The Correlation Between Pedaling Rate and Gross Efficiency of Road Bike Cycling

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Outline

01 Introduction

02 Methods

03 Results

04 Discussion

1

Introduction

Introduction

01

One key factor in rode bike cycling:

Spend as little energy as possible for a specific output (e.g., speed, power or intensity).

02

Adjusting cadence (pedaling rate) is one common strategy to optimize physiological output as well as biomechanical efficiency (Williams, 1985).

03

The effects of pedaling cadence on cycling efficiency need for further clarification.

Optimal Cadence

- Seabury et al. (1977): from 42 rpm to 62 rpm.
- Foss and Hallen (2004): from 60 rpm to 120 rpm
- Banister & Jackson (1967); Chavarren & Calbet (1999): around 50 rpm
- Coast & Welch (1985): from 35 to 57 rpm
- Hagberg et al. (1981): from 80 to 90 rpm
- Widrick et al. (1992): from 90 to 105 rpm

Research Purposes

1. To investigate the existence of an optimal cadence for a specific work rate for road bike cycling system.

2. To examine whether the optimal cadence varies with different work rate on a road bike cycling system.

2 Methods

Methods

Participants

1. Ten volunteer male amateur cyclists.

Age	Weight	Height	FTP	VO_2max
21.1 ± 10.4	71.4 ± 10 kg	178.1 ± 5.6 cm	183.6 ± 22.2 watts	54.4 ± 6.7 mL · min^{-1} · kg^{-1}

2. All study procedure followed the Declaration of Helsinki and has been approved by the Institutional Review Board of National Cheng Kung University (Document No. A-ER-108-095).

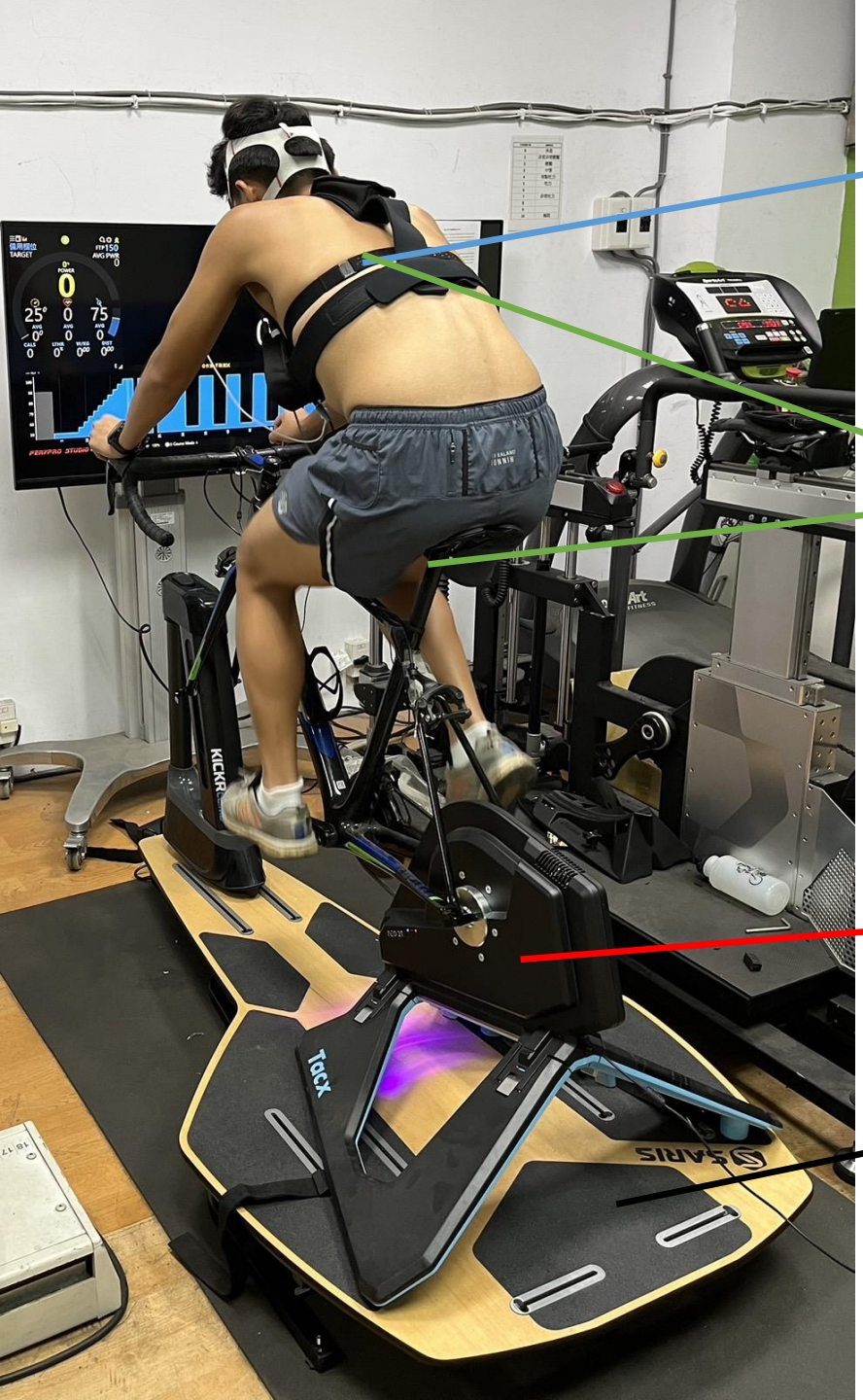
Protocol

Each participant completed five tests：

（1）Maximal Incremental test

（2）The functional threshold power (FTP) test

（3） Three Multi-cadence riding test



Chest strap
(Polar H10)

