Characterizing Individualized Maximal Power-Cadence Relationships At Various Fatigue Levels For Recreational Cyclists

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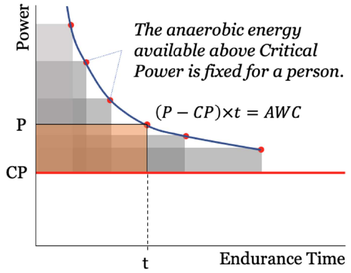
ABSTRACT

- Our work builds upon the well-known parabolic relationship between maximal cycling power and pedaling cadence by quantifying reductions in relation to fatigue.
- Four subjects were recruited, and each participated in six test sessions, separated by at least one week to ensure full recovery.
  - Sessions 1-4 were devoted to determining participants' CP and AWC
  - Sessions 5 & 6 focused on determining maximal power and cadence at various fatigue levels
- We found across all subjects that the parabolic power-cadence curve contracted with fatigue.
  - Each power-cadence parabolic model had R^2 values of greater than 0.9, indicating excellent fits.
  - Comparing maximal power, cadence, and cadence at maximal power between the fresh and fatigued states, there were significant differences between maximal cadence (p=0.039), cadence at maximal power (p=0.039), but not maximal power (p=0.101).

BACKGROUND

Maximum Endurance Time vs. Exertion Intensity:

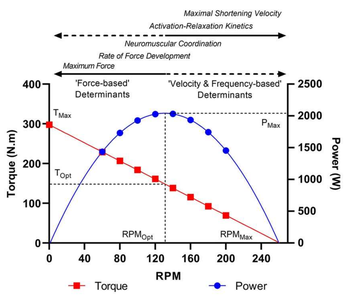
- The larger the exerted energy, the less time it can be sustained.
- Anerobic Work Capacity (AWC or W'): the energy stored within the body and can be burned without oxygen.
- Critical Power (CP): The maximum exertion level the body can maintain purely aerobically.
- The maximal power follows a hyperbolic Curve



Power-Pedaling Rate Relationship [1]

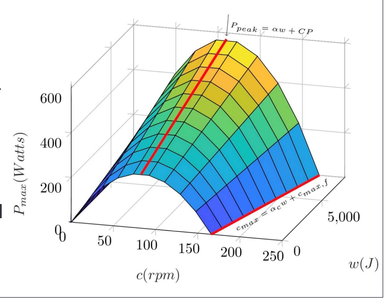
- The pedaling cadence (RPM) and maximal power relationship are parabolically related.
- This holds true at fatigue, but the fatigue level has not been quantified before.
- The goal of this project was to determine the relationship between power, RPM, and fatigue.

1. Douglas, J., Ross, A. & Martin, J.C. Maximal muscular power: lessons from sprint cycling. Sports Med - Open 7, 48 (2021). https://doi.org/10.1186/s40798-021-00341-7



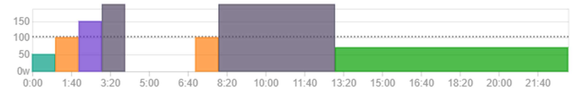
Our 3D Power Curve Hypothesis :

- We hypothesized that maximal power and cadence decays linearly with fatigue.
- When plotting power and rpm with fatigue that decay should create a shrinking tunnel shape.
- Our goal was to investigate this model and generate a 3D Power Curve with participant data



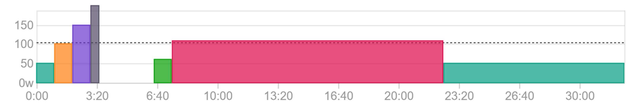
METHODS

- Day 1 consisted of two max power and max cadence sprints to determine the participants' fitness level
- Days 2-4 use fixed powers to find three points along a participant's power curve. Fixed powers above the participant's sustainable power were used to eliminate the mental barriers to all-out exertions common in the 3-minute all-out test.
  - Day 2 targets a very difficult power sustainable for less than 2 minutes

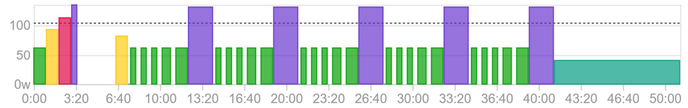


  - Day 3 targets a difficult power sustainable for less than 5 minutes

  - Day 4 targets a slightly difficult power sustainable for less than 10 minutes



- Days 5 & 6 followed the same protocol, which targets maximal power and RPM at different fatigue levels. The test was repeated to ensure reliability



- The protocol consists of a series of 5 sprints (0 W resistance, then simulated grade of 0%, 4%, 8%, and 12%), each followed by a dynamic recovery time to ensure fatigue level is maintained throughout and concluded with 2 minutes at CP_8 (power that will completely fatigue the participant after 8 continuous minutes). The key values in these sprints are the maximal power and power at maximum cadence, which were recorded. That series is then repeated till failure to find the maximal power and cadence at complete fatigue.

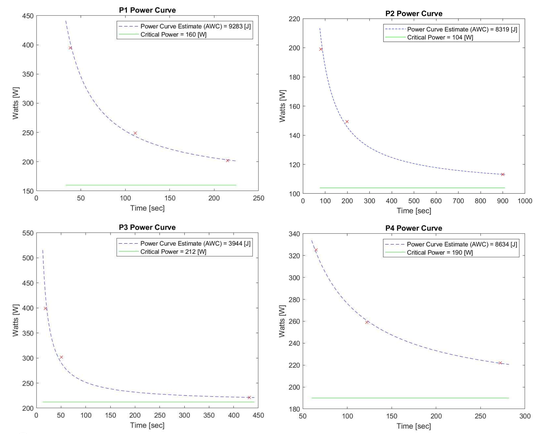
EQUIPMENT

- Favero Assioma Duo pedal-based power meters (primary power data)
- Wahoo Kickr Core smart trainer (backup power data)
- Moxy Monitor (muscle oxygen data)
- Polar H9 (heartrate data)

RESULTS

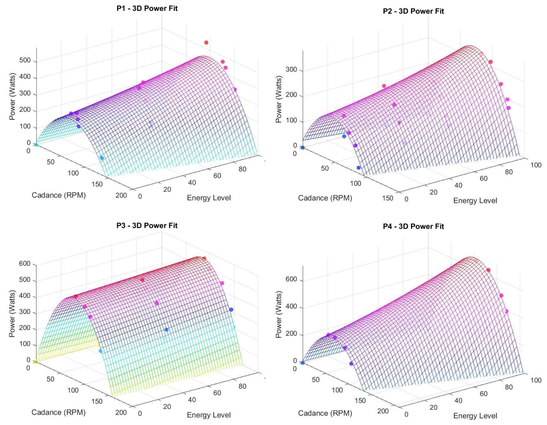
2D Power Curve:

- Using the three endurance time points and a hyperbolic fit the participant's AWC and CP were reliably found for all participants.



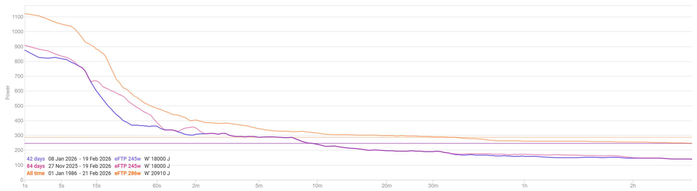
3D Power Curve:

- Taking the power at maximal cadence for each sprint, the fatigue tunnel is formed.



FUTURE WORK

- We plan to utilize participants' historical power curve to eliminate testing days 1-4 in future testing.



- Future testing comparing natural vs optimized pacing.