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Physiological and Mechanical Comparisons between Clipless and Flat Pedals

Katelyn Conroy

PHYSIOLOGICAL AND MECHANICAL COMPARISONS BETWEEN CLIPLESS AND FLAT PEDALS

By

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ABSTRACT

Physiological and Mechanical Comparisons between Clipless and Flat Pedals

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The purpose of this study was to investigate the physiological and mechanical comparisons between clipless and flat pedals. Participants (n=4) completed two at-home 20-minute FTP tests: using clipless and flat pedals using Zwift. The order of conditions were randomized for each participant. Participants used their personal Smart Trainers, clipless pedals, and cycling shoes while flat pedals were provided (Syun-LP, Road Bike Platform Pedals). Power, heart rate and cadence were recorded and used for analysis. All dependent variables were compared using paired t-tests. Power was significantly greater for clipless (226.7 ± 46.2 W) vs. flat (215.2 ± 41.8 W) pedals ($p < 0.05$). Heart rate was significantly greater for flat (138.5 ± 17.4 bpm) vs. clipless (135.2 ± 18.1 bpm) pedals ($p < 0.05$). However, cadence was not significantly different between clipless (70 ± 8.7 rpm) vs. flat (71.7 ± 13.3 rpm) pedals ($p > 0.05$). The greater power when using clipless pedals combined with a lower heart rate is an indication that clipless pedals are preferable to flat pedals.

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CHAPTER 1

INTRODUCTION

Triathlon is a sport that consists of three segments: swimming, cycling, and running. Performance is measured by the total time to complete each segment as well as the time to transition between segments. There are two transitions during the entire race: Transition 1, from swimming to cycling and Transition 2, from cycling to running. As such, competitive triathletes not only train to improve their fitness per segment, but also practice their transitions.

Transitions can be improved by selecting the right equipment for each segment. For example, triathletes often wear 'trisuits' for the swim, cycle and run segments versus changing clothing between each segment, adding detrimental time to their overall performance. However, there are times where triathletes benefit from using sport-specific equipment. For example, triathletes will typically wear cycling shoes during the bike segment and running shoes for the run segment. Cycling shoes are compatible with clipless pedals, which have a clip on the pedal (Figure 1) and creates a firm attachment, making it easy to contribute to the downstoke (Cole, 2020).

Clipless pedals have been reported to improve various aspects of cycling; including aerodynamics of the shoe/pedal interface, reduction in pedal weight, and diminished foot surface pressure with the removal of straps (Gregor & Wheeler, 1994). Researchers have also reported more efficient transfer of force through the lever created by the riders' leg, foot and pedal (FitzGibbon, Vicenzino, & Sisto, 2016; Gregor & Wheeler, 1994; Sanderson, Hennig, & Black, 2000) and decreased electromyography (EMG) in a variety of leg muscles for clipless compared to toe-clipped pedals (Cruz & Bankoff, 2001). In elite- or Olympic-level triathlons, clipless pedals are most commonly used (Hug & Dorel, 2009). While quantitative evidence is limited on clipless pedals and their direct performance benefits, anecdotal evidence has been reported. Athletes have reported that clipless pedals have improved their power output and decreased their time to completion for selected races.

Two other types of pedals, flat (Figure 2) and cage pedals (Figure 3), are not commonly used since the introduction of clipless pedals (Gregor & Wheeler, 1994). However, beginner bike riders and mountain bike riders are most likely to use flat pedals as those types of pedals provide athletes with increased range of foot position and rotation as well as quick and easy removal of their foot off the pedal (Gregor & Wheeler, 1994). Cage pedals have been reported, anecdotally, to increase the forces during the upstroke. In contrast, no differences were reported in oxygen consumption and heart rate between toe-clipped (a pedal type similar to cage pedals) and clipless pedals (Anderson & Sockler, 1990; Ostler et al., 2008). Plantar pressure differences between different types of cycling shoes have been extensively studied (Davis et al., 2011; Ostler et al., 2008; Sanderson et al., 2000); however, physiological and mechanical comparisons between clipless and flat pedals are limited.

If the triathlete wears the same shoes for the cycling and running portions, the time spent for the second transition would be improved. However, it is not clear if there is a performance disadvantage for wearing running shoes on flat pedals vs. cycling shoes using clipless pedals.

