# EFFECTS OF HIIT ON PERFORMANCE IN SWIMMING: A REVIEW ARTICLE

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**ABSTRACT**
*High-intensity interval training (HIIT) has emerged as a widely adopted training modality across sports disciplines, offering time-efficient improvements in aerobic capacity, anaerobic performance, and cardiometabolic health. In swimming, HIIT is particularly relevant given the sport's physiological demands and the need for balancing performance gains with reduced training volume. This review synthesizes current evidence on the effects of HIIT in swimming, focusing on physiological adaptations, performance outcomes, and training efficiency. A systematic search of PubMed, Web of Science, and Scopus was conducted using predefined keywords, with studies included if they examined swimming-specific HIIT protocols and reported physiological or performance measures. Findings indicate that HIIT can significantly enhance maximal oxygen uptake, lactate tolerance, and sprint performance in competitive swimmers, often with reduced total training time compared to traditional high-volume training. Moreover, HIIT may positively influence stroke efficiency and metabolic flexibility, suggesting its potential as a complementary approach within periodized training programs. However, the reviewed literature also highlights methodological limitations, such as small sample sizes, heterogeneous protocols, and short intervention durations, which limit generalizability. Future research should focus on long-term adaptations, sex- and age-specific responses, and comparisons with mixed training modalities. Overall, HIIT represents a promising and efficient training method for swimmers, but further high-quality studies are warranted to optimize its application in competitive and developmental settings.*

***Keywords:*** *high-intensity interval training, swimming, performance, physiology, aerobic capacity, anaerobic capacity*

## INTRODUCTION

High-intensity interval training (HIIT) has emerged as one of the most effective training modalities for improving both aerobic and anaerobic performance in athletes. In swimming, where performance is determined by a combination of aerobic capacity, anaerobic power, technical efficiency, and muscular strength, the application of HIIT offers potential advantages over traditional endurance-based training (Nugent et al., 2017). HIIT typically involves repeated bouts of short to moderate efforts performed at high or maximal intensity, interspersed with rest or active recovery. Such intermittent training can induce significant cardiovascular, metabolic, and neuromuscular adaptations within a relatively short time frame compared to continuous training methods (Sperlich et al., 2010). Previous reviews have emphasized that HIIT can elicit substantial performance improvements in swimmers, although the magnitude of its effects varies depending on training status, age, and the design of the intervention (Papadimitriou & Savvoulidis, 2017; Nugent et al., 2017). Notably, younger athletes appear particularly responsive to HIIT, showing enhancements in aerobic capacity, sprint swimming times, and competition outcomes. At the same time, studies have suggested that specific HIIT protocols (e.g., swimming-based, dry-land, core-focused) may yield unique benefits in technical efficiency and muscular power (Amara et al., 2023). Given the increasing application of HIIT in competitive swimming programs, it is timely to synthesize the recent experimental evidence. Therefore, the aim of this review is to analyze intervention studies examining HIIT in swimming, summarizing their impact on physiological adaptations, swimming performance, and related fitness outcomes.

## METHODOLOGY

### *Search Strategy*

A comprehensive literature search was conducted in electronic databases, including PubMed, Web of Science, and Scopus, to identify relevant studies examining the effects of high-intensity interval

training (HIIT) in swimming. The search included articles published up to September 2025 and combined the following keywords and Boolean operators: "high-intensity interval training" OR "HIIT" AND "swimming" OR "swimmers" AND "performance" OR "aerobic capacity" OR "anaerobic capacity" OR "physiology." Inclusion criteria were: (a) original research articles published in peer-reviewed journals, (b) studies involving competitive or recreational swimmers of any age or sex, (c) interventions applying HIIT protocols in water-based swimming training, and (d) outcomes reporting physiological, performance, or health-related parameters. Exclusion criteria were: (a) review papers, meta-analyses, conference abstracts, or non-peer-reviewed sources, (b) studies not applying HIIT in a swimming context (e.g., dryland-only protocols), (c) participants with clinical conditions unrelated to swimming training, and (d) articles not written in English.
The screening of articles was conducted using Rayyan, a web-based and mobile application designed for systematic reviews, which efficiently removed duplicate records and produced the PRISMA flow diagram (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Figure 1). Data extraction was performed independently by two reviewers, focusing on participant characteristics, intervention duration, frequency, intensity, and main performance and physiological outcomes. Discrepancies were resolved through discussion and consensus. To ensure data harmonization, all extracted variables were standardized according to common training descriptors (e.g., session frequency, %$VO_2$max, and intervention duration). The methodological quality and risk of bias of the included studies were evaluated based on sample size adequacy, randomization, blinding of assessors, completeness of outcome data, and clarity of intervention protocols. Most studies demonstrated moderate to high methodological quality, although some exhibited potential biases due to small sample sizes, lack of control groups, or incomplete reporting of training load and adherence.

