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The Effect of Polarized Training on Functional Threshold Power in Road Bike Cyclists

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Abstract

Evaluating the effectiveness of training programs by monitoring athletes' skills makes a crucial contribution to endurance sports such as road cycling. The purpose of this study was to examine the effect of polarized training on FTP (Functional Threshold Power), which is defined as the maximum power that an athlete can maintain for approximately 60 minutes. There were 5 expert cyclists aged 17-20 years from ISSI Kota Bandung, involving pre-test and post-test stages using an experimental method. 80% of the training sessions were low intensity, with the remaining 20% being high intensity, and participants had to follow a polarized training schedule for a period of 6 weeks. A Wahoo KICKR smart trainer with MyWhoosh FTP20 settings was used to assess FTP. A t-test was performed after a Shapiro-Wilk test to check whether the data was normally distributed or not in the statistical process. Outcomes indicated a substantial FTP improvement, rising from 3,514 to 3.820 W/kg ($t = -6.372$, $p = 0.003 < 0.05$). Polarized training significantly increases FTP among road cyclists, as shown in these findings. This demonstrates that the use of polarized intensity allocation is a scientifically proven approach to increasing FTP, an essential measure of cycling skill or ability marked by FTP.

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INTRODUCTION

For athletes, better results in competitions are achieved through effective training, which can be realized by preparing objective data on the achievements of a program that is very important for performance monitoring (Skarbalius et al., 2019). FTP stands for Functional Threshold Power, which is a useful performance scale in cycling, especially among recreational and elite riders (Jeffries et al., 2021). FTP refers to the maximum power that can be maintained or sustained for approximately 60 minutes under constant conditions (Allen et al., 2006). In determining the appropriate level and zone for sustained endurance activities, alternative assessment techniques for establishing intensity and monitoring training adaptation are very helpful, and these indicators are becoming increasingly popular among recreational and elite cyclists (Denham et al., 2020; Jeffries et al., 2021). Because skilled cyclists usually produce more stable power outputs than unskilled (less experienced) cyclists, the reliability of FTP assessments is highly dependent on the athlete›s ability or skill in maintaining a constant effort during the test (Currell & Jeukendrup, 2008; Science et al., 2025; Valenzuela et al., 2018).

The consistency of FTP readings is significantly influenced by the athlete›s endurance level, as demonstrated by the FTP aspect, primarily in aerobic endurance (Vinetti et al., 2023). Findings from FTP evaluations are influenced by factors beyond training volume, such as the role of training intensity distribution, as both adapt to physiological roles related to endurance that underlie FTP evaluation results (Borszcz et al., 2018; Cesanelli et al., 2022). It is important to take a holistic approach, including time management for training, increased intensity and frequency with the goal of benefiting all participants at the expense of minimal adverse effects. This is the way to efficiently increase endurance capacity (Seiler, 2010). The evidence from polarized training, wherein participants are trained to give 75-80% of their sessions at low intensity and 15-20% at high intensity, while deliberately reducing their intake of moderate intensity for better endurance, improve the ability to handle high-intensity efforts, and induce beneficial physiological responses in cyclists (Neal et al., 2013; Silva Oliveira et al., 2024; T. L. Stöggl & Sperlich, 2015). Patterns in elite endurance athletes are the basis for this logic, as they instinctively follow a highly charged pattern for optimal bodily regulation (Seiler & Tønnessen, 2009). Low-intensity training improve metabolic effectiveness and heart health without overwhelming fatigue (Esteve et al., 2007). While high-intensity ones drive up VO2max, lactate handling, and peak power (Neal et al., 2013; T. Stöggl & Sperlich, 2014).

Multiple research back the edge of polarized training over other methods. A six-week of polarized training led to greater gains in peak power and endurance compared to threshold-oriented training, and it also resulted in larger increases in VO2peak and time to exhaustion relative to high-volume or high-intensity training alone (Neal et al., 2013; T. L. Stöggl & Sperlich, 2015). Polarized training also matches the demands of road cycling, which demands prolonged endurance and intermittent high-effort bursts (Faria et al., 2005). Moreover, research has shown its advantages for elevating muscle power, stamina, and energy use effectiveness (Hebisz & Hebisz, 2021; Nøst et al., 2024).