Therefore, the purpose of this study was to determine if bike performance is influenced by the shoe/pedal interface. Specifically, to compare physiological and mechanical parameters while using clipless and flat pedals during a 20-minute functional threshold power (FTP) test on an indoor cycle trainer. It was hypothesized that no significant differences would be present between clipless and flat pedals for a 20-minute FTP test regarding performance measures, physiological and mechanical.

Figure 1 Image of one of the various designs of clipless pedal.

Figure 2 Image of one of the various designs of cage pedals.

Figure 3 Image of one of the various designs of flat pedals.

CHAPTER 2

REVIEW OF RELATED LITERATURE

This chapter will begin with a review of the literature, with a concentration on shoe/pedal interfaces and thorough descriptions of each type. Next, cycling power, more specifically functional threshold power (FTP) and its applications will be defined. Finally, empirical studies measuring various physiological and mechanical variables while comparing the shoe/pedal interfaces will be reviewed. The purpose of this review is to offer insight of the current research in this area as well as provide reasoning for the research question.

Different Types of Pedals

There are three general categories of cycling pedals: flat, toe-clip/cage pedals, and clipless. Flat pedals are the most seen pedal and are typically found to be used by commuters, recreational riders, BMX and mountain bikers. These pedals resemble a flat platform where the foot can rest and move freely throughout a ride. The riders foot is given the higher range of motion and a quick escape from the pedal during a crash situation. Flat pedals are made of plastic or metal and come in a variety of designs; bulky with reflectors, slim and light, etc. This allows no specific footwear type, if any, making it the simplest pedal to use.

Toe-clip/cage pedals are like flat pedals in terms of the population who utilizes them, however the design does differ. These pedals have a platform; however, they have an adjustable cage attachment that holds the foot in place. This prevents a rider's feet from slipping off the pedal and injuring themselves. With many designs, the platform and cage can be made of plastic or metal. Similar to flat pedals, toe-clip/cage pedals do not require specific footwear, as long as the shoes fit into the cages.

Clipless pedals are found on the bikes of experienced road and mountain bikers and triathletes. The name clipless comes from the missing toe-clip or cage attachments. These pedals require a specific shoe which attaches to the pedal via clip mechanism on the bottom of the rider's foot; around the area of the ball of the foot. Once clipped in, the rider twists their foot slightly to the side to disengage from the pedal. This type of pedal provides the most secure attachment off the three categories.

The shoe/pedal interface has been consistently changing with the intention of giving competitive cyclists the greatest performance in both power and efficiency (FitzGibbon et al., 2016). The introduction of the clipless pedal and its firm attachment has been reported to assist in a portion of the revolution of a pedal stroke as well as an increased force transmission (FitzGibbon et al., 2016; Gregor & Wheeler, 1994). However, it is unknown if clipless pedals out-perform flat pedals in all performance aspects.

Functional Threshold Power (FTP)

Endurance cycling performance can be measured using a variety of variables; both physiological and mechanical. Metrics such as lactate threshold (LT) and functional power threshold (FTP) are often measured to provide good indicators of cycling performance. Lactate threshold – the intensity of the exercise where lactate begins to accumulate in the blood faster than it can be removed – is a physiological reflection of the cyclist's ability to match energy supply to their energy demands aerobically. Exercising at intensities greater than the LT is generally limited in time since it represents the intensity that the anaerobic system starts to contribute to energy demands at a greater rate. Lactate levels are not necessarily easy to measure whereas cycling power meters have become a common for cyclists to use. As such, FTP has become a common parameter for cyclists to gauge cycling fitness (Borszcz et al., 2018).

Operationally, FTP is the highest power the cyclist can maintain for 60-minutes (Borszcz et al., 2018; Denham et al., 2017). This definition coincides with a mechanical measure of a cyclist's performance. The definitions of LT and FTP are similar, however they measure two different values. The LT is a point where lactate exponentially increases due to its inability to be removed faster than it is being produced, whereas FTP is the maximum effort a cyclist can maintain for one hour (specifically). In short, a cyclist's LT is not equivalent to their FTP (Jeffries et al., 2019).

FTP, which has been reported to be estimated through a 20-minute full-effort cycling test by subtracting 5% of the average power, has been suggested to be important when predicting cycling performance (Denham et al., 2017). Other variables such as peak power and VO_{2max} can be used to predict FTP; making the measure seemingly a good representation of the aerobic capability of a cyclist (Denham et al., 2017).

