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Review paper *Pregledni rad*

Fighting Fit: How Interval Training Shapes Physical Performance in Martial Arts — A Systematic Review

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Abstract: *Success in martial arts and combat sports relies heavily on an athlete's ability to integrate strength, endurance, speed, agility, and coordination in dynamic situations. Interval training is relevant because it stimulates multiple energy systems through moderate to high intensity training with short recovery periods. This study is a systematic review compiled according to PRISMA guidelines, reviewing articles from the PubMed database over the past five years. Six of the 212 articles identified met the inclusion criteria for further analysis. The results indicate that high-intensity interval training (HIIT) combined with specific techniques and HIIT with strength or plyometric training effectively improves aerobic and anaerobic capacity, muscle strength, speed, agility, and technical skills. In contrast, non-specific interventions such as photobiomodulation showed no significant effects. However, interindividual variation in training response exists, necessitating a personalized approach and ongoing performance monitoring. Methodological limitations in previous studies also emphasize the need for further studies with more consistent designs and more diverse populations. Overall, interval training, particularly technique-based HIIT, can be recommended as an effective strategy in improving the physical performance of martial artists.*

Keywords: *Interval Training, High-Intensity Interval Training (HIIT), Martial Arts, Combat Sports, Physical Performance*

Introduction

Success in martial arts and combat sports depends heavily on the athlete's ability to integrate various physical fitness components in high-pressure, time-limited scenarios. (Clemente-Suárez, 2022). Disciplines such as wushu, taekwondo, judo, and mixed martial arts demand exceptional muscular strength, anaerobic power, cardiovascular endurance, speed, agility, and coordination to execute techniques with efficiency, accuracy, and endurance. (Ribeiro et al., 2022). These multifactorial physiological requirements reflect combat's dynamic and unpredictable nature, where peak performance depends on the athlete's capacity to transition smoothly between explosive bursts and sustained effort. (Salar et al., 2022). Conventional training programs that isolate individual fitness elements may fail to replicate the integrated physiological demands encountered in real-time competition. (Tong et al., 2024). Consequently, there is a growing need for training interventions that can simultaneously develop multiple performance attributes in a sport-specific and time-effective manner (Pol et al., 2020). Interval training has been widely accepted as a method capable of substantially improving aerobic and anaerobic performance across the athletic population. (Boullosa et al., 2022).

This training approach, which is characterized by repeated bouts of moderate to high intensity effort interspersed with recovery periods (Çimke et al., 2024), allows targeted stimulation of multiple energy systems over a short period of time (Thurlow et al., 2023). It has been shown to improve cardiovascular fitness, muscular endurance, metabolic efficiency, and neuromuscular adaptations, making it particularly relevant to sports that combine power and endurance demands (Akbar et al., 2022). In combat sports, where athletes must repeatedly engage in high-intensity action with minimal recovery, interval training is increasingly used as a practical conditioning strategy (Billaut, 2022). Its intensity, volume, and rest manipulation flexibility allow for tailored application to various martial arts disciplines' biomechanical and physiological characteristics (Mulla & Keir, 2023). Despite its growing application, the scientific literature on interval training in martial arts and combat sports remains fragmented and lacks consensus (Poon et al., 2023). Several major studies have examined its impact on performance variables such as VO_2max, anaerobic capacity, strength, agility, and fatigue resistance (Hov et al., 2023). However, heterogeneity in study designs, interval

protocols e.g., HIIT, MIIT, SIT, outcome measures, and athlete populations presents challenges in interpreting the broader efficacy of these interventions (Jr, 2025). Additionally, recent reviews of interval training have primarily focused on general athletic or endurance populations (Szinay et al., 2020). With a limited focus on the context of martial arts (Osorio et al., 2024). The absence of a systematic synthesis specific to martial arts hampers the development of evidence-based guidelines for practitioners and researchers to optimize physical preparation in this domain (Ribeiro et al., 2022). Therefore, this systematic review aims to synthesize current empirical evidence on the effects of interval training on physical performance parameters in martial arts and combat sports (Ribeiro et al., 2022). Specifically, this study aims to evaluate which interval training modality is most effective in improving key fitness attributes relevant to combat performance (Siew et al., 2024). To identify patterns and limitations in existing research, and to provide appropriate recommendations for sport practitioners and future research (Khodadadi et al., 2023). By addressing this gap, this review contributes a sport-specific perspective to the broader body of knowledge on interval-based conditioning, offering theoretical insights and applied implications for advancing performance training in combat sports (Havenetidis et al., 2023).

This study presents novelty by presenting the first systematic synthesis specifically examining the impact of different forms of interval training on physical performance parameters in the context of martial arts and combat sports. (Folhes et al., 2023). Unlike previous reviews, which tended to focus on general athletes or endurance sports (Novaković et al., 2023). This study draws attention to the unique and complex physiological demands of sports such as wushu, taekwondo, judo, and MMA (Guppy et al., 2021).

