Design of a Performance Tricycle for Persons with Paraplegia Powered by Functional Electrical Stimulation of Leg Muscles

Nicholas Lanese

Advisors: Andrew Murray, Ph.D. & David Myszka, Ph.D.

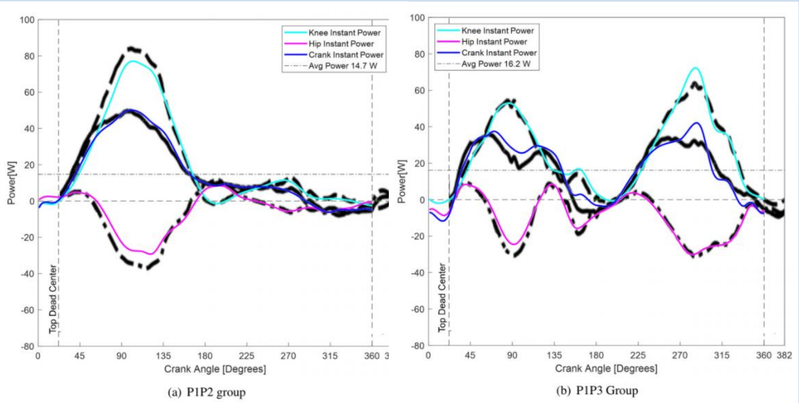
Department of Mechanical & Aerospace Engineering

University of Dayton

Objective: Develop and optimize a tricycle design for functional electrical stimulation (FES) riders which produces more power over one full rotation of the wheel.

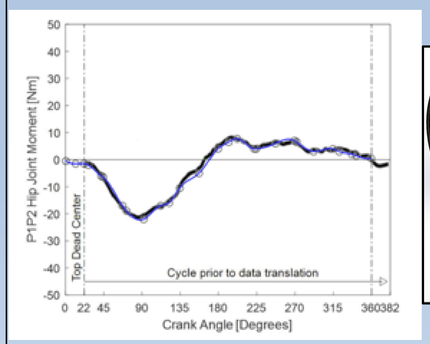
Traditional Trike Validation

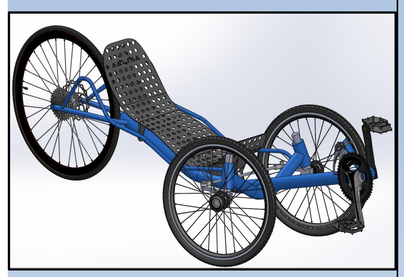
Prior research shows two groups of FES riders, P1P2 and P1P3 groups. These riders were pedaling with a power of 15 W per leg. To validate the Traditional Trike process, power curves generated are matched with prior research closest to 15 W .



Joint Torque Matching

Both P1P2 and P1P3 groups produce different joint torque at different angles. In order to properly calculate these torques, data was interpolated from prior research for P1P2 & P1P3 Hip and Knee Torque

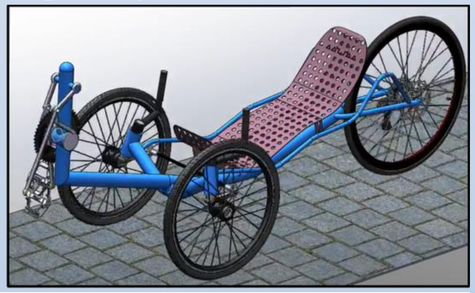


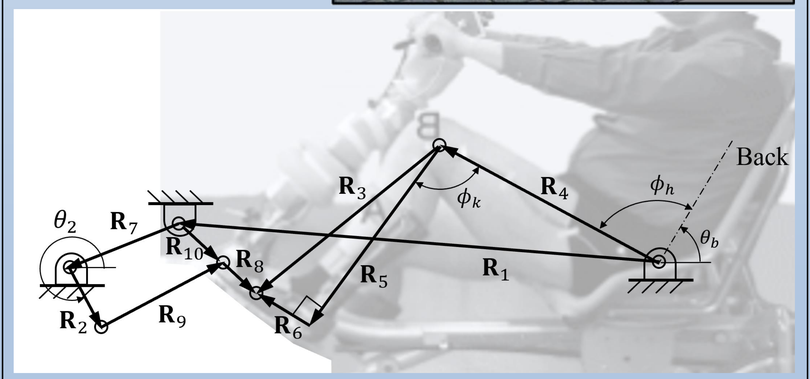


Alternative Design Optimization

Optimization code generated by improving upon initial parameter dimensions when calculating inverse kinematics, quasi-statics, hip and knee joint torques, and energy power analysis. The result from the optimization returns parameter values for the highest power output trike configuration. Once alternative trike parameters (either CDT or CRT) are determined, they are analyzed for singularity concerns.

Crank Rocker Trike (CRT) Concept





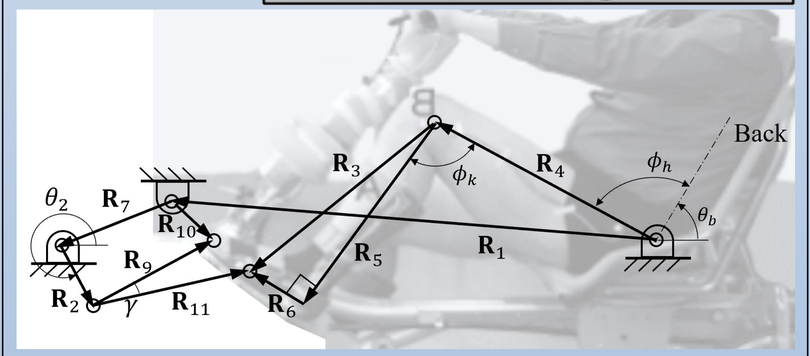
Optimization Results

After completing the optimization for the CRT design, we are achieving power outputs at 29W. These results are showing a 150% increase in average crank power based on 10 design parameters.

Addressing Visibility Concern

One concern with alternative designs is visibility while riding. Optimization does not restrict crank placement because all forces are two force members. Therefore, we allow an angle insertion between $\mathbf{R}_8$ and $\mathbf{R}_{10}$ to rotate the crank four bar around the rocker arm fixed pivot, maintaining the same power.

Coupler Driver Trike (CDT) Concept



Continuing Work

- **Summer 2021** — Complete Optimization Code for Coupler Driver Trike
- **Fall 2021** — OpenSim Biomechanic Studies for all 3 Trikes
- **Spring 2022** — Mechanical Development of Trike with Highest Feasibility
- **End of Spring 2022** — Manufacture Prototype Trike