Respiratory data
(Metamax 3B)

IMU
(Xsens Dot)

Grade simulation
(Wahoo kickr climb)

Trainer
(Tacx Neo 2T)

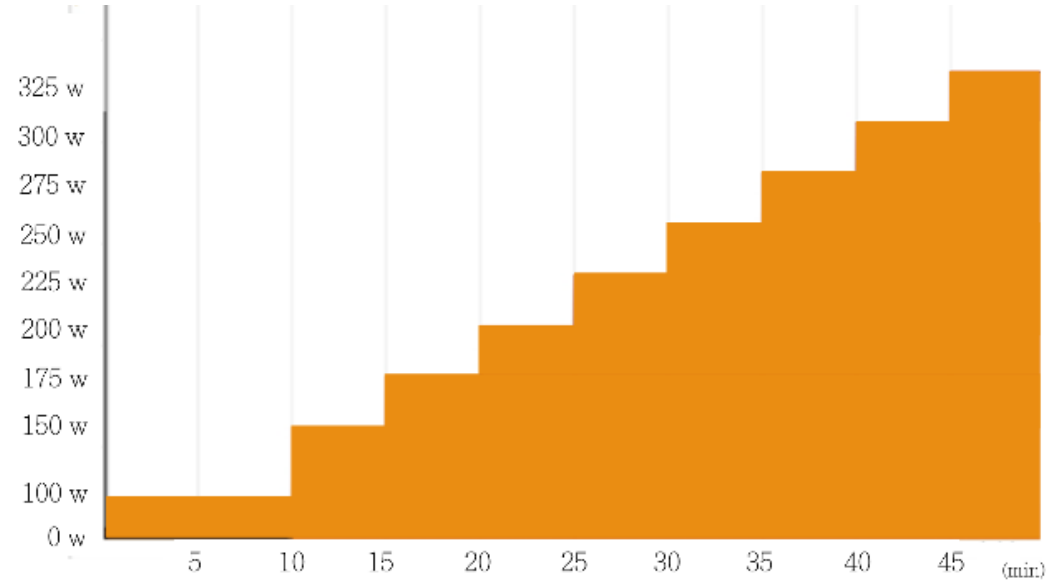
Road simulation
(Saris MP1 NFINIT)