This study aimed to synthesize empirical evidence systematically addressing the effects of interval training on physical performance parameters in martial arts and combat sports. (Mañas-Paris et al., 2022). This study specifically aims to identify the most effective interval training modalities—such as high-intensity interval training (HIIT), moderate-intensity interval training (MIIT), and sprint interval training (SIT)—in improving key fitness components relevant to combat performance, including aerobic capacity (VO_2max), anaerobic capacity, muscular strength, speed, agility, and muscular endurance. (Hov et al., 2023). In addition, this study aims to explore the patterns of results, methodological approaches, and limitations found in previous studies. (Escoto-vasquez et al., 2024), so that it can provide a more comprehensive understanding of the effectiveness of interval training in martial arts (Palumbo et al., 2023). Through this review, it is hoped that evidence-based recommendations can be produced that are applicable and specific for coaches, athletes, and martial arts practitioners in designing physical conditioning programs that are efficient, integrated, and in accordance with the competitive demands of each martial arts branch. (Kadlec et al., 2023).

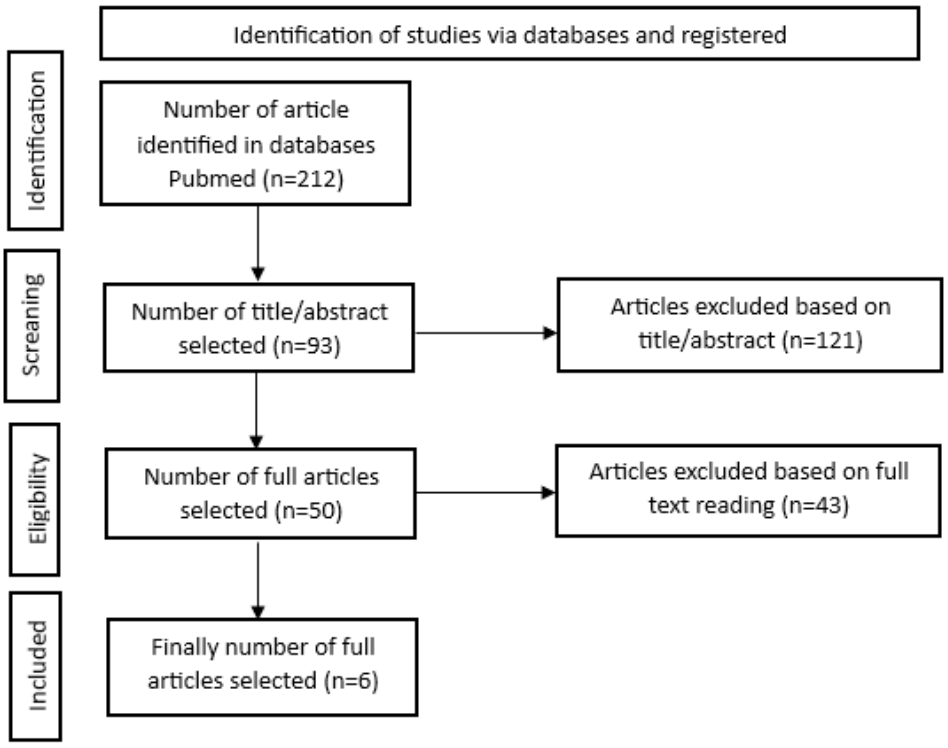
Methods

Research Design

This study employed a systematic review method by searching various journal databases, including PubMed, which is considered a leading global platform for aggregating publications with scientific impact and relevance. The study was structured according to PRISMA guidelines. This review aimed to identify, evaluate, and synthesize scientific articles examining the effects of interval training on physical performance in martial arts and combat sports.

PRISMA Flow Diagram

Table 1. *PRISMA Flow Diagram of the Article Selection Process*



Tabel 1. Diagram alir PRISMA dari proses pemilihan artikel

Kriteria kelayakan

Kriteria inklusi dalam penelitian ini adalah artikel yang diterbitkan dalam 5 tahun terakhir dan artikel yang membahas Interval Learning dan Cardiorespiratory. Pengecualian untuk penelitian ini adalah artikel yang diterbitkan dalam jurnal terkenal.

Proses

Judul artikel, abstrak, dan teks lengkap telah diperiksa, divalidasi, dan ditransfer ke perangkat lunak Mendeley. Sebanyak 171 artikel dari basis data Pubmed dikumpulkan pada langkah pertama. Kecukupan judul dan abstrak menjadi dasar untuk penyaringan berikutnya terhadap 59 artikel pada tahap kedua. Dua belas produk dipesan untuk pemrosesan tambahan selama tahap ketiga. Pada titik ini, kami menyaring artikel berdasarkan kesesuaian umumnya. Sebelas makalah yang memenuhi kriteria inklusi kemudian dipilih untuk putaran analisis akhir menggunakan observasi sistematis. Penelitian ini mematuhi pedoman Penilaian Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) untuk operasi standar.

