Proceedings of the 6th International Conference on Biological Engineering and Medical Science
DOI: 10.54254/2753-8818/2026.37322

Effects of High-Intensity Interval Training on Cardiorespiratory Fitness and Endurance Cycling Performance

Siquan Wang

Xi'an TieYi International Curriculum Center, Xi'an, China
wangsiquan2027@163.com

Abstract. High-intensity interval training (HIIT) has gained popularity as a time-efficient alternative to traditional continuous endurance training. Endurance cycling performance depends largely on cardiorespiratory capacity, oxygen transport and skeletal muscle oxygen utilization, with maximal oxygen uptake (VO_2max) as a core physiological marker. Through a literature review, this article examines the effects of HIIT on cardiorespiratory fitness and endurance cycling performance, with a particular focus on the mechanisms underlying HIIT-induced adaptations, including cardiovascular, skeletal muscle, and metabolic adaptations. Existing literature shows that high-intensity interval training (HIIT) can effectively improve cardiorespiratory fitness, especially VO2max. Moreover, the cardiovascular, skeletal muscle, and metabolic adaptations induced by HIIT can improve oxygen utilization, lactate metabolism, and fatigue resistance, thereby contributing to better endurance cycling performance. HIIT is a training strategy with high time efficiency, but its effect is still affected by factors such as training intensity, training duration and athlete training status.

Keywords: High-intensity interval training (HIIT), Cardiorespiratory fitness, VO_2max, Endurance cycling, Physiological adaptation

1. Introduction

Road cycling is a type of endurance sport. Its performance depends largely on athletes' aerobic capacity, oxygen transport capacity, and metabolic efficiency. In cycling exercise, the human body needs to continuously deliver oxygen to working muscles through the cardiovascular system, where skeletal muscle mitochondria use oxygen to produce energy aerobically. Therefore, cardiorespiratory fitness is considered a key factor in determining endurance performance. Among them, VO_2max is the most commonly used physiological indicator to evaluate aerobic capacity. VO_2max represents the maximum ability of the human body to ingest and utilize oxygen under maximum exercise intensity. Its level is affected by factors such as cardiac output, stroke volume, blood volume and muscle oxygen extraction capacity. Studies show that higher VO_2max is usually linked to better endurance performance in long and high-intensity cycling. However, VO_2max cannot fully explain the difference in endurance cycling performance. In addition to oxygen uptake capacity, cycling performance is also affected by factors such as functional threshold power (FTP), lactate threshold,

© 2026 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

DOI: 10.54254/2753-8818/2026.37322

cycling economy and fatigue resistance. Therefore, improving endurance performance requires not only enhanced cardiovascular function but also skeletal muscle adaptations and improved metabolic efficiency. Traditional endurance training has long been regarded as the main way to improve aerobic capacity. However, this training method usually requires a lot of time, and its physiological benefits may diminish as athletes' training levels improve. Therefore, researchers have increasingly explored more time-efficient training strategies. HIIT is a research direction in the field of endurance training in recent years. HIIT usually consists of repeated bouts of high-intensity exercise and recovery intervals, which can produce higher physiological stress in a shorter training time. Compared with traditional continuous endurance training, HIIT can stimulate the cardiovascular system, skeleton muscle and energy metabolism at the same time. Studies have shown that HIIT has a significant effect on VO_2max improvement. The existing meta-analysis found that both HIIT and continuous endurance training can improve VO_2max, but HIIT showed higher improvement efficiency [1]. In addition, HIIT has also been found to promote mitochondrial biogenesis, improve oxidative enzyme activity, and improve lactate metabolism. These adaptations may further contribute to endurance cycling performance. Although a substantial body of research has examined the effects of HIIT in healthy populations and athletes, the physiological mechanisms through which HIIT improves endurance cycling performance remain to be further clarified. Therefore, this literature review analyzes the impact of HIIT on cardiorespiratory fitness and endurance cycling performance. It also examines the physiological mechanisms underlying these adaptations. Firstly, from an exercise physiology perspective, this review analyzes how HIIT may improve endurance capacity through cardiovascular, skeletal muscle, and metabolic adaptations. Secondly, it provides a basis for endurance cycling training and helps to understand the application value of HIIT in improving aerobic performance.

