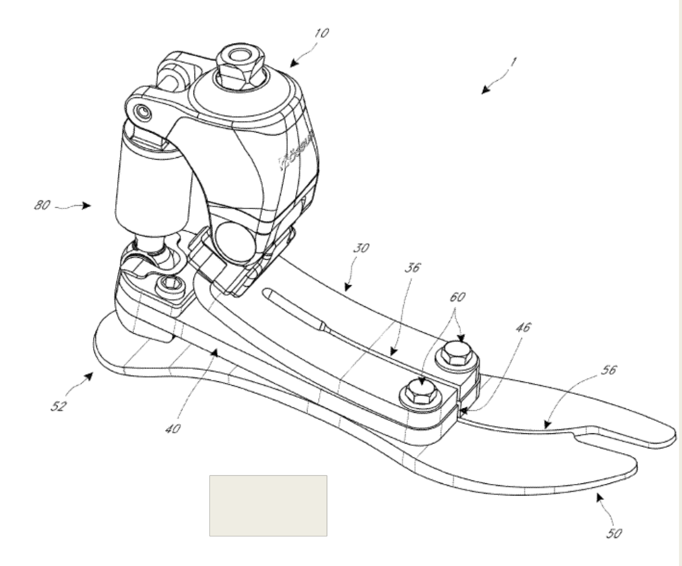

Figure 5: Ossur Prosthetic Foot

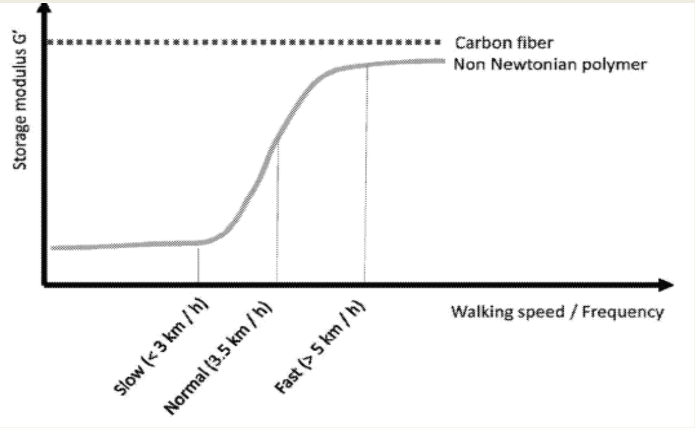

Figure 6: Non-Newtonian Polymer

Design Improvement

- As stated before, active prosthesis are very expensive and not accessible to some in developing countries
- In a study by Narang *et al*, the study sought to examine the effects of altering mass and/or moment of inertia properties on hip power and work
- Decreasing mass and moment of inertia results in less hip work and power needed to achieve able-bodied kinematics
- I would like to apply this concept and apply it to a passive below-knee prosthesis
- As future work, I would like to perform a Finite Element Analysis to determine the viability of improvements

Acknowledgements

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References

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[2] K. E. Zelik *et al*., "Systematic Variation of Prosthetic Foot Spring Affects Center-of-Mass Mechanics and Metabolic Cost During Walking," in IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 19, no. 4, pp. 411-419, Aug. 2011, doi: 10.1109/TNSRE.2011.21590

[3] S. K. Au, J. Weber and H. Herr, "Powered Ankle-Foot Prosthesis Improves Walking Metabolic Economy," in IEEE Transactions on Robotics, vol. 25, no. 1, pp. 51-66, Feb. 2009, doi: 10.1109/TRO.2008.2008747.

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