For example, FTP has been positively correlated to VO_{2max} (Denham et al., 2017) – measure of aerobic fitness – as well as a cyclist's 40-km time-trial performance (Coyle et al., 1991). FTP is also used by coaches and athletes to construct training programs and FTP, paired with heart rate data, is used to track fitness levels throughout a program. For example, in an ideal situation, as the FTP increases, the heart rate decreases as it produces the same (or higher) power.

In contrast, there are some disadvantages to utilizing an FTP as opposed to an incremental cycling maximal effort test for predicting performance. An incremental cycling test consists of an initial starting power and timed incremental increases in power to a specific power. The most notable disadvantage is FTP does not allow other physiological measures to be made such as cycling economy and LT. That being said, a disadvantage to an incremental maximal effort test to exhaustion negates the importance of pacing – which is reflected in FTP tests (Denham et al., 2017). Although FTP is the power that can be sustained for 1-hour, it is common to estimate FTP the power a cyclist can sustain for 20-minutes.

Mechanical Comparisons

Mechanical comparisons have been made between different pedal types extensively. Power is the product of force and how fast that force is applied. While published literature comparing force with different pedal types is limited, there are some investigations on pedal types. For example, Burns and Kram (2020), compared clipless and toe-clipped pedals during a cycle that was a maximal sprint. It was reported that maximum power for clipless pedals was greater ($p < 0.05$) than the toe-clipped pedals, which led this study to conclude that the clipless pedals positively influence cycling performance during an uphill sprint (Bruns & Kram, 2020).

Another dependent variable that has been investigated is plantar pressure - which provides insight of the pressure field interaction between the foot and pedal. Davis et al. (2011) investigated plantar pressure differences between toe-clipped and clipless pedals. This study reported plantar pressures significantly greater ($p < 0.05$) for clipless pedals across the entire foot (Davis et al., 2011). This was explained by the firm attachment that the cycling shoe and clipless pedal creates during the entire pedal revolution.

Another variable that has been investigated are knee joint moments between pedal types – which are the sum of all internal moments provided by muscles - in order to investigate joint stress and injury prevention. Knee joint moment differences between flat, toe-clip/cage and clipless pedals was investigated, and it was reported that the knee and ankle joint moments were greater for flat pedals, however these results lead researchers to conclude that the flat pedals were less effective throughout the pedaling phases (Seo et al., 2016).

Physiological Comparisons

Ostler and colleagues (2008) investigated gross cycling efficiency to determine if there were differences between flat pedals and toe-clipped pedals and reported no significant differences in VO_{2max}, heart rate and power output. The study reported that cycling efficiency is not altered between flat pedals and toe-clipped pedals (Oslter et al., 2008).

Additionally, Straw and Kram (2016) investigated shoe and pedal types on the efficiency of cycling and found no significant differences in efficiency between flat and clipless pedals during 5-minute sprint trials at various powers (Straw & Kram, 2016). However, clipless pedals have been reported to be more efficient than toe-clip/cage pedals. EMG activity between toe-clipped and clipless pedals has been investigated and it was observed that there is decreased electromyographic activity in clipless pedals (Cruz & Bankoff, 2001; Hug & Dorel, 2009; Mornieux et al. 2008; Seo et al., 2016). Cruz & Bankoff (2001) concluded that the reduced EMG activity reported for clipless pedals correlated to more efficient cycling.

Summary

While there is literature investigating physiological and mechanical variables between pedal types (e.g. Mornieux et al., 2008; Ostler et al., 2008), the comparison between flat pedals and clipless remain limited. Literature with FTP as a variable is limited, however it includes predictor qualities of endurance performance. Analyzing the variable could provide insight on endurance performance for cyclists. Since the comparison of direct performance benefits (physiologically and mechanically) between the two pedal types has yet to be researched, this information could influence the equipment commonly seen in races as well as kick-start the future designs for a flat pedal interface.

CHAPTER 3

METHODS

Participants

Three male and one female trained cyclists (mean ± standard deviation; 51.5 ± 11.67 years, 79.38 ± 8.71 kg) volunteered to participate in the study. Participants were required to have at least 2 years of experience competing in triathlon events and currently be logging at least 160 km a week. Participants were also required to have completed at least one Functional Threshold Power (FTP) test prior to this study. All participants reviewed and provided written informed consent after the protocol and risks of the study were described to them, in writing.

In order to participate in this study, participants needed to have a smart trainer and an interactive account with Zwift. If the participant did not have an account with Zwift, a free trial was used.