Although the benefits of polarized training in improving aerobic capacity have been extensively established, direct empirical research on its effects on Functional Threshold Power (FTP) remain limited. It does not delve deeper into the core methodology underlying how polarized training can increase FTP, with FTP evaluation using an intermediary (indirect) method through a broader assessment of ability applied in previous studies. There is little research to suggest how FTP is affected by the allocation of polarization intensity, and therefore there is limited understanding of how it affects sustained power delivery. The existing observations make this study useful for assessing the significant impact of polarized training on FTP in road cyclists. Furthermore, this study is also useful for providing empirical data on the impact of this training approach on cyclists› power output capacity.

METHOD

In order to examine the causal correlation between polarized training and FTP in road cyclists, this study used an experimental framework. This is useful for describing the procedure by which this training approach affects FTP. This variable is aligned and directed to serve as verification of its causal impact on ability indicators through experimental techniques (Creswell & Creswell, 2023). This experimental approach involves a pre-test and post-test design on a single quantitative group. Although there is no comparison control group, this implies that the same participants are assessed at the beginning and end of the intervention to measure whether or not there has been a change.

Five male road cyclists from ISSI or the Indonesian Cycling Federation in Kota Bandung, aged between 17 and 20 years old, were the sample for this study. Each individual must have no history of muscle, bone, or joint injuries in the past six months, have at least three years of experience in competitive cycling at the national or regional level, participate in a total of 14 hours of training over seven days (one week), and have a stable average weight of 55.6 kg. They also reported no injuries to their muscles, bones/joining during the last six months. All athletes meeting the specified criteria were selected as subjects using a total sampling method. This approach was attributed to the limited population and the exceptional nature of the targeted group (Newhart & Patten, 2023).

The study utilized a targeted training approach that involved polarized training to enhance Functional Threshold Power (FTP) in road cyclists. A structured approach to cycling was followed over a six-week period, with different levels of intensity. Endurance was supported by endurance training, which took place on Mondays, Wednesdays and Fridays so it was supplemented with two to three independent low-intensity rides a week.

In the polarized training framework, there is an 80/20 distribution of intensity where as much as 80% of the total training volume is at low intensity (Zone 1, which has less than 65% PPO), and 20% at high intensity (Zone 3, ≥ 80% PPO). Specifically, sessions in the moderate intensity zone (Zone 2, consisting of 66% to 79% of PPO) are intentionally excluded to circumvent suboptimal physiological outcomes (Neal et al., 2013). High-intensity training involves a 10-minute warm-up phase, followed by six four-minute intervals each at intensities of 80% PPO or higher, interspersed with two-min active recovery periods, and ending with 10 min cool-down. Conversely, low-intensity workouts involve 45 to 90 minutes of continuous endurance cycling, with a PPO concentration below 65%.

To measure the highest average power that can be maintained during a 20-minute period, Functional Threshold Power or FTP using the FTP20 protocol was the evaluation tool used in this study. Based on the status of FTP as a recognized measure of aerobic endurance in cycling activities, this was aligned with the selection of tools and protocols in this study (Borszcz et al., 2018; Klitzke Borszcz et al., 2020). The Wahoo KICKR Smart Trainer is a data collection tool, which is the most widely used and most accurate electric-powered training device. With an R2 score exceeding 0.999 and an average of -1.5%, this device is considered highly valid and reliable compared to the SRM power meter (Hoon et al., 2016).

The FTP test was conducted twice by each cyclist, first during the pre-test (at the start of the training intervention) and second during the post-test (after the 6-week intervention). Kevin Poulton, a coach certified by the UCI, developed the MyWhoosh app, which established the standard procedures, identical environmental conditions, and use of uniform equipment for this assessment. FTP was measured by multiplying the average power maintained at maximum effort over 20 minutes by 0.95, giving an approximate reading of that power level that could be maintained for 60 minutes under constant physiological conditions. The MyWhoosh app can easily gather data and export it for statistical analysis while maintaining the reliability, consistency & accuracy of FTP readings for participants both before and after the polarized training program.

The FTP data was quantitatively analyzed using IBM SPSS Statistics ver 25 after and during the test. Prior to and following the polarized training program, the measurements of this FTP were taken. This software used to conduct a comprehensive and systematic analysis of how the intervention affected cycling abilities. The process started with examining whether the data was distributed flawlessly through normality testing. Given the limited sample size, the Shapiro-Wilk test was chosen as the preferred method (Mishra et al., 2019). If the p-score is equal to or less than 0.05, the data is not normal, whereas if the p-score exceeds 0.05, the data is normally distributed in this study.