2 cameras film from behind and beside

Methods

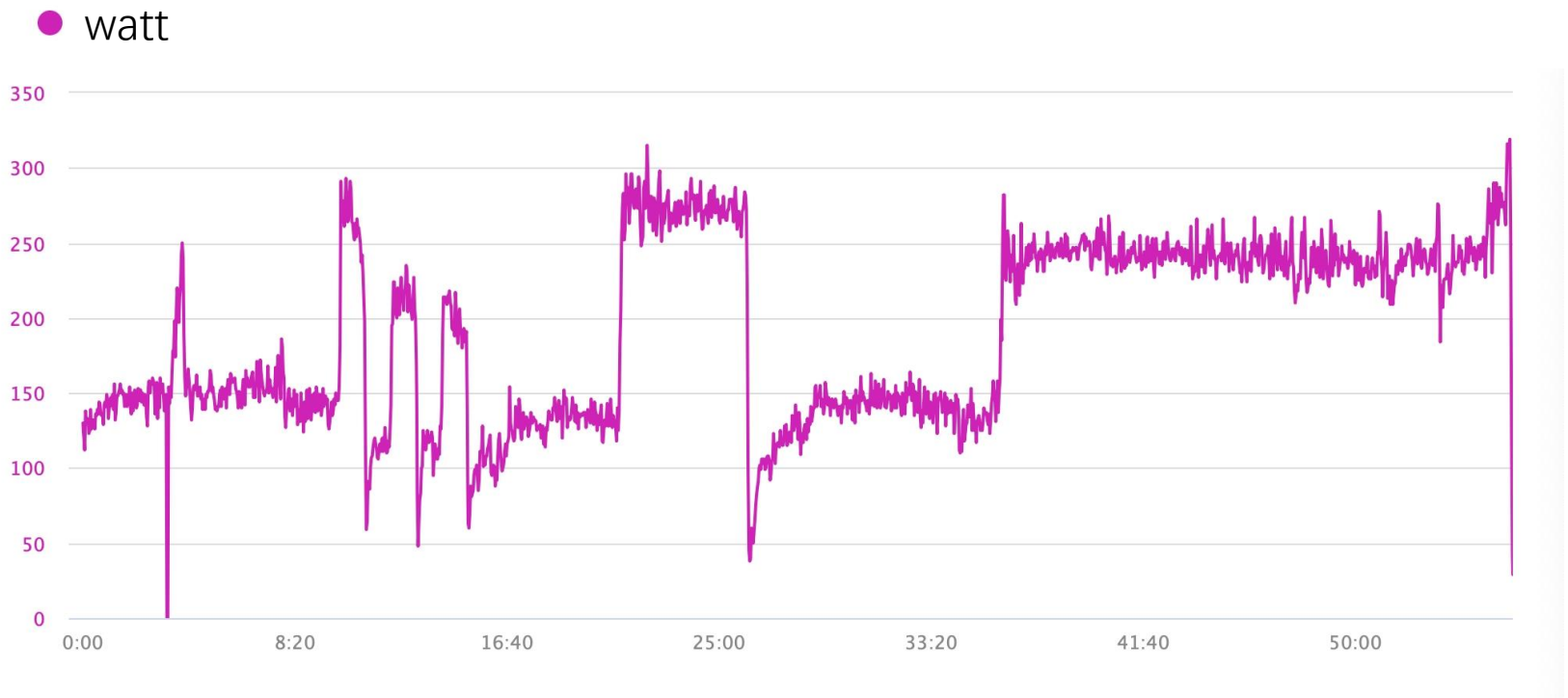
Maximal Incremental Test

- After a 10- min warm-up at 100 watts (W), the test began at 150 W and had 25 W increment for every 5-min until exhaustion (level off in VO2, RER ≥ 1.10, RPE of ≥18, and/or HR of ±10 bpm of the age-predicted maximum (220-age)).
- VO2max was classified as the highest 1-min average VO2 during the test



