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Conference Abstract

Gender Differences in Cycling Cadence and Related Physiological Responses for Amateur Cyclists

Tai Jia Xian [1], Ying-ju Chen[1,2], Liang-cheng Huang [1], Ya-han Chang [2], Chin-lai Huang [2] and Tsang-hai Huang [1,*]

[1] Institution of Physical Education, Health &Leisure Studies, National Cheng Kung University, Taiwan
[2] i-WOW research center, GIANT MFG. CO. LtD., Taiwan

* Correspondence: (TH) tsanghai@mail.ncku.edu.tw

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Abstract

Introduction: The aim of this study was to investigate the gender differences in pedaling rate and various physiological responses during cycling.

Methods: Thirty-eight cyclists in both gender (N=19 for both gender) were recruited. Each participant completed two tests, which were the functional thresholds power (FTP) test, and a multi-cadence cycling test.

Result: Male cyclists showed significant higher pedaling power output, $\dot{V}O_2$ (L/min) ($p<0.05$), lower gross efficiency (GE, %)($p<0.05$), higher mean power output (watts) ($p<0.05$) and numerically higher pedaling cadence (rpm)($p=0.068$). Both genders showed similar trend of cadence rate vs. GE relationship.

Conclusions: Male and female cyclists revealed physiological and mechanical capacity while conducting cycling exercise. At consistent cycling power output, the downward relationship between cadence rate and GE were similar between males and females.

Keywords: Cadence, Gross Efficiency, Pedaling Rate.

1 Introduction

1.1 *Background*

Since a so-called Lance Armstrong era, pedaling at a higher cadence has become a distinct trend in road cycling field. The regular pedaling cadence of professional cyclists has increased from an average of 80 revolutions per minute (rpm) to 90 to 100 rpm, and even higher (Leirdal & Ettema, 2009, 2011; Lucia et al., 2001; Zimmermann, 2012). This pedaling strategy also show significant influence on many amateur cyclists.

Previous studies (Annaheim et al., 2010; Formenti et al., 2019;) found evidence for lower cadences are more efficient. On the other hand, several other studies (Leirdal & Ettema, 2009; Lucia et al., 2001; Zimmermann, 2012) have identified demonstration higher cadence get better gross efficiency.

Women have anatomical differences compared to men, not only in limb proportions (Brunkhorst & Kielstein, 2013; Van der Zwaard et al., 2019) but also in body mass distribution (Chambers et al., 2010). These differences suggest that merely resizing the frame of bike to accommodate the relatively smaller stature of women may not entirely meet or address the gender difference.

While some studies have focused on female professional or amateur cyclists (Berry et al., 1993; Graham et al., 2018), there has been relatively little research comparing the metabolic effects of different cadences during cycling between women and men.

Hopker and colleagues compared the gross efficiency (GE) between female and male cyclists riding at 150W and 180W power outputs, revealing that women had less muscle mass in lower limbs and higher GE when comparing to men (Hopker et al., 2010). The study did not delve deeper into the issue of whether there are gender differences regarding the effects of cadence variations.

1.2 *Purpose of the study*

The purpose of the current study was to investigate the gender differences in cycling cadence as well as related physiological responses.

2 Material and Methods

2.1 *Participants*

Participants in the study included amateur cyclists or triathletes in various proficiency levels (N=19 for both male and female participants). Following the explanation of the experiment, all participants signed a consent form before proceeding with the experiment process. The study was approved by the National Cheng Kung University Hospital-Human Research Ethics Review Committee (Document No. A-ER-108-095).

2.2 *Experimental Protocols*

The current study included two testing procedures, which were a functional threshold power (FTP) test and a multiple-cadence test. FTP test was used for determination of personal submaximal power output with a main secession of 20-minute voluntarily maximal cycling (see Table 1 for testing details). FTP is defined as the highest average pedaling power (watts) a person is capable to maintain for one hour. (Allen et al., 2019).