To test the hypothesis, a sample t-test is employed, but ensure that the data is distributed in unbiased order. Provided that the variance between matched pairs is normal, this statistical method can be used to determine the difference in means between equivalent groups at two points in time. The purpose of this test is to determine if there is a statistically significant variation in the mean score between the pre-test and post-test scores. In this study, the level of statistical significance was set at α equal to 0.05. If the p-score obtained was not less than 0.05, H0 was rejected and H1 was accepted. Conversely, if the p-score exceeds or equals 0.05, H0 can be retained. This analytical framework ensures that the conclusions drawn are competent in drawing conclusions about the impact of polarized training on FTP increases in expert road cyclists.

RESULTS AND DISCUSSION

A method that verifies whether or not a sample conforms to a normal data distribution is called the Shapiro-Wilk test. The data will be subject to this test. The assessment output is presented in **Table 1**, which outlines the essential data needed for future statistical analyses.

Table 1. Shapiro-Wilk Normality Test Result

Variable	Shapiro-Wilk Statistic	df	Sig. (p)	Description
Pre-test Functional Threshold Power (FTP)	0.937	5	0.644	Normal
Post-test Functional Threshold Power (FTP)	0.821	5	0.120	Normal

Data distribution in the pre-test and post-test is normally distributed because the results show p-scores above 0.05. Parametric analysis, including the t-test, was used to test the hypothesis. This test is designed to determine if there has been a significant change in behavior at the FTP level since the polarized training program was introduced. The results are outlined in **Table 2.**

Table 2. Paired Sample t-Test Result

Variable	Mean	SD	t	df	Sig. (2-tailed)	Description
Pre-test Functional Threshold Power – Post-test Functional Threshold Power	-0.306	0.107	-6.372	4	0.003	Validated Increase

This was an increase from average FTP of 3.51 W/kg pre-test to 3.820 W/kg. After a 6-week period of polarized training. A significant boost in capability during the testing phase is indicated by this rise. A p-score of 0.003 was obtained by the t-test, which is low for a significance level of only 0.05; suggesting that there has been essentially some statistical difference between the pre-test and post-test scores. Thus, the surge in FTP is probably not a random event but rooted in actual training.

The physical effects of polarized intensity determination are responsible for this surge. Large amounts of low-intensity work encourage mitochondrial development, capillary expansion, and fat burning, refining aerobic metabolic processes (Foster et al., 2022). The lesser high-intensity segments activate type II muscle fibers and ramp up oxidative enzyme function, aiding lactate removal and anaerobic resilience (Neal et al., 2013; T. Stöggl & Sperlich, 2014). Both aerobic and anaerobic skills are reinforced by these transformations in paired form, which increases the FTP level. This discovery fits with earlier research demonstrating that polarized training brings about bigger gains in VO2max, stamina, and exhaustion duration than threshold-oriented approaches (Neal et al., 2013; Silva Oliveira et al., 2024). The organized equilibrium between training pressure and rest probably kept tiredness from building up, enabling peak bodily adjustment.

These physiological adaptations are reflected clearly in the outcomes of this study. The rise in FTP from pre-test to post-test illustrates how the prescribed intensity distribution translated into measurable performance gains. The statistical results further affirm that the intervention exerted a meaningful effect, indicating that the athletes were able to sustain higher power outputs after completing the training cycle. Such improvement suggests that the synergistic influence of enhanced aerobic efficiency and strengthened anaerobic capacity had begun to manifest in their threshold performance. Overall, these findings reinforce the understanding that when intensity zone are balanced strategically, these resulting physiological adjustments contribute directly to higher FTP values and more resilient endurance performance.

CONCLUSION

The FTP of skilled road cyclists increased showed a clear improvement during polarized training with an 80:20 split between low- and high-intensity sessions, which was encouraging. The mean FTP score rose noticeably between the first test to that of the second test, and a t-test showed average scores of 0.003 < 0.05. Studies indicate that polarized training can be an effective method for improving cycling abilities. This study proves that polarized intensity allocation is a reliable way to improve FTP, and that it is an important cycling skill marker.

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