Methods

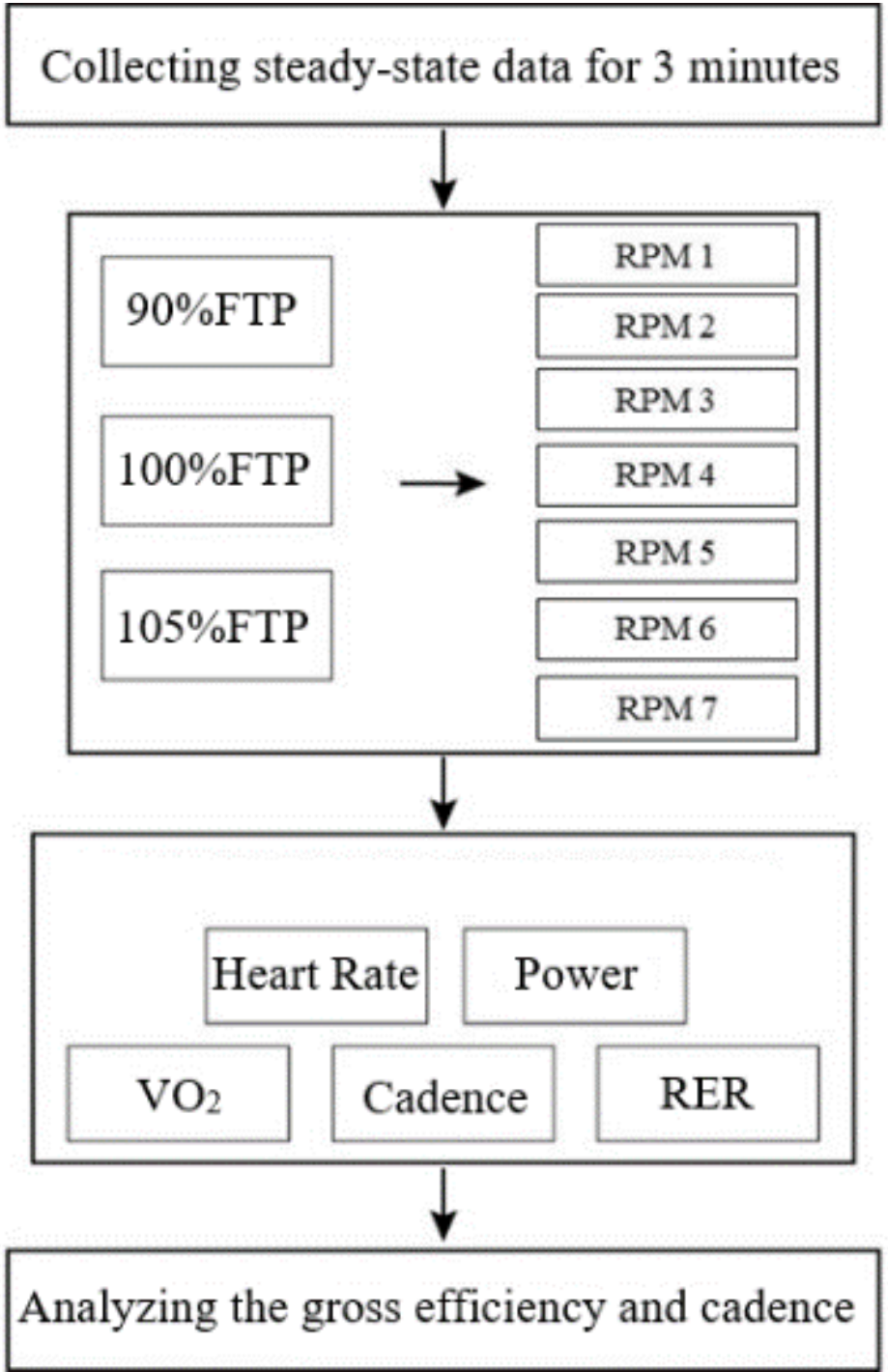
Functional Threshold Power (FTP) Test



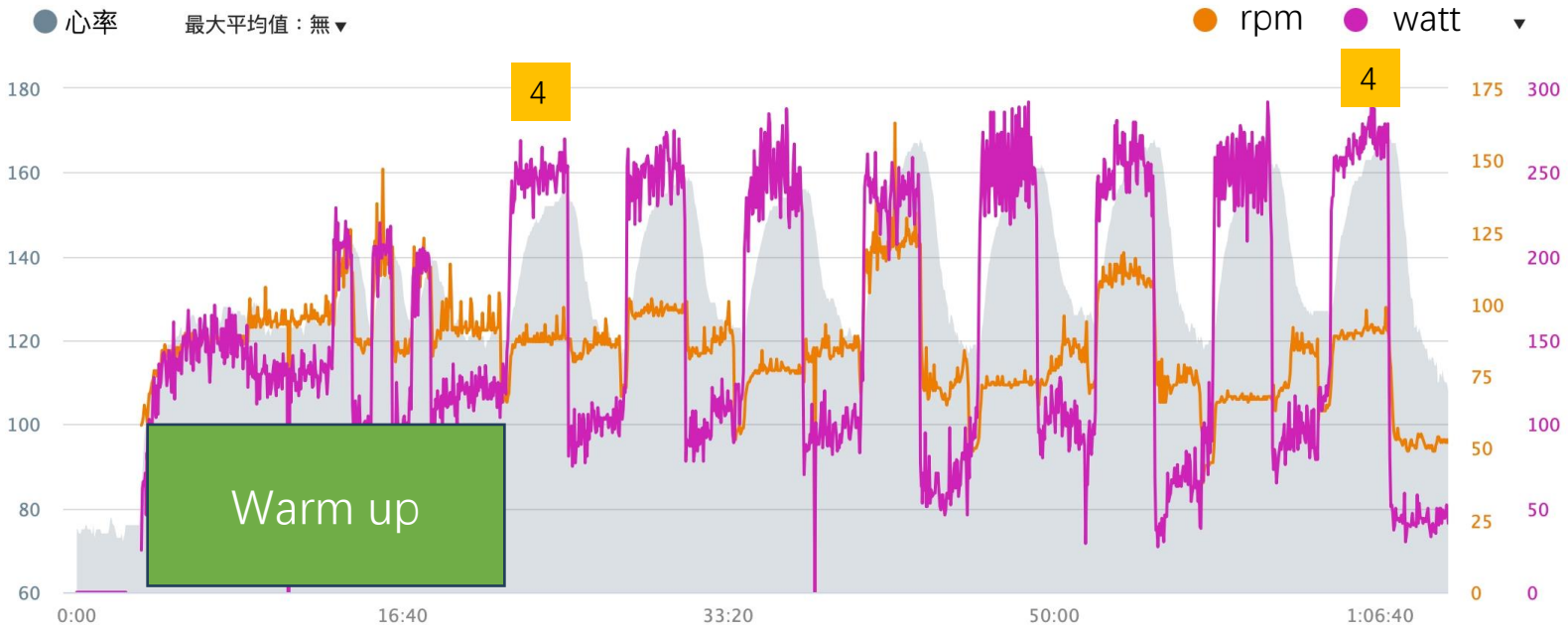
Methods

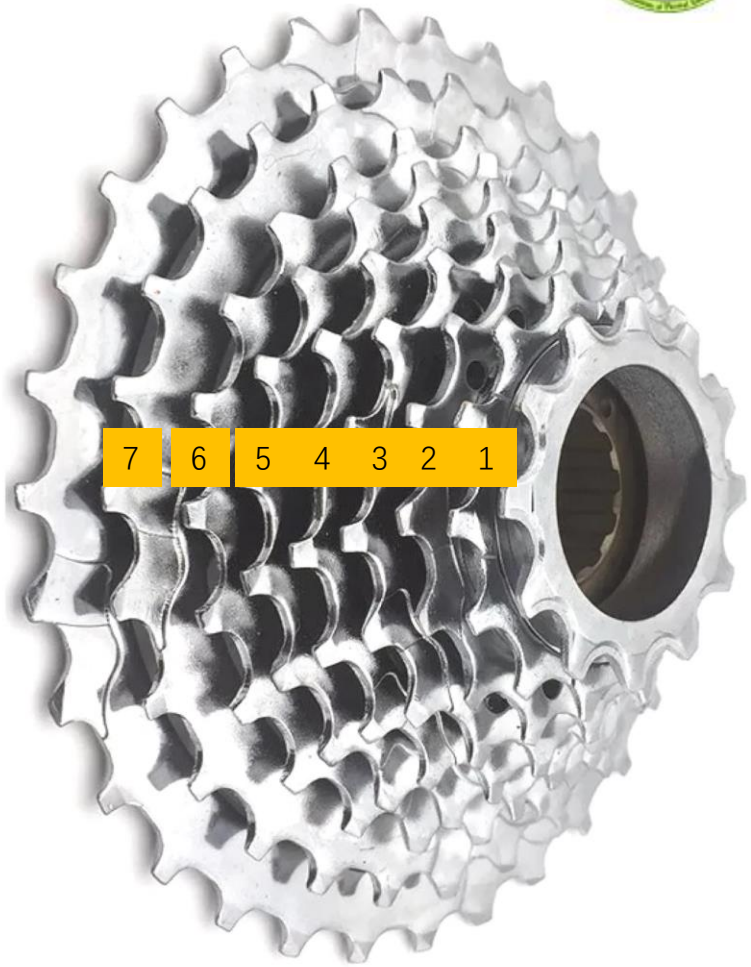
Multi-cadence ride test

1. The participants will be asked to find their personal optimal gear ratio before riding and set it as gear 4.
2. Based on gear 4, three another lighter (e.g., gear 1, 2&3) and three another heavier gear ratio (gear 5, 6&7).
3. The test includes a ten-min warm-up and follow up a 3-min pedaling for each gear ratio.
4. There will be 3-min recovery time between different gear ratio.



Methods


心率
最大平均値：無
rpm
watt
4
4
Warm up
180
160
140
120
100
80
60
175
150
125
100
75
50
25
0
300
250
200
150
100