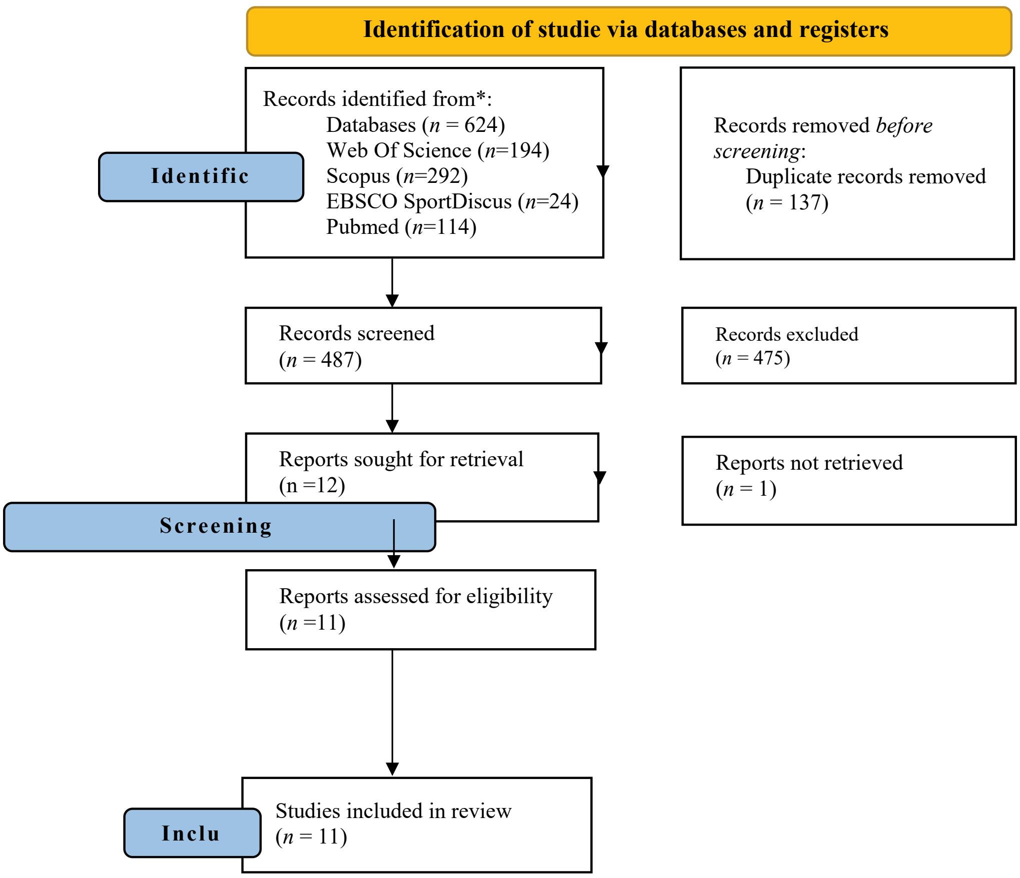


**Figure 1.** *PRISMA statement*

RESULTS
A total of 11 intervention studies were identified, including 482 participants across children, adolescents, and elite swimmers. Program durations

ranged from 4 to 12 weeks, with session frequencies of 2 to 5 sessions per week. Interventions varied widely in intensity (90–110% of $VO_2$max or race-pace effort), volume, and modality (swimming-specific, dry-land, upper-body, lower-body, or core-focused HIIT). Consistently, HIIT has improved performance outcomes, including sprint swimming times, $VO_2$max, core stability, and swimming technique.