Prior to testing, participants were asked to fill out a questionnaire, disclosing demographic and specific cycling information (Appendix A). Participants were asked to treat the test days as an event and consume food similarly on both days in order to match energy intake between the test days as well as refrain from heavy physical activity prior to the test. Additionally, participants were asked to complete each test at the same time of day for both test days.

Instrumentation

Each participant used their personal equipment. Specifically, they used their own bike, smart trainers, heart rate monitors, shoes, and recording device. Participants used their own pedal (clipless) whereas flat pedals were provided to them to use (Syun-LP, Road Bike Platform

Pedals, Flat Pedals, Aluminum Alloy). Participants were required to change the pedals on their own since this study was being conducted during the COVID-19 restrictions and the study was designed to be a remote test (i.e. no face-to-face interaction).

Participants used their own bike shoe for the clipless pedal condition and their own running shoe for the flat pedal condition. The model information for all equipment was recorded in Table 1.

It is important to note that due to instrumentation, one participant did not have cadence values recorded for this study.

Procedures

Participants completed two test days that were at least 7 days and no more than 14 days apart. The order of testing the type of pedal was randomized for participants. Written instructions were provided. The instructions given to each subject are presented in Appendix B.

Participants were instructed to ensure their heart rate monitors were functioning and to not change bike settings (seat height, power meter calibration, etc.) between tests. The structure for each test began with a 20-minute timed warm-up, a 20-minute FTP test, and a 5-minute cool-down. The critical aspect of this test was the second 20-minute section, after warm-up. During this part of the test, subjects were prompted by the Zwift interface to pedal with as much power as they could sustain for a 20-minute ride.

Upon completing each test (i.e., warm-up, 20-min ride, cool-down), participants were asked to save their data files (either .csv or .fit) and email them for data analysis. Instructions for exporting were also provided and presented in Appendix B.

Data Reduction

Each data set contained 45 minutes of data. The data for the 20-minute test session were extracted for analysis. Power, heart rate, and cadence were averaged for this 20-minute section of data. This was done on Training Peaks as a method to extract dependent variables from the FTP test.

Statistical Analysis

The independent variable in the present study is the type of shoe/pedal interface, which had two levels: clipless and flat pedals. The dependent variables were power, cadence, and heart rate.

Data were analyzed using dependent t-tests (α-level = 0.05) using SPSS Statistics (version 27.0.1.0).

ID	SMART TRAINER	CLIPLESS PEDALS	SHOES
Participant 1	Saris Fluid 2	Wellgo Road Bike	Zol Fondo Road Cycling
Participant 2	Wahoo Kickr	Shimano Dura Ace SPD	Giro Trans (carbon sole)
Participant 3	Tacx NEO	Speedplay X2	Sidi T2
Participant 4	Wahoo Kickr	Time xpro 10	Shimano Sphyre

Table 1 Description of smart trainer brand, clipless pedal brand and shoe brand by participant

CHAPTER 4

RESULTS

Power was significantly greater for clipless (226.7 ± 46.2 W) vs. flat (215.2 ± 41.8 W) pedals ($t(3) = 5.1$, $p < 0.05$, Figure 4). Heart rate was significantly greater for flat (138.5 ± 17.4 bpm) vs. clipless (135.2 ± 18.1 bpm) pedals ($t(3) = -4.33$, $p < 0.05$, Figure 5). However, cadence was not significantly different between clipless (70 ± 8.7 rpm) vs. flat (71.7 ± 13.3 rpm) pedals ($t(3) = -0.625$, $p > 0.05$, Figure 6).

