ENGINEERING DESIGN OF LOWER EXTREMITY PROSTHETIC FOR HIGH AMBULATION PATIENTS IN DEVELOPING NATIONS

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Design improvement, while maintaining low-cost, for lower extremity prosthetic devices is a large need in developing nations. Our research group at LeTourneau University's Biomechanics Laboratory is designing a knee prosthesis for specific use in Cure's Bethany Crippled Children's Clinic in Kenya. Four varied lower extremity prosthetic devices are being developed and tested for direct implementation with high ambulation children in Kenya. A range in age and specific use of devices creates a need for varied designs. Ability to perform daily activities and reduced energy expenditure are important criteria for these designs. Biomechanical analysis is being used in the design so that stress on the rest of the body is minimized.

Delrin is the material selected for the foot and knee unit in our prosthetic device, alternate materials are also feasible. Design of the foot and knee units is based on literary review and critical analysis of capabilities in the Kenyan clinic. Components of the prosthetic are built in less than an hour each, and can be made in advance, using the equipment already present on site in Kenya. The total cost of the prosthetic unit is less than one-hundred dollars US, which is less than the cost of the current non-articulating design. Prosthetics in the US cost between three and thirty thousand dollars. Challenges in creating highly functional prosthetic devices on a significantly reduced budget are focused around the knee, foot, and socket. Injection molding is out of the price range, and precision milling is not available, so the designs we have created are made with detailed templates, basic materials, and inexpensive machinery.

Figure 1: Initial lamination socket and Knee Unit.

Biomechanical performance is being assessed with motion analysis equipment and gait analysis software in our laboratory. Energy expenditure is being assessed through oxygen consumption at varying activity levels. Test subjects in the local area are completing the experiment with their current high performance prosthetic device, one of our prototypes, and with a solid leg like those currently used in Kenya. Gait analysis results are compared with published studies. Output data from the Motion Analysis™ system is directed into an inverse dynamics program to investigate effects on the joints and muscles of the body during use of these prosthetic designs. Mechanical performance is being quantified with compression, torsion and fatigue testing following ISO standards.

Technology and experience gained during this study will be applied in future years working towards direct application of biomechanical principles to needs in developing nations. A Similar project with upper extremity prosthetics stated that these traits were important: "functionality at a minimum cost, durability, simplicity, ease of repair, adaptability to local materials, and cultural acceptability" (Sitek et al., 2004). Comprehensive designs tested computationally, mechanically, and in application will be provided to the clinic, alternate materials will also be listed. The clinic plans on adding this design and process to their teaching curriculum following proof of success with a group of patients in Kenya. Mechanical experience and testing facilities allow for rapid improvement in prosthetics for definite applications.

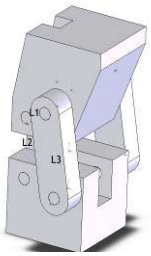

Figure 2: Four Bar Polycentric Knee Unit

References:

Sitek, Alison J. et al., (2004) "Development of an Inexpensive Upper-Extremity Prosthesis for use in Developing Countries". Journal of Prosthetics and Orthotics 16(3):1-9.

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