**Table 1.** *Summary of included HIIT interventions in swimming*

| Study | Participants | Duration | Frequency | Intensity | Type of HIIT | Main Outcomes |
|---|---|---|---|---|---|---|
| Papadimitriou & Savvoulidis (2017) | 40 young swimmers | 8 wks | 3x/wk | 90–100% effort | Swimming HIIT | Improved sprint performance |
| Amara et al. (2023) | 48 age-group swimmers | 8 wks | 3x/wk | Race-pace | Swimming HIIT + dry-land | ↑ Strength, technique, 100m butterfly |
| Hiruntrakul et al. (2025a) | 32 male swimmers | 6 wks | 4x/wk | >90% $VO_2$max | Swimming HIIT | ↑ $VO_2$max, vital capacity |
| Zhang et al. (2025) | 36 elite swimmers | 6 wks | 3x/wk | High-intensity intermittent | Upper-body HIIT | ↑ $VO_2$max, energy metabolism |
| Papadimitriou & Savvoulidis (2020) | 30 children swimmers | 6 wks | 3x/wk | 90–100% effort | Swimming HIIT (different rests) | ↑ Efficiency, performance |
| Sperlich et al. (2010) | 19 children swimmers | 8 wks | 2–3x/wk | >100% race pace | Swimming HIIT | ↑ $VO_2$peak, lactate tolerance, competition results |
| Hanafi & Hasanuddin (2025) | 28 adolescents | 6 wks | 3x/wk | Sprint-based | Swimming HIIT | ↑ 50m freestyle sprint speed |
| Jin et al. (2025) | 40 elite swimmers | 4 wks | 4x/wk | 95–105% $VO_2$max | Lower-body HIIT | ↑ $VO_2$max, metabolism |
| Karabıyık et al. (2023) | 50 adolescents | 12 wks | 3–5x/wk | High / moderate / low volume | Volume-based HIIT | High-volume training most effective |
| Hiruntrakul et al. (2025b) | 40 swimmers | 6 wks | 3x/wk | High intensity | Core muscle HIIT | ↑ Core stability, power |

## DISCUSSION

This review demonstrates that HIIT is an effective method to enhance both physiological and performance-related outcomes in swimmers. Across various protocols, improvements were consistently observed in sprint swimming times, aerobic capacity, $VO_2$ max, and swimming efficiency. These findings align with earlier systematic reviews that highlighted the broad applicability of HIIT across competitive levels (Nugent et al., 2017). Notably, children and adolescents appear particularly responsive to HIIT interventions, showing rapid gains in aerobic and anaerobic systems (Sperlich et al., 2010). Meanwhile, elite swimmers benefit from targeted protocols, such as upper- or lower-body HIIT, which can refine specific components of performance (Zhang et al., 2025; Jin et al., 2025). HIIT has been applied across various sports, including running, cycling, and team sports such as soccer and basketball. In these sports, HIIT first of all targets cardiovascular efficiency, lactate threshold improvement, and anaerobic power (Buchheit & Laursen, 2013). Unlike dry land sports, in swimming, the use of traditional load-monitoring methods are difficult (e.g., power meters) is impractical and necessitates adaptations in monitoring for swimmers.

An important observation from the reviewed studies is the variety in HIIT program design. Frequencies ranged from two to five sessions per week, with durations spanning 4–12 weeks. Intensity was consistently high, often exceeding 90% $VO_2$max or performed at race-pace efforts. The combination of swimming-specific HIIT with dry-land or core exercises suggests a complementary effect, supporting both muscular strength and technical execution (Amara et al., 2023; Hiruntrakul et al., 2025b). Nevertheless, variability in training volume and rest intervals underscores the need for individualized programming to maximize performance adaptations while minimizing fatigue. HIIT also demonstrates strong health benefits, including improved insulin sensitivity, reduced postprandial glycemia, and a reduced risk of metabolic syndrome. This makes it a vital tool not only in sports training but also in preventive and therapeutic practices. However, despite its numerous advantages, it is necessary to adequately adapt the protocol to the individual characteristics of the subjects or athletes to maximize the effects and minimize the risk of injury or overtraining (Milanović, Sporiš & Weston, 2015).

Overall, the results reinforce HIIT as a time-efficient and highly effective approach in swimming training. Future research should emphasize longitudinal studies, standardized reporting of HIIT protocols, and the integration of HIIT into periodized training plans to better understand long-term effects and transferability to competition.

## CONCLUSION

HIIT is a versatile and powerful training method for swimmers, improving aerobic fitness, sprint speed, swimming technique, and overall competition performance. Programs lasting 4–12 weeks with 2–5 sessions per week, typically performed at 90–110% $VO_2$max or race-pace intensity, demonstrated consistent benefits. Integrating swimming-based HIIT with dry-land and core stability work may further enhance outcomes. Coaches and practitioners are encouraged to apply HIIT strategically, tailoring intensity, volume, and recovery to athlete age, level, and training goals.

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