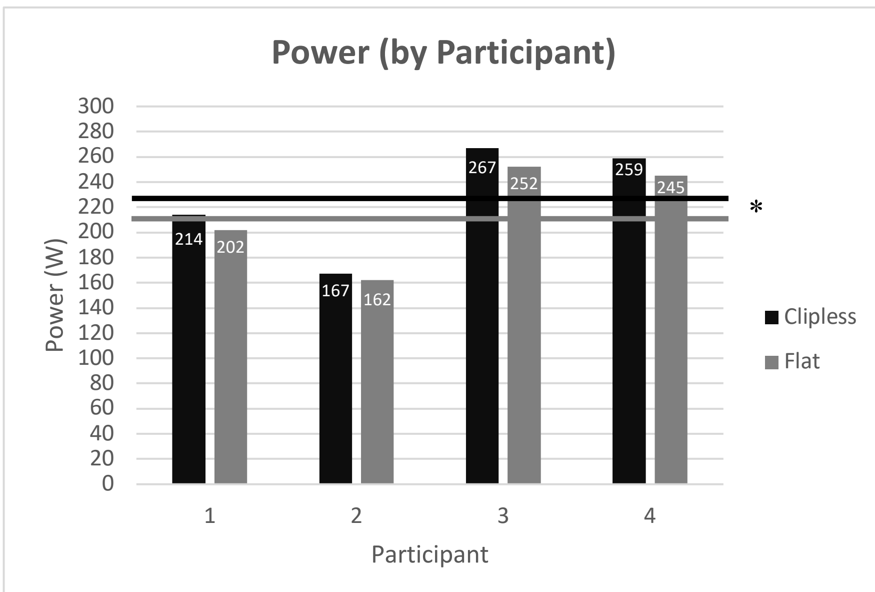


Figure 4 Individual power values and average power during a 20-minute FTP test while using clipless and flat pedals. *Average power was different between conditions ($p < 0.05$)

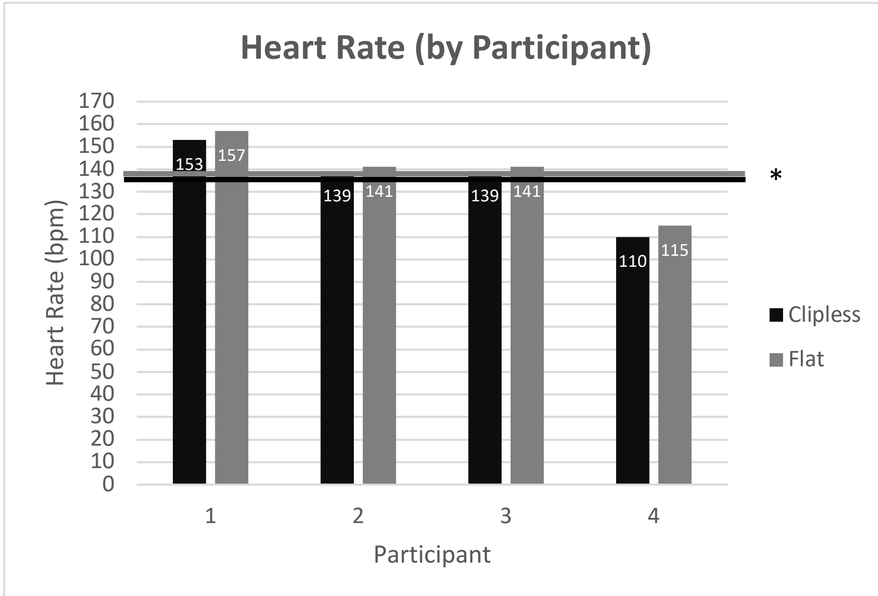


Figure 5 Individual heart rate values and average heart rate during a 20-minute FTP test while using clipless and flat pedals. *Average heart rate was different between conditions ($p < 0.05$).