50
0
0:00
16:40
33:20
50:00
1:06:40


7
6
5
4
3
2
1

Methods

RER→ ratio of the Carbohydrate and fat

V'O2*Carbohydrate%*5.047+V'O2*Fat%*4.686=True Kcal

Respiratory Data

Gross Efficiency

=Kcal/True kcal

Power

VS

Cadence

Watt(J/s)*60/4.18/1000=Kcal

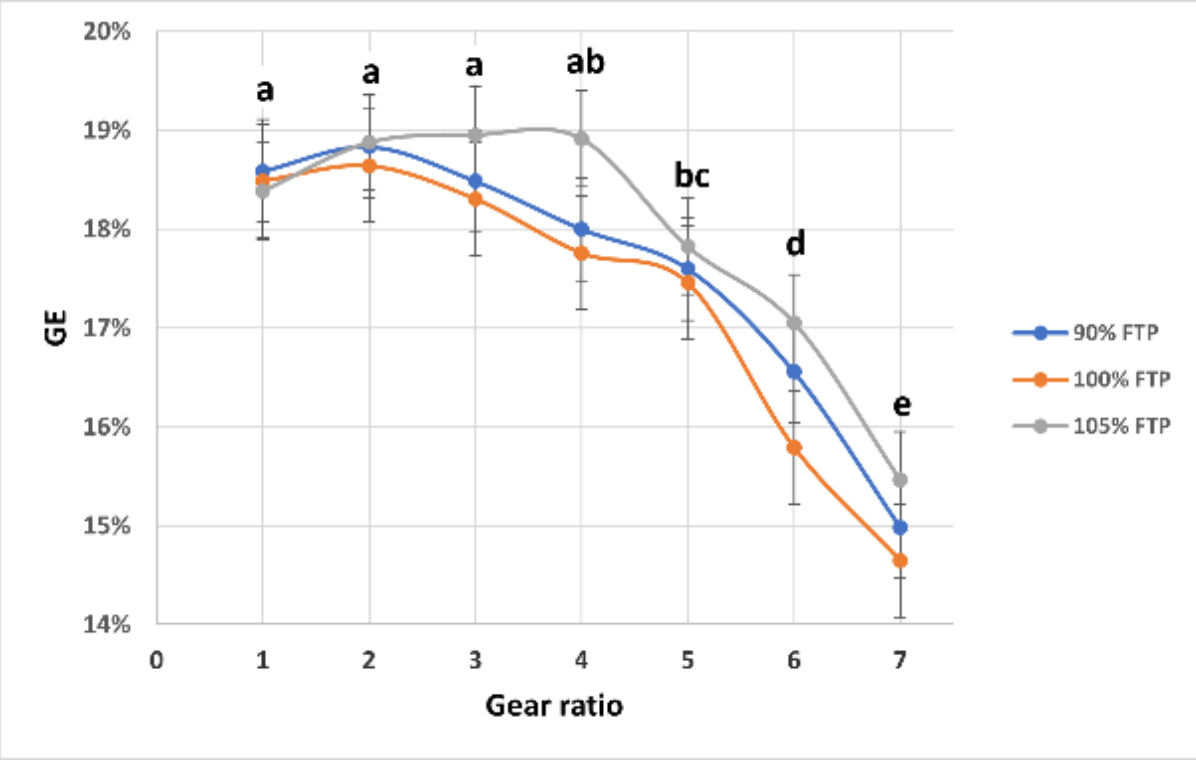
Methods

Statistical Analysis

Repeated-measures 2-way ANOVA analysis of variance (SPSS 17.0) with two factors [three intensities (90% FTP, 100% FTP and 105% FTP) × 7 gear ratios (no. 1 to 7)] were used to identify the effects of exercise intensities and cadence on different variables. Pearson's correlation was conducted to calculate investigate the relation between gross efficiency (GE) and cadence (rpm).