2. Effect of HIIT on cardiorespiratory fitness

VO_2max is an important indicator for evaluating cardiorespiratory fitness and aerobic capacity, representing the maximum capacity of the human body to take in, transport, and utilize oxygen during maximal exercise. In endurance sports, such as road cycling, VO_2max is closely related to performance because it reflects the cardiovascular system and skeletal muscle's ability to utilize oxygen [2]. The improvement of VO_2max mainly depends on central adaptations and peripheral adaptations. Central adaptations include the improvement of cardiac output, stroke volume and blood volume, while peripheral adaptations mainly involve the improvement of mitochondrial density, oxidative enzyme activity and oxygen extraction ability in skeletal muscle [2]. HIIT allows athletes to approach their maximal oxygen uptake through repeated bouts of high-intensity exercise, thereby generating a strong physiological stimulus [3, 4]. Research shows that HIIT can effectively improve VO_2max. It was found that high-intensity interval training can produce more obvious VO_2max improvements than moderate-intensity training [5]. In addition, a comparison between HIIT and moderate-intensity continuous training found that the HIIT group showed a greater improvement in VO_2max. After an 8-week training intervention, the HIIT group increased VO_2max by approximately 7.2%, while the moderate-intensity training group improved by approximately 4.5%, suggesting that higher exercise intensity may provide a stronger stimulus for improving aerobic capacity [5]. However, the effectiveness of HIIT on VO_2max improvement is not completely consistent across all studies. Some research has reported no significant difference between HIIT and traditional endurance training when the total training load is matched. For example, the difference between HIIT and continuous training was smaller when both groups completed similar exercise volumes and achieved comparable levels of physiological stress [1]. These results show that the

DOI: 10.54254/2753-8818/2026.37322

advantages of HIIT may be affected by many factors, such as training intensity, interval duration, recovery period, participant training status, and the total training volume. Therefore, current evidence suggests that HIIT can effectively improve aerobic capacity within limited training time. However, HIIT should not be considered to be able to completely replace traditional endurance training. Its training effect still depends on the specific training protocol, individual physiological adaptations and the athletes' own training status.

3. Physiological mechanisms of HIIT adaptation

The improvements in endurance performance induced by HIIT result not only from training intensity itself but also from long-term physiological adaptations, including cardiovascular, skeletal muscle, and metabolic adaptations [5]. HIIT-induced central cardiovascular adaptations synergize with peripheral skeletal muscle and metabolic adaptations, jointly mediating the improvement of endurance cycling ability.

3.1. Cardiovascular adaptations

HIIT can stimulate the cardiovascular system effectively, so that the heart rate and cardiac output can be maintained at a high level for a long time, thus promoting cardiovascular adaptation. Among them, the increase of stroke volume is an important factor in improving VO_2max. Higher stroke volume allows the heart to deliver more oxygenated blood to the working muscles with each contraction, thereby improving oxygen delivery. HIIT can produce strong cardiac stimulus and promote obvious cardiovascular improvement. For endurance cycling, this adaptation can help cyclists maintain higher power output under the same physiological stress and slow down fatigue [6]. In short, enhanced stroke volume and cardiac output improve systemic oxygen delivery, enabling cyclists to sustain higher workloads under the same physiological strain and delay the onset of fatigue during prolonged cycling.

3.2. Skeletal muscle adaptations

The impact of HIIT on skeletal muscle is mainly reflected in mitochondrial adaptation and oxidative capacity improvement. The metabolic stress generated by HIIT can promote mitochondrial biogenesis, improve mitochondrial function, and make muscle cells more effectively use oxygen for aerobic energy production. Short-term sprint interval training can induce skeletal muscle adaptations similar to those observed with traditional endurance training, including increased mitochondrial enzyme activity [7]. The research further proves that low-volume sprint interval training can improve skeletal muscle oxidative capacity, which shows that HIIT, even with short practice time, can also produce obvious metabolic adaptations [8]. Therefore, enhanced mitochondrial function and oxidative enzyme activity boost skeletal muscle oxygen utilization efficiency, helping cyclists produce more aerobic-driven power and reduce reliance on anaerobic metabolism during endurance cycling.