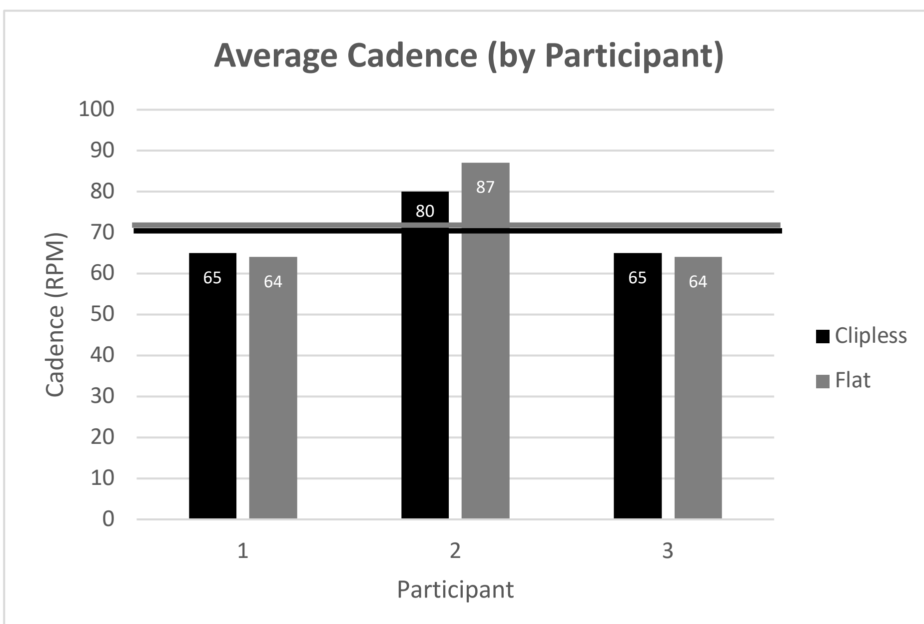


Figure 6 Individual cadence values and average cadence during a 20-minute FTP test while using clipless and flat pedals. Average cadence was not different between conditions ($p > 0.05$). One participant did not have cadence values.

CHAPTER 5

DISCUSSION

The most important observation of this experiment was that power and heart rate were different between pedal types. Power was significantly greater (5.3% ± 1.39%) for clipless pedals than flat pedals and heart rate was significantly greater (2.4% ± 1.47%) for flat pedals than clipless pedals. Another important finding was that cadence was not significantly different between pedal types ($p > 0.05$). Based upon the experiment conducted and analysis, the hypothesis of no significant differences in physiological or biomechanical parameters when using either clipless or flat pedals for a 20-minute FTP test is refuted.

The purpose of this study was to determine if bike performance is influenced by the shoe/pedal interface, more specifically, to compare physiological and mechanical parameters while using clipless and flat pedals during a 20-minute FTP test on an indoor cycle trainer. Based on the results of this study, there is evidence of performance benefits when using clipless pedals. When considering whether there is an advantage to changing into cycling shoes during T1 to then change into running shoes for T2 will require further investigation. Those investigations would determine if the time lost using a running shoe – flat pedal interface would be offset by a faster transition time between the bike-run segments of a triathlon.

Flat pedals yielded an average power of 215 ± 41.8 W while clipless pedals yielded 226 ± 46.1 W, a significant 5.3% increase ($p < 0.05$) for clipless pedals. Since research is limited in the field of comparing pedal types, the results of this study can only be compared to similar studies. For example, Hintzy et al. (1999), reported a significant increase in the maximum power output participants could produce during an all-out sprint with clipless pedals (Hintzy et al. 1999). Although this increase was for maximum power output, the increase in power using clipless pedals was observed in both studies. Furthermore, the results of this study are similar to numerous studies who reported more efficient transfer than flat pedals because of the lever system clipless pedals produce (Jarboe et al., 2003; Sanderson, Hennig, & Black, 2000)

In the present study, heart rate for clipless pedals yielded an average of 135.2 ± 18.1 bpm while flat pedals yielded a 138.5 ± 17.4 bpm, a significant increase (2.4%) than when using flat pedals ($p < 0.05$). These results parallel previously reported data (Jarboe et al., 2003). Heart rate provides insight on the body's effort by objectively measuring how hard the body is working to perform the exercise. This means, that the relationship between exercise intensity and heart rate is linear. Cruz and Bankoff (2001) reported a decrease in electromyography (EMG) activity in a variety of lower extremity muscles for clipless pedals when comparing to toe-clipped pedals (Cruz & Bankoff, 2001). Although heart rate was not directly measured by Cruz and Bankoff (2001), the 2.4% increase in heart rate for flat pedals observed in the present study can be linked to the reported findings in decreased EMG activity. Clipless pedals did not require the same muscle activity, therefore decreasing the amount of effort the heart needed to function.

It is important to note that a confounding factor for this study was pacing. It was considered that participants did not pace appropriately for the entirety of the 20-minute FTP test. That is, it was thought that there might have been a tendency to have a higher power in the beginning of the test and not have the inability to maintain that effort for the full 20 mins. A follow up analysis was conducted on normalized power. Normalized power can be calculated by taking the desired section of power data, raising those values to the 4^{th} power, taking the average, and then calculating the 4^{th} root of the average (Hurley, 2021). This calculation yields a normalized power which considers workout variances and is said to be a better measure of physiological cost (Ganoung, 2021). If a participant paced the test evenly across the 20-min ride, then normalized power would be the same as average power. Or, the more fluctuations in pace will yield different magnitudes of normalized and average power. A follow up t-test was used to compare clipless and flat pedals between average and normalized power and it was determined there was no difference between conditions ($t(3) = -1.19$, $p > 0.05$ and $t(3) = -1.41$, $p > 0.05$, respectively). This is an indication that the pace was reasonably consistent across the 20-min ride.