From the article selection process, the eligibility criteria for inclusion in this study were articles published within the last five years and articles discussing Interval Training and Martial Arts. Articles published in reputable journals were excluded.

Article titles, abstracts, and full texts were reviewed, validated, and transferred into the Mendeley software. The initial search identified 212 articles relevant to the study topic. A first screening process was conducted based on titles and abstracts, resulting in 93 suitable articles. One hundred twenty-one articles were eliminated for not meeting the initial criteria or for being irrelevant based on their titles and abstracts. The next stage was a feasibility evaluation, which involved thoroughly reading the contents of the 50 selected articles. After a full review of the contents, 43 articles were deemed not to meet the inclusion criteria or not substantially relevant to the study focus and were therefore excluded from further analysis. Ultimately, only 6 articles were considered to meet all selection criteria and were included in the final review. This process demonstrates a rigorous and systematic selection process to ensure that only truly relevant and high-quality articles were used in this study.

Results

Writer	Sample Characteristics	Study Design	Intervention	Results (Summary)	Complete Results
(Dos Santos Junior et al., 2023)	11 male Brazilian Jiu-Jitsu athletes (age 28.7 ± 8.3 yrs)	Randomized, crossover, double-masked clinical trial	Photobiomodulation with 6J or 12J per point vs placebo	No dose-dependent ergogenic effect on anaerobic performance observed	No significant ergogenic effects were found on high-intensity intermittent anaerobic performance. Although anaerobic capacity decreased in the second and third sets of the Wingate test, the effects of photobiomodulation (PBM) at doses of 6 J and 12 J per point did not significantly improve performance compared to placebo.
(Ouergui et al., 2022)	59 adolescent judo athletes (15 ± 1 yrs, M/F)	Randomized controlled trial with 3 interventions and 1 control group	4 weeks of intensified training using Kumi-kata, Uchi-komi, or running + 12-day tapering	Kumi-kata improved CMJ and isometric JCT; Uchi-komi improved UST; JPFT improved in all experimental groups	Kumi-kata training improved vertical jump (CMJ) performance and isometric strength (chin-up judogi); uchi-komi training improved uchi-komi speed (UST); and the Judo Physical Fitness Index (JPFT) increased in all intervention groups. However, the Judo-Specific Fitness Index (SJFT) did not show significant differences between groups.
(Ojeda-Aravena, Herrera-Valenzuela, Valdés-Badilla, Martín, et al., 2021)	12 Taekwondo athletes (M=8, F=4), age 16.8–17.8 yrs	Randomized trial with two groups: technique-specific HIIT vs repeated sprints	4 weeks HIIT using specific techniques vs repeated sprints, 3 sessions/week	Technique-specific group improved SJ, KDI, total kicks, and 20MSR; higher proportion of responders	The particular technique group (TS-G) demonstrated increased total kick count, decreased kick drop index (KDI), and improved 20-meter shuttle run performance. This group also had a higher proportion of athlete responders than the repeated sprint group (RS-G), particularly in the SJ, CMJ, and kick count tests.
(Ojeda-Aravena, Herrera-Valenzuela, Valdés-Badilla, Cancino-López, et al., 2021)	10 youth karate athletes (M=6, F=4), age 15.2 ± 1.6 yrs	Randomized controlled trial (EG vs CG)	HIIT with specific techniques for 4 weeks (3 sessions/ week)	EG improved SJ (15.2%), CODS (-1.7%), and a higher responder rate than CG	The experimental group receiving HIIT with specific techniques showed a 15.2% increase in jump height (SJ) and a -1.7% increase in change of direction ability (CODS). The proportion of responders was also higher than that of the control group (40% vs. 20%). However, not all fitness components related to TKD showed significant improvements.
(Quan et al., 2024)	40 national-level male karate athletes (21.2–21.7 yrs)	Randomized controlled trial with 5 groups	8-week short sprint interval training (sSIT), resistance training (RT), or concurrent (sSIT+RT/RT+sSIT)	All training improved physical fitness; CT groups showed the largest effects without sequencing impact	All intervention groups (SSIT, RT, and a combination of both) showed significant improvements in physical fitness (jumps, sprints, shuttle runs), muscle strength, and anaerobic capacity (peak and mean power). The combination of sSIT + RT had the greatest effect, although no differences were found based on the training order (sSIT + RT vs. RT + sSIT).