After ≥ 48 hours of the FTP test, each participant visited our lab for conducting the multiple-cadence test. Briefly, a 10-min warm-up pedaling was arranged for all cyclists before they started to perform a test composed of different gear ratio cycling. Before conducting the main test, each participant was asked to make their own choice of personal favorite gear ratio while executing personal 95% FTP pedaling. Subsequently, participants started to conduct a multi-cadence pedaling test, which included eight 3-min pedaling secessions with different gear ratio at 95% FTP. With the 1st and last run of 3-min pedaling using personal favorite gear ratio, the gear ratio of the 2nd to 7th 3-min pedaling secessions will include 3 heavier and 3 lighter gear ratios in a randomized order (Figure 1).

Table 1. Protocol of functional threshold power test.

	Duration	**Description**
Warm-up	10 min	Endurance pace
	3*1 min (1min rest)	High cadence 100 RPM
	5 min	Easy pedaling
Main set	5 min	All-out effort
	10 min	Easy riding
	20 min	Test

Each participant was instructed not to have intense training 48 hours before FTP and multi-cadence testing. We performed all testing procedures under similar environmental conditions (24~26 Celsius degree).

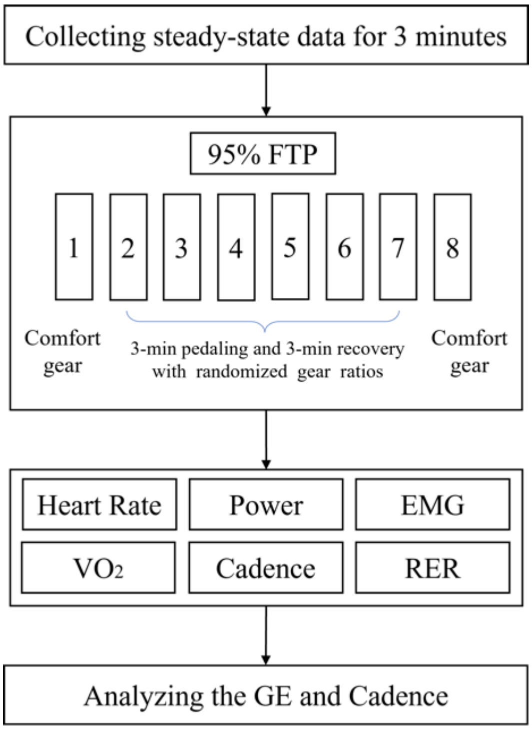

Figure 1. The protocol of multi gear ride test.

2.3 Data collections

All participants use their own regularly ridden bicycles for both cycling tests. The bicycle's rear wheel is removed, and the frame was placed on an indoor trainer (Tacx NEO, Garmin, Taiwan). Power output and cadence (rpm) are measured by the indoor trainer, and data transmission is facilitated using ANT+ technology.

A Portable gas analysis equipment, METAMAX® 3B (METAMAX® 3B, Cortex, Germany) is used to collect data of respiratory indices.

2.4 Statistical Analysis

Student's T- test was used to compare gender differences. Nonlinear correlation analysis was used for investigating the relationship between cycling cadence and GE (%). Standard software (SPSS 17.0, IBM, USA) was used to conducted statistical analyses.

3 Results

There was a significant difference in overall pedaling gross efficiency (GE) between females and males (Figure 2), females exhibited higher overall pedaling efficiency compared to males (females vs. males: 19.21±1% vs. 18.18±1.52%, $p<0.05$). In overall pedaling cadence (rpm) (Figure 3), males exhibit higher overall pedaling efficiency (females vs. males: 80.14 ± 8.94 rpm vs 85.71± 9.33 rpm, $p=0.068$). No significant difference between genders was shown in respiratory exchange ratio (RER) (Figure 4). Mean power output was significant lower in female cyclists (females vs. males: 125.3 ± 19.7 watts vs 170.7 ± 41.3 watts, $p<0.05$). Also, mean $\dot{V}O_2$ (L/min) demonstrated significant lower values in females. (females vs. males: 1.94 ± 0.28 vs 2.77 ± 0.59, $p<0.05$) while no significant difference was shown in mean $\dot{V}O_2$ per kg body mass (mL/kg/min).

Cycling cadence vs. GE correlations of both male and female cyclists were conducted. Both genders showed similar correlation trends that GE tended to decrease significantly while the cadence higher than 90 (Figure 8).