It was also considered that the order of pedal type could influence the participants performance. However, order was counterbalanced to minimize the chance of an order effect – two participants completed clipless pedals first and two participants completed flat pedals first.

Power is mathematically calculated as the quotient of the amount of work over time, where work can be described further as the product of force and displacement. This allows an alternative method of representing power: the product of force and velocity. In this study, power was measured using the smart trainer. Cadence was also measured and can serve as a proxy for pedal velocity. Based upon the results of this study, since cadence yielded no significant difference between pedal conditions ($p > 0.05$), the force component that is perpendicular to the pedal causing rotation when using the clipless pedals must have been greater then when using the flat pedals. It is conjectured that this increase may be partially caused by the shoe composition itself. Specifically, there are many differences between a running shoe and cycling shoe system made for clipless pedals. To describe this increase in force, specifically pedal force, it is important to note that running shoes have an insole and forefoot that provide support and cushioning. For example, Jarboe et al., (2003) reported greater forefoot pressure across the entire foot for stiffer-soled cycling shoes (carbon fiber found in cycling shoes) and additionally reported a larger power output with the stiffer cycling shoes (Jarboe et al., 2003). Furthermore, because the running shoe does not directly attach to the pedal, it may be that the tangential component of force applied to the pedal causing rotation is reduced. Further research is needed to determine if the difference in power between types of shoe-pedal interfaces used in this study is related to magnitude of force and/or direction of force applied to the pedal.

This study is limited in that trained, experienced triathletes were tested and it is not clear if primarily endurance cyclists would respond similarly. This study is limited to the number of participants and cannot be generalized to a larger population.

This study took advantage of using at-home smart trainers that allowed subjects to complete the 20-min ride on their own bike, in their own setting, using all of their own equipment. Of course, the downside of this type of approach is that there was less control on factors such as the environmental conditions, clothing worn, or time of day of testing, for example. Furthermore, it was not possible to control the visual feedback that the subjects received regarding the amount of power generated during the test. Although there is a great potential to conduct studies in real-life situations such as the at-home cycle trainer, it would be interesting to repeat this study in a laboratory setting in which several of these factors can be controlled. Nevertheless, given the constraints of the experiment, it is interesting to note that all four subjects responded similarly in terms of greater power, reduced heart rate, and no change in cadence when using clipless vs. flat pedals.

Conclusion

Power was greater when completing a 20-min FTP test using clipless vs. flat pedals and heart rate was greater when using flat pedals. Cadence was not different between pedal types. The greater power when using clipless pedals combined with a lower heart rate is an indication that this shoe-pedal interface is preferable to a running shoe-flat bottom pedal interface.

However, it is not clear if the time lost using a running shoe – flat pedal interface would be offset by a faster transition time between the bike-run segments of a triathlon. Further research would extend the current study's 20-minute FTP test to a long-distance endurance time in order to apply these results to the triathlon community.

APPENDIX A

PRE-TEST Questionnaire

Start of Block: Part One

Q1 What is your biological sex?

Q2 What is your age (in years)?

Q3 What is your weight (in pounds)?

End of Block: Part One

Start of Block: Part Two

Q4 Describe your cycling experience: (for example ‘riding for 26 years, been competing in triathlons for 20 years’)

Q5 Please fill in the following information regarding your Smart Trainer/Bike:

- Smart Trainer Brand (1) ____
- Smart Trainer Model (2) ____
- Any Further Information: (3) ____

Q6 Please fill in the following information regarding your bike pedals and shoes:

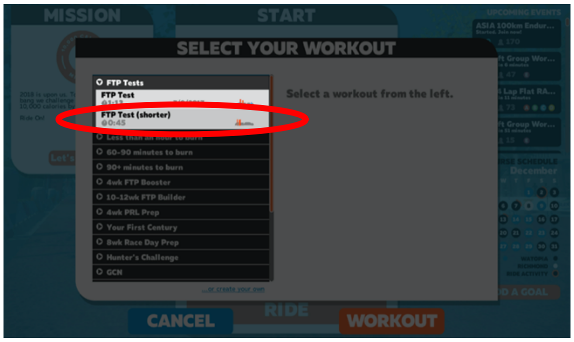
- Pedal Brand (1) ____
- Pedal Model (2) ____
- Shoe Brand (3) ____
- Shoe Model (4) ____