3 Results

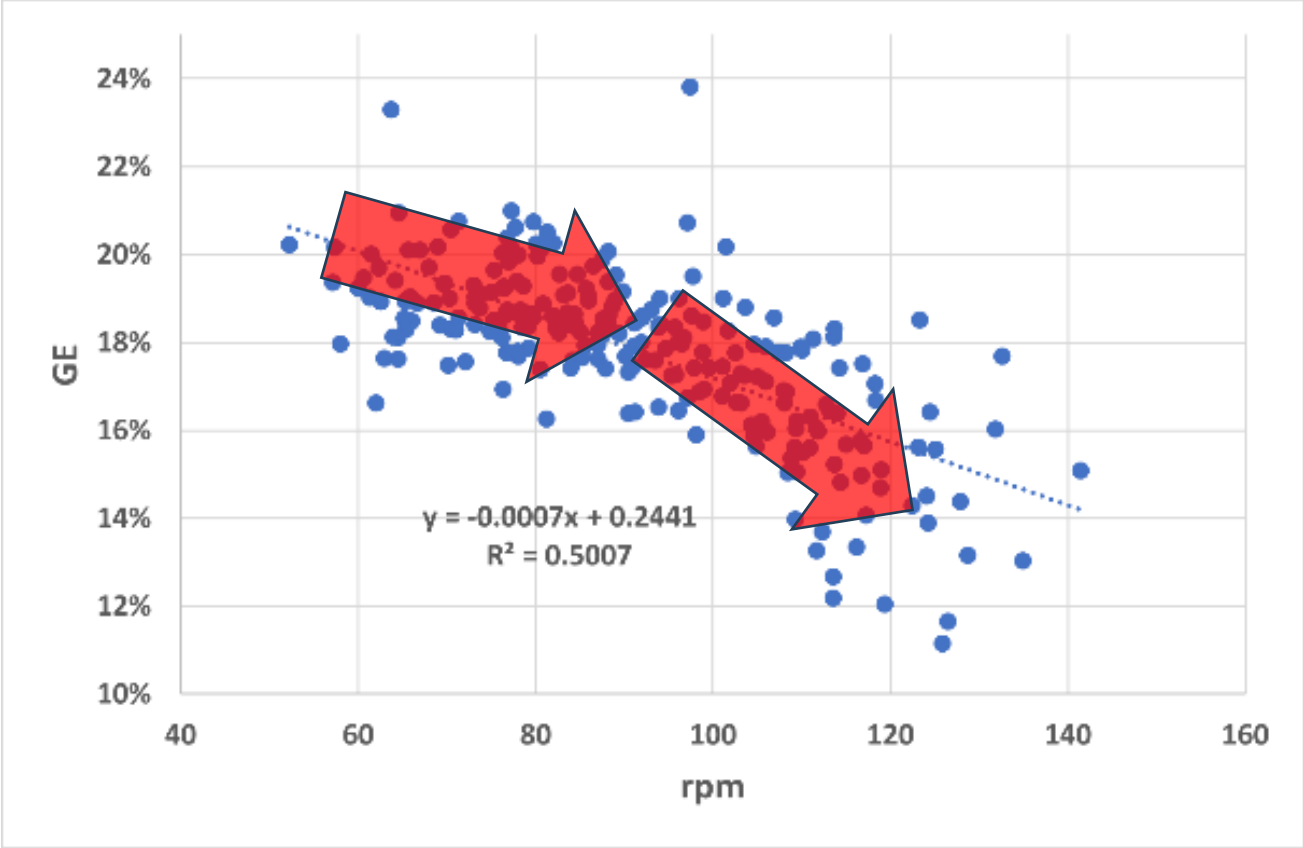
Results



Overall

- The main effect of intensity did not show a statistically significant difference in efficiency.
- Among the different gear ratios, there were no significant differences in efficiency observed between gear ratios 1 to 4 or 5.
- However, gear ratios 6 and 7 demonstrated a significant difference in efficiency compared to the other gear ratios.

