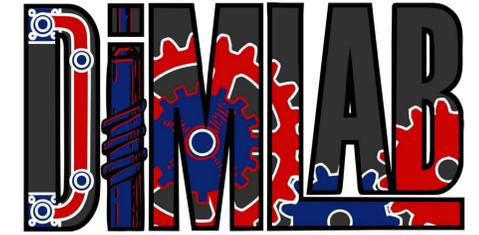# Design of a Trike for Paraplegics Powered By Functional Electrical Stimulation of Leg Muscles

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Objective: To develop an effective method of transferring variable torque, generated by electrically stimulated muscle contractions, to the rear axle in the interest of propelling the trike forward.

Motivation

Dead Zones (the portion of the pedal cycle where neither leg actively contributes productive torque) are a significant challenge to FES cycling. Approximately one-third of the pedal cycle cannot be stimulated using traditional FES electrodes, resulting in power generation 15-25 less than capable cyclist. A design that overcomes dead-points and efficiently transmits torque will provide these individuals the opportunity to maintain a healthy, active lifestyle.

Functional Electrical Stimulation & Cycling

- FES is used to stimulate contractions in individual muscle groups within the upper leg
- Muscle contractions must be timed to pedal position
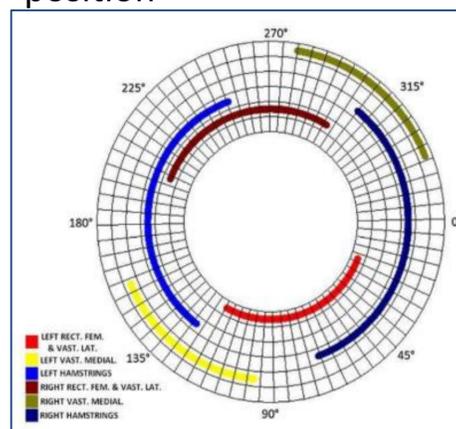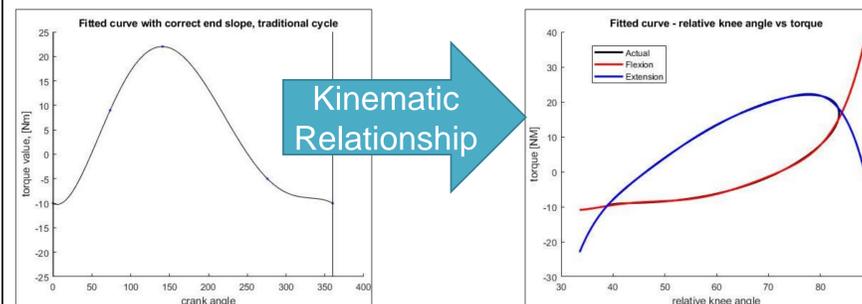

Traditional Trike

Objective

1. To ensure pedaling is smooth through TDC and BDC, thus reducing the two kinematic dead zones
2. To develop the greatest amount of productive torque through each cycle
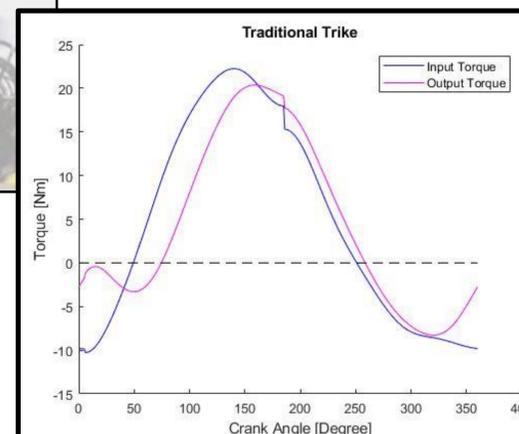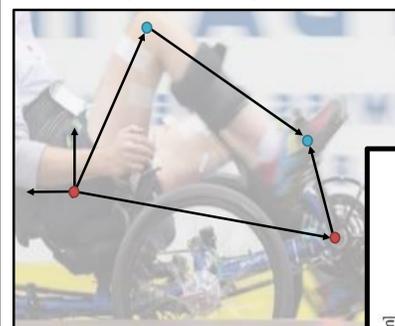
Input Torque

Torque is solely generated at the knee during FES Cycling and is a function of relative knee angle. The input torque curve was generated by matching data from our FES Cycling literature review.

Kinematic Relationship

Traditional Trike Baseline Model

This model used a four-bar mechanism to calculate the output torque throughout one full cycle.

Quasi-Statics

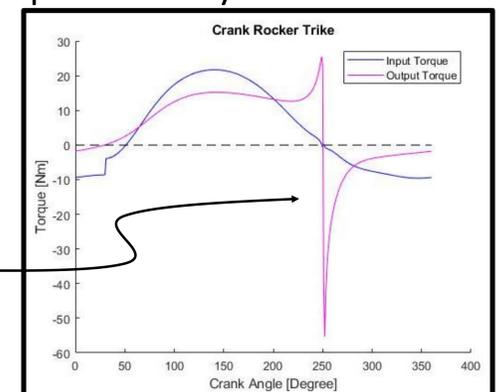## Alternative Design Concepts

Coupler Driver Trike

Crank Rocker Trike

Crank Rocker Model and Optimization

A comparative model, similar to the traditional trike, was developed to compute output torque as a function of the same input torque *and* several parameters that have been optimized to produce the greatest amount of torque over a cycle.

Theoretically infinite mechanical advantage at 250°

Continuing Work

- Develop coupler driver model and optimize
- Conceive new and innovative mechanisms
- Compare output torque on all alternative designs