(Mañas-Paris et al., 2022)	32 young judokas (age 12.8 ± 1.7 yrs, M/F=9/7)	Non-randomized experimental intervention (control vs experimental)	3 weeks of plyometric + HIIT training in addition to regular judo practice	Improved SJFT score and angular velocity in the experimental group	The experimental group that followed plyometric and HIIT training for 3 weeks showed a significant decrease in SJFT scores (indicating improved performance) and increased angular velocity on the X and Y axes. This suggests that combining HIIT and plyometrics can improve judoka children's technical and physiological performance.

This table summarizes six international studies evaluating various training interventions for combat sports athletes, such as BJJ, judo, taekwondo, and karate. Each study contains key information, such as participant characteristics, study design, intervention type (e.g., HIIT, plyometrics, photobiomodulation, and training combinations), and key outcomes. The goal is to provide a concise yet comprehensive overview of the effectiveness of each approach on athletic performance.

Technique-specific HIIT and combining HIIT with plyometric training are most effective in improving strength, speed, and anaerobic endurance. (Michailidis et al., 2023). In addition, combination training (concurrent training), such as resistance training combined with short interval sprints, also shows positive results without significant differences in the order of implementation. (Lee et al., 2020). In contrast, in studies conducted on BJJ athletes, photobiomodulation did not significantly impact anaerobic performance. (Tomazoni et al., 2019). The effectiveness of an intervention depends largely on the type of training, the athlete's characteristics, and the approach used. Several studies also emphasize the importance of considering individual responses to training, as not all athletes show the same improvements. (Mueller et al., 2022)Therefore, these results can be an important reference for coaches and sports practitioners who want to develop more targeted, evidence-based training programs. (Bagheri et al., 2023).

Discussion

The discussion in this study emphasizes the relevance and urgency of using interval training as the main method in improving the physical performance of martial arts athletes (Vaccari et al., 2020). Sports such as wushu, taekwondo, judo, and MMA demand complex physical capacities, involving rapid transitions between explosive strength and sustained endurance in unpredictable situations (Pol et al., 2019). Interval training, which combines high-intensity work phases with recovery phases, allows multisystem stimulation in a single session and is therefore particularly suited to the dynamic characteristics of combat sports (Wahl et al., 2022). This method has been proven to increase fitness components such as aerobic and anaerobic capacity, muscle strength, speed, agility, and functional endurance simultaneously and efficiently (Campo et al., 2021).

One of the important findings of this review is the effectiveness of high-intensity interval training (HIIT), especially when adapted to sport-specific techniques, which showed significant results in improving functional performance, such as the number and quality of techniques, explosive strength, and motor response speed. (Reed et al., 2022). In addition, combination training approaches such as concurrent training—which integrates HIIT with strength or plyometric training—also yield positive results regardless of the order of execution, confirming the synergistic value of an integrated approach to training. (Markov et al., 2023). However, this study also revealed inter-individual variation in response to training interventions, indicating that athletes' physiological responses are not uniform. This reinforces the importance of a personalized approach in designing training programs based on individual performance measurement and monitoring. (Arora et al., 2024).

This review highlights methodological limitations in the previous studies, such as varying study designs, non-uniform training protocols, varying intervention durations, and the diversity of performance measurement instruments. (Bashir et al., 2022). This fragmentation poses a major challenge in generalizing findings and applying research results broadly in training practice. (Vankov & Bowers, 2020). Nevertheless, this systematic review has organized and integrated the scattered evidence, providing a more complete and useful picture. (Aftab et al., 2020)These results provide significant contributions for sports practitioners and researchers to develop more effective, efficient, and evidence-based training programs and open up opportunities for further, more focused research, including on

underrepresented populations, such as female athletes, adolescents, or non-Olympic martial arts disciplines. (Mujika & Taipale, 2019; Smith et al., 2022)

Thus, it can be concluded that interval training, especially HIIT adapted to technique, and combination training, is a promising training approach in improving the specific physical capacity of martial arts athletes. (Khan & Khan, 2022). These findings contribute to the science of physical conditioning in combat sports and offer direct implications for enhancing athletes' competitive performance through structured, adaptive, and applicable training methods. (Arora et al., 2024; Lu et al., 2022).

Conclusion

The conclusions of this systematic review confirm that interval training, specifically high-intensity interval training (HIIT) and combined forms such as HIIT with plyometrics or strength training, is an effective training strategy for improving a variety of crucial physical performance parameters for martial arts athletes, including aerobic and anaerobic capacity, strength, speed, agility, and technical ability. These trainings have been shown to replicate the physiological demands of combat sports, which emphasize high intensity with short recovery intervals. Their effectiveness is highly dependent on protocol design, athlete characteristics, and individual variation in training response, making it crucial for coaches to adopt a personalized approach and monitor performance. However, limitations in previous research methodology suggest the need for further studies with more consistent designs and more diverse populations. This article contributes to synthesizing the scattered scientific evidence and establishing a solid foundation for developing more targeted, efficient, and specific evidence-based training strategies for combat sports.

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