Results

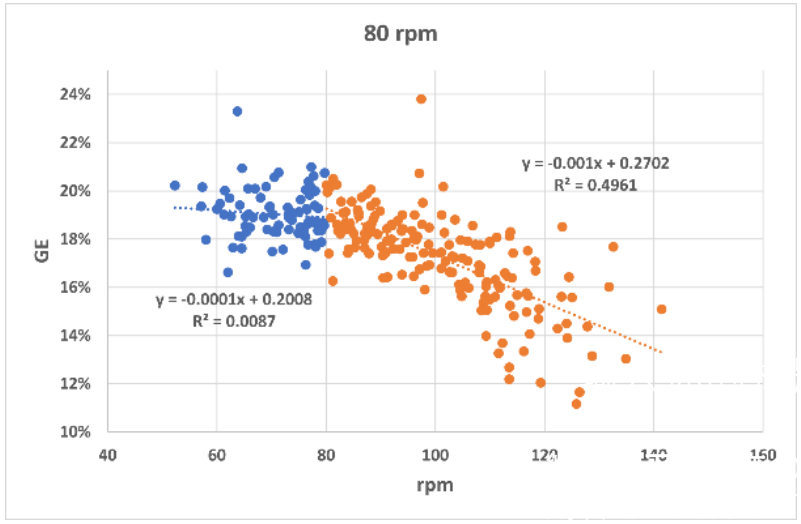


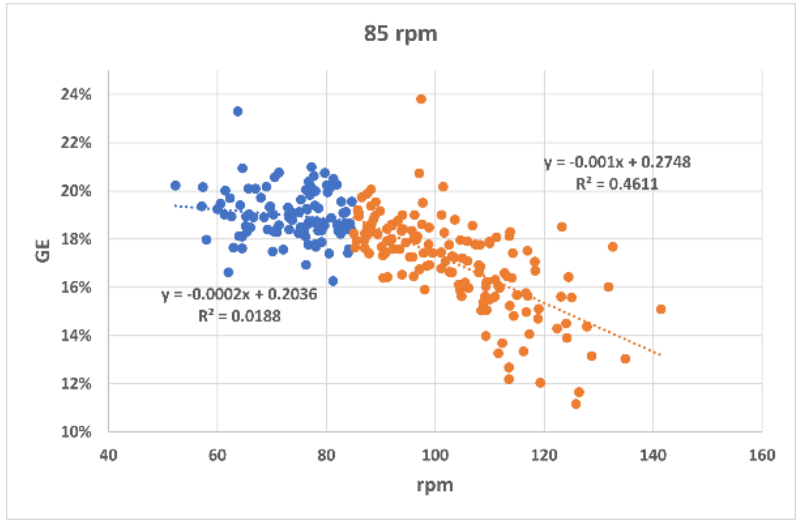
Overall

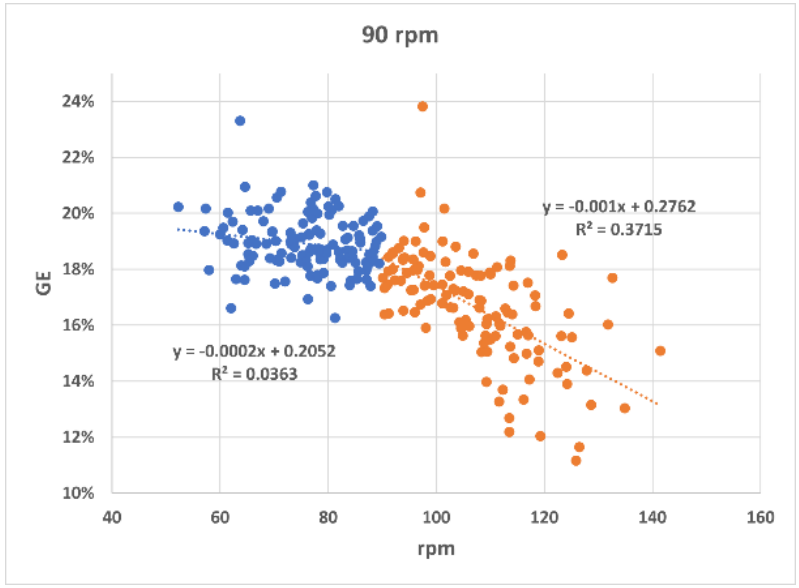
1. As the cadence getting higher, the gross efficiency gets lower.

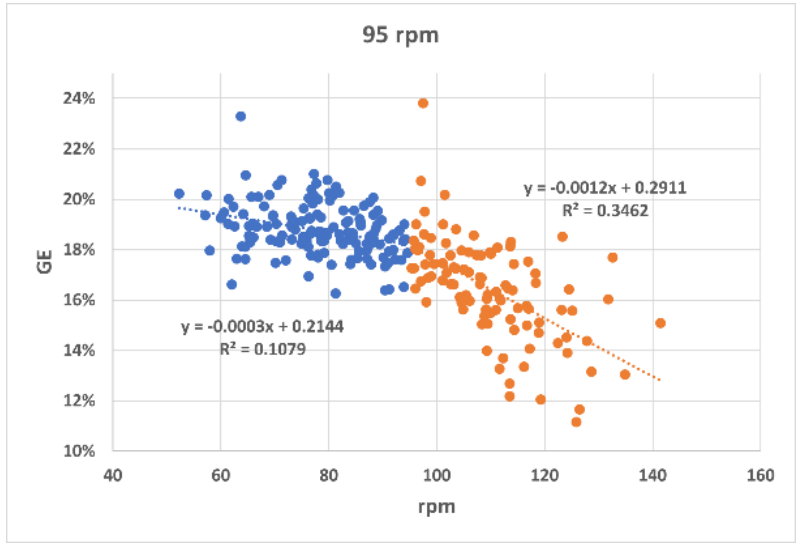
2. There seems to be a turning point in the regression line.