3.3. Metabolic adaptations

HIIT can also improve metabolic function, including lactate metabolism, energy utilization and oxidative capacity. Because HIIT includes repeated high-intensity efforts, the human body needs to improve lactate clearance ability and metabolic regulation to adapt to the high-intensity sports environment. HIIT can enhance mitochondrial function and promote metabolic remodeling, thereby

DOI: 10.54254/2753-8818/2026.37322

improving the efficiency of aerobic metabolism in skeletal muscle [9]. These metabolic adaptations can help endurance cyclists slow down fatigue and improve performance in long-term exercise. Collectively, these metabolic remodelling effects strengthen lactate clearance and energy regulation capacity, allowing cyclists to tolerate higher exercise intensities before lactate accumulates excessively in prolonged cycling.

4. Effects of HIIT on endurance cycling performance

4.1. Effects on cycling power output

Cycling power output is an important indicator for evaluating cyclist performance. Functional Threshold Power (FTP), in particular, reflects the ability of cyclists to sustain a high power output over an extended period. HIIT can improve sustainable power output by improving VO_2max, cardiovascular function and muscle oxidative capacity. The systematic review of endurance-trained cyclists shows that interval training can improve the physiological characteristics and performance indicators of cyclists, suggesting that HIIT has a positive effect on cycling performance [10]. Quantitative studies have reported measurable improvements in cycling-specific performance after HIIT interventions. After a 6-week high-intensity interval training program, cyclists' peak power output increased from 404 ± 40 W to 424 ± 53 W, representing approximately a 5% improvement. Additionally, their 40-km time trial performance improved, with average work rate increasing from 291 ± 43 W to 327 ± 51 W, indicating an enhanced ability to sustain higher power output during endurance cycling [11].

4.2. Effects on cycling economy

The cycling economy is an important physiological indicator to measure the exercise efficiency of cyclists under fixed power output. HIIT may improve cycling economy by improving mitochondrial efficiency, oxygen utilization, and metabolic regulation, thereby enhancing cyclists' ability to maintain higher power output and sustain higher exercise intensity during prolonged cycling performance [10]. This adaptation can help athletes improve performance efficiency during prolonged endurance cycling, delay the onset of fatigue, and improve time-trial performance. Therefore, HIIT can not only improve aerobic capacity, but also promote the improvement of special cycling performance by improving cycling economy.

4.3. Effects on lactate threshold and fatigue resistance

Lactate threshold is an important indicator of endurance capacity, representing the highest intensity that athletes can maintain exercise without producing a large amount of lactate accumulation. HIIT can enhance lactate clearance through repeated exposure to high-intensity exercise, enabling athletes to sustain exercise at higher intensities. Research points out that after a 6-week high-intensity interval training intervention, participants showed significant improvements in lactate threshold, with increases of 4.3 ± 3.2% in the once-per-week training group and 8.2 ± 2.6% in the twice-per-week training group [12].

5. Conclusion

Based on the literature reviewed, HIIT is an effective way to improve cardiorespiratory fitness and endurance cycling performance. Existing research shows that HIIT can improve VO_2max through

DOI: 10.54254/2753-8818/2026.37322

cardiovascular and skeletal muscle adaptations. Among these adaptations, increases in stroke volume and oxygen delivery can enhance cardiovascular function, while improvements in mitochondrial function and oxidative capacity can enhance the ability of skeletal muscle to utilize oxygen. In addition to improving VO_2max, HIIT may also affect endurance cycling performance by improving metabolic function. For example, improving lactate metabolism, cycling economy and fatigue resistance can help cyclists maintain a longer time of exercise under higher power output. Studies on endurance-trained cyclists also show that interval training can improve many physiological characteristics and cycling performance indicators. In general, the training effect of HIIT is not caused by a single physiological adaptation, but the result of the joint action of cardiovascular adaptation, skeletal muscle adaptation and metabolic adaptation. These adaptations can ultimately improve aerobic capacity and endurance performance.