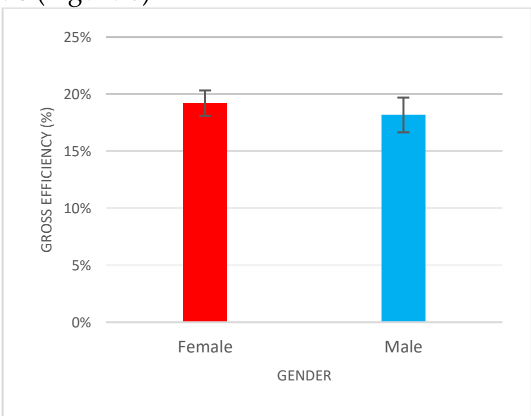

Figure 2. Comparing the pedaling gross efficiency (GE) between females and males ($p<0.05$).

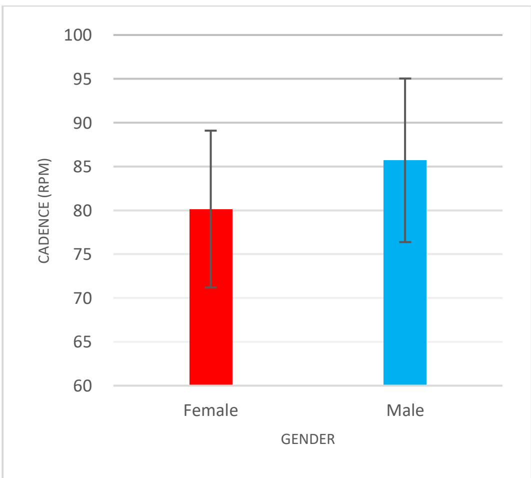

Figure 3. Comparing the pedaling cadence (rpm) between females and males ($p=0.068$).

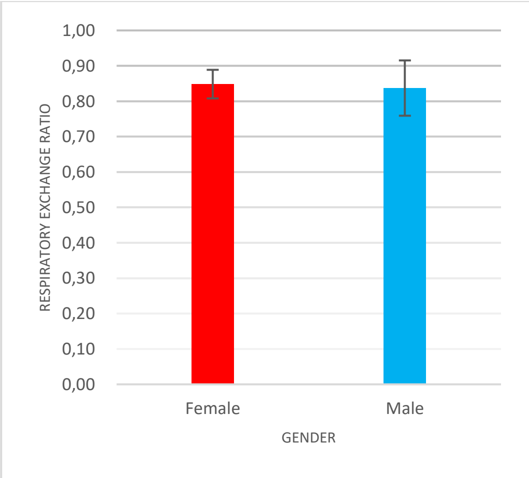

Figure 4. Comparing the respiratory exchange ratio between females and males ($p=0.582$).

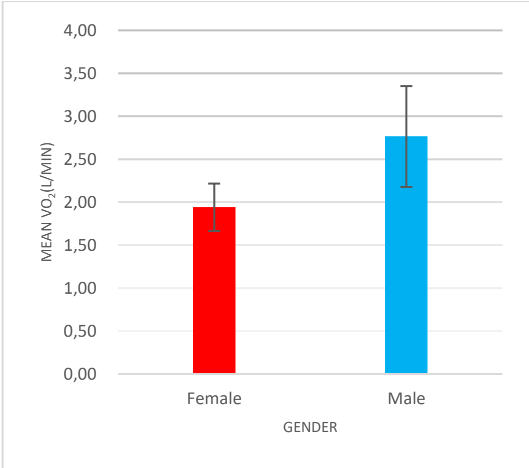

Figure 6. Comparing the mean $\dot{V}O_2$ (L/min) between females and males ($p<0.05$).

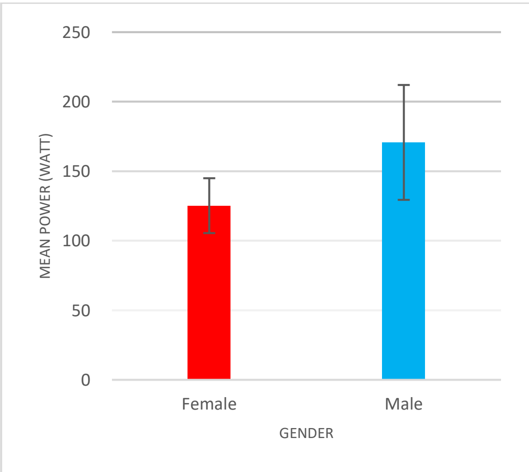

Figure 5. Comparing the mean power output (Watt) between females and males ($p<0.05$).