Results


80 rpm
GE
rpm
y = -0.001x + 0.2702
R² = 0.4961
y = -0.0001x + 0.2008
R² = 0.0087


85 rpm
GE
rpm
y = -0.001x + 0.2748
R² = 0.4611
y = -0.0002x + 0.2036
R² = 0.0188

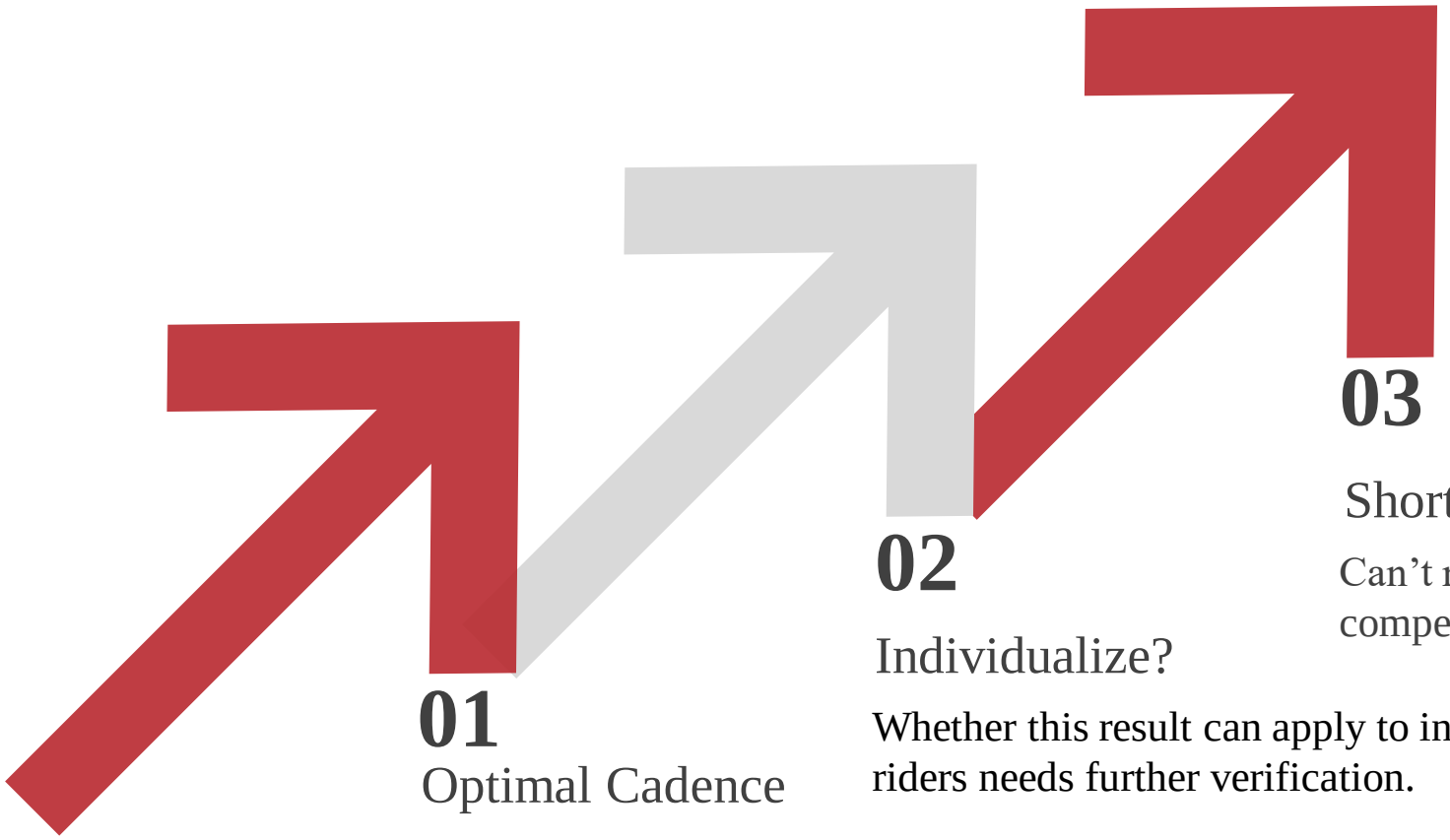

90 rpm
GE
rpm
y = -0.001x + 0.2762
R² = 0.3715
y = -0.0002x + 0.2052
R² = 0.0363


95 rpm
GE
rpm
y = -0.0012x + 0.2911
R² = 0.3462
y = -0.0003x + 0.2144
R² = 0.1079

4

Discussion

Discussion



01

Optimal Cadence

It’s a range.

02

Individualize?

Whether this result can apply to individual riders needs further verification.

03

Short-term Test

Can’t represent the real field of competition or practice

Thank you for listening