There are still some limitations in this literature review. First of all, there are differences in the HIIT protocols adopted by different research institutes, including exercise intensity, interval duration, recovery period and training frequency, so the results of different studies are not easy to compare directly. Second, participants differ in their training backgrounds and fitness levels, which may influence their responses to HIIT. In addition, the training intervention time of some studies is relatively short. There is still a lack of sufficient evidence of the long-term impact of HIIT on endurance cycling performance.

Future research can further explore the impact of different HIIT intensities and training on cyclists to compare the long-term effects of different training protocols on VO_2max, cardiorespiratory fitness and cycling performance. In addition, future research should investigate adolescent endurance athletes and examine how long-term HIIT affects their physiological adaptations, aerobic capacity, and endurance performance, thereby providing a better understanding of their responses to prolonged training.

References

[1] Milanović, Z., Sporiš, G., & Weston, M. (2015). Effectiveness of high-intensity interval training (HIT) and continuous endurance training for VO2max improvements: A systematic review and meta-analysis of controlled trials. *Sports Medicine, 45*(10), 1469-1481.

[2] Bassett, D. R. (2000). Limiting factors for maximum oxygen uptake and determinants of endurance performance. *Medicine & Science in Sports & Exercise, 32*(1), 70.

[3] PB, B. M. L. (2013). High-intensity interval training, solutions to the programming puzzle: Part I: Cardiopulmonary emphasis. *Sports Med, 43*(5), 313-338.

[4] Buchheit, M., & Laursen, P. B. (2013). High-intensity interval training, solutions to the programming puzzle: Part II: Anaerobic energy, neuromuscular load and practical applications. *Sports Medicine, 43*(10), 927-954.

[5] HOFF, J. (2007). Aerobic high-intensity intervals improve V˙ O2max more than moderate training. *Medicine & Science in Sports & Exercise, 39*(4), 665-671.

[6] Wisløff, U., Ellingsen, Ø., & Kemi, O. J. (2009). High-intensity interval training to maximize cardiac benefits of exercise training?. *Exercise and Sport Sciences Reviews, 37*(3), 139-146.

[7] Gibala, M. J., Little, J. P., Van Essen, M., Wilkin, G. P., Burgomaster, K. A., Safdar, A., ... & Tarnopolsky, M. A. (2006). Short-term sprint interval versus traditional endurance training: Similar initial adaptations in human skeletal muscle and exercise performance. *The Journal of Physiology, 575*(3), 901-911.

[8] Burgomaster, K. A., Howarth, K. R., Phillips, S. M., Rakobowchuk, M., MacDonald, M. J., McGee, S. L., & Gibala, M. J. (2008). Similar metabolic adaptations during exercise after low volume sprint interval and traditional endurance training in humans. *The Journal of Physiology, 586*(1), 151-160.

[9] Gibala, M. J., Little, J. P., MacDonald, M. J., & Hawley, J. A. (2012). Physiological adaptations to low-volume, high-intensity interval training in health and disease. *The Journal of Physiology, 590*, 1077-1084.

[10] Norte, B., Steele, J., & Wright, J. (2024). Physiological and performance adaptations to interval training in endurance-trained cyclists: An exploratory systematic review and meta-analysis. *International Journal of Strength and Conditioning, 4*(1).

DOI: 10.54254/2753-8818/2026.37322

[11] Westgarth-Taylor, C., Hawley, J. A., Rickard, S., Myburgh, K. H., Noakes, T. D., & Dennis, S. C. (1997). Metabolic and performance adaptations to interval training in endurance-trained cyclists. *European Journal of Applied Physiology and Occupational Physiology, 75*(4), 298-304.

[12] Dalleck, L., Bushman, T. T., Crain, R. D., Gajda, M. M., Koger, E. M., & Derksen, L. A. (2010). Dose-response relationship between interval training frequency and magnitude of improvement in lactate threshold. *International Journal of Sports Medicine, 31*(8), 567-571.