End of Block: Part Two

APPENDIX B

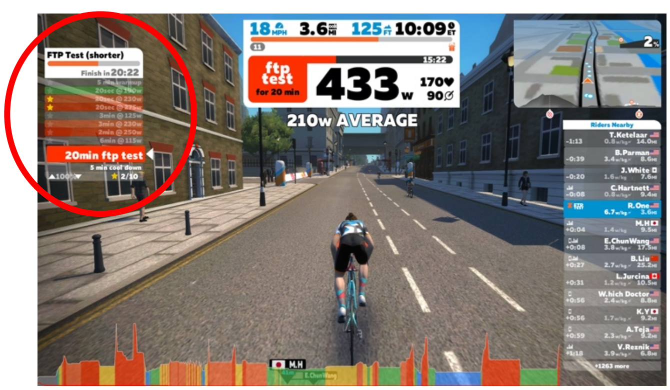
Zwift FTP Test

On the dashboard, select Select Your Workout. Select FTP Test (shorter). This is the 20-minute FTP test.



The test should begin with a 20-minute warm-up. Make sure your heart rate monitor is working properly. Your smart trainer will utilize ERG mode for the warm-up, make sure that when the 20-minute FTP test portion begins that ERG is off. For target power, switch to your own FTP and type in the desired power value. *If you do not know this value, please see reference to calculate value. Please remember this value, as it will be the same value for the second test. Select Workout.

You will be instructed to cycle through targeted wattages (see red circle for example). When you reach the 20-minute FTP test, you will begin to pedal at the highest sustainable wattage for the entire 20-minutes. This is an example of an FTP test screen.



Export your FTP workout to your training log platform (e.g. TrainingPeaks, Strava). On your training log platform, export FTP data to a .fit or .csv file.

For TrainingPeaks, please refer to:
https://help.trainingpeaks.com/hc/en-us/articles/204985370-Data-Export

For Strava, please refer to (Export Original):
https://support.strava.com/hc/en-us/articles/216918437-Exporting-your-Data-and-Bulk-Export

Calculate Target FTP

Determine your physical performance, from 1 (elite) to 5 (not trained). Multiple your Power/Weight value by your weight (in kilograms). NOTE: the commas are denoting decimal points.

Men	Power/weight (W/kg)
1 (elite)	5,05 and more
2	3,93 - 5,04
3	2,79 - 3,92
4	2,23 - 2,78
5 (beginer)	less than 2,23

Women	Power/weight (W/kg)
1 (elite)	4,30 and more
2	3,33 - 4,29
3	2,36 - 3,32
4	1,90 - 2,35
5 (beginer)	less than 1,90

For example: A man, whose weight is 80 kg, performance is self-determined as 2.80.
2.80 x 80 = 224
The target FTP is 224 W.

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CURRICULUM VITAE

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EDUCATION

2019 - Present M.S. Kinesiology

University of Nevada, Las Vegas

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2013 - 2017 B.S. Human Physiology

University of Oregon

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RESEARCH INTERESTS

Improving sports performance through investigating performance variables and their correlations with factors such as equipment, sport-specific routines, and training

RESEARCH EXPERIENCE

2019 - Present Core Temperature Project, Las Vegas, Nevada

Research Focus:

Influences on core temperature while wearing a wetsuit

Methodology:

BodyCap, e-Celsius Core Temperature Pill while swimming with and without a wetsuit

Scholarly Product:

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Research Advisor:

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2019 - Present EMG Project, Las Vegas, Nevada

Research Focus:

Shoulder muscle activity while swimming with different wetsuits and swimming paces

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Cometa Surface EMG Systems on shoulder muscle while swimming in different wetsuits

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TEACHING EXPERIENCE

2013 University of Oregon, Eugene, Oregon

Teaching Assistant, Human Physiology Department

Course: Muscle Structure, Function and Plasticity

2012 - 2013 University of Oregon, Eugene, OR

Teaching Assistant, Human Physiology Department

Course: Biostatistics

COMMUNITY SERVICE

2019 Rock 'n' Roll Marathon

Equipment Check-In/ Storage, Las Vegas, NV

2014 - 2017 PeaceHealth Medical Group

Neurology Floor – re-stock cart supplies, clean empty rooms, scanning/faxing, Eugene, Oregon