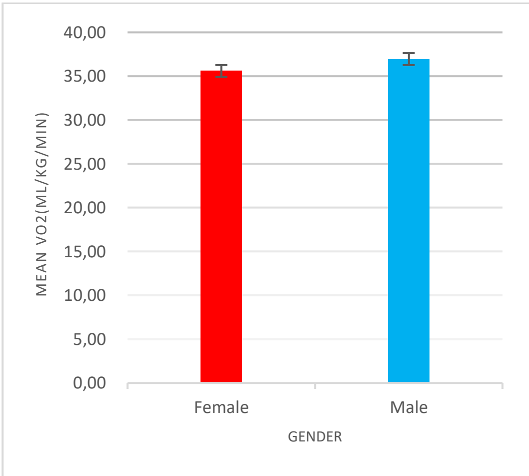

Figure 7. Comparing the mean $\dot{V}O_2$ per kg body mass (L/kg/min) between females and males ($p=0.500$).

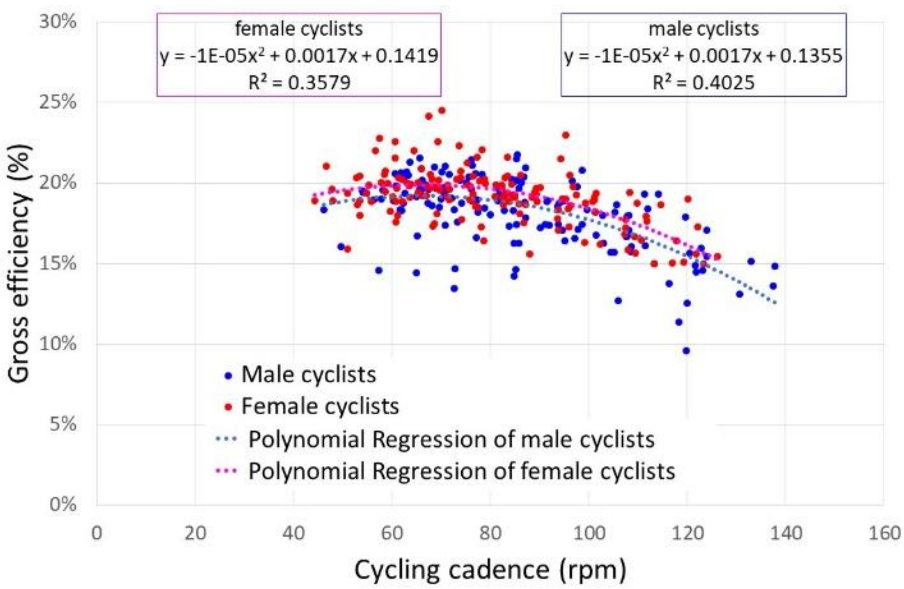

Figure 8. Non-linear correlations between cycling cadence and gross efficiency (GE) in males and females.

4 Discussion

Through a multi-cadence pedaling test, female and male cyclists showed different power output, which might be due to different physiological capacity (e.g. $\dot{V}O_2$). Nevertheless, normalized aerobic capacity ($\dot{V}O_2$ per kg) (Figure 7) showed no gender difference. The higher GE demonstrated in female cyclists might imply a different physiological potential worthy for future study. With various gender difference in cycling performance, both genders showed similar downward trend of GE while the cycling cadence surpass a specific range of rpm (e.g. 90 rpm). Whether this specific rpm show individual difference would be worthy for future studies.

5 Practical Applications

Through the multi-cadence test of the current study, coaches and cyclists are able to determine personal cadence and GE correlation, which can be further applied to observe personal optimal cycling cadence.

6 Conclusions

Gender differences in physiology were demonstrate in the current cycling test. Future studies will be clinically valuable to investigate the existence of personal optimal pedaling rate.

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