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The Effectiveness of High-Intensity Interval Training (HIIT) in Enhancing the Aerobic Endurance of Karate Specialization Students at PKO FIK UNIMED

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Abstract
The low aerobic endurance of karate specialization students often became an obstacle in maintaining performance during prolonged training and match simulations. This condition indicated the need for an effective and time-efficient training method that matched the intermittent physiological demands of karate. This study aimed to determine the effectiveness of high-intensity interval training in improving the aerobic endurance of Karate Specialization Students at the Coaching Education Program, Faculty of Sports Science, Universitas Negeri Medan. The study employed a quasi-experimental method using a one-group pretest-posttest design. The participants consisted of 20 karate specialization students selected through purposive sampling. Aerobic endurance data were collected using the multistage fitness test to estimate maximal oxygen uptake. The training program was implemented for six weeks with a frequency of three sessions per week. The results showed a significant increase in students' aerobic endurance after the training intervention, indicated by improved maximal oxygen uptake scores in the posttest compared to the pretest. The findings confirmed that high-intensity interval training effectively enhanced aerobic endurance in karate specialization students. The novelty of this study lay in the application of high-intensity interval training within the context of university-level karate specialization learning, which had rarely been explored in previous studies.

Keywords: high-intensity interval training, aerobic endurance, karate students, maximal oxygen uptake, sports coaching education

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A. Introduction

Karate is a combat sport that demands an integration of technical proficiency, tactical decision-making, psychological control, and high levels of physical fitness. Among the physiological components required for optimal performance, aerobic endurance plays a central role because it supports repeated high-intensity efforts, accelerates recovery between exchanges, and maintains movement quality throughout training sessions and competition bouts. Although karate performance frequently involves explosive intermittent actions, the aerobic energy system remains essential for sustaining repeated attacks, defensive transitions, and recovery during cumulative match duration (Franchini et al., 2019); (Yue et al., 2025)(Chaabène et al., 2021);. Therefore, improving aerobic endurance has become an important objective in karate conditioning programs.

Within higher education settings, particularly in the Sports Coaching Education Program of the Faculty of Sports Science at Universitas Negeri Medan, students enrolled in Karate Specialization courses are expected not only to master sport-specific techniques but also to demonstrate adequate physical readiness. This expectation is important because coaching education students are prospective trainers, teachers, and practitioners who must understand both theoretical and applied conditioning principles. Inadequate aerobic fitness may reduce training volume tolerance, impair technical consistency, and limit students' ability to participate effectively in practical learning sessions (Bompa & Buzzichelli, 2019); Kenney et al., 2021).

Preliminary observations among Karate Specialization students at PKO FIK UNIMED indicated that several students experienced declining movement intensity during prolonged sessions, slower recovery after repeated drills, and reduced work capacity in the final phases of practice. These indicators suggest suboptimal aerobic endurance. Similar conditions have been reported in university sport participants when conditioning programs rely excessively on conventional continuous training methods that are less engaging and insufficiently aligned with the intermittent metabolic demands of combat sports (Buchheit & Laursen, 2013);(Astorino & Edmunds, 2022). If not addressed, this issue may negatively affect learning outcomes, skill execution quality, and readiness for competition or coaching practicum activities.

One training model increasingly recommended to improve endurance efficiently is High-Intensity Interval Training (HIIT). High-Intensity Interval Training consists of repeated short-to-moderate bouts of vigorous exercise interspersed with active or passive recovery periods. Compared with moderate continuous training, HIIT has been shown to produce substantial improvements in maximal oxygen uptake (VO_2max), mitochondrial adaptation, cardiac efficiency, and exercise tolerance with lower time commitment (Gillen & Gibala, 2018)(Milanović et al., 2019)(Wen et al., 2019). Because karate competition involves repeated bursts of effort followed by brief recovery, HIIT theoretically provides a more specific conditioning stimulus than traditional endurance methods.

Empirical evidence supports the effectiveness of HIIT in combat sports. Previous studies reported that HIIT significantly improved aerobic endurance, repeated sprint ability, agility, and physiological recovery in karate athletes, taekwondo athletes, judokas, and other striking or grappling sport populations (Hadi & Yudhistira, 2023)(Wijianto, 2024)(Yulfadinata et al., 2025). A recent meta-analysis also concluded that HIIT produces meaningful gains in both aerobic and anaerobic capacity across Olympic combat sports populations (Yue et al., 2025). These findings indicate that interval-based training is highly

compatible with the energetic profile of martial arts performance.

However, important research gaps remain. First, many previous studies focused on elite athletes, club competitors, or adolescent performance pathways rather than university students in coaching education programs. Second, most studies emphasized competition outcomes, anaerobic power, or sport performance indicators, while fewer investigations examined academic sport specialization contexts where participants balance training with coursework and limited practice time. Third, there is still limited evidence regarding the practical implementation of structured HIIT programs for karate specialization students in Indonesian universities, particularly using accessible field-based measurements such as the multistage fitness test (Indrawan & Yudhistira, 2025)(Nainggolan & Siahaan, 2025). This gap is important because training prescriptions effective for elite athletes may not automatically transfer to student populations with different workloads, adaptation capacity, and educational objectives.

From a theoretical perspective, the principle of specificity states that training adaptation is greatest when exercise stimuli resemble the movement pattern, intensity profile, and recovery characteristics of the target sport (Bompa & Buzzichelli, 2019). Since karate performance consists of repeated explosive actions separated by brief pauses, HIIT may offer superior transferability to karate demands compared with monotonous continuous running. In addition, time-efficient conditioning strategies are particularly relevant in university environments where scheduled learning hours are limited.

Based on the above rationale, this study aimed to determine the effectiveness of a six-week HIIT program in improving the aerobic endurance of Karate Specialization students at PKO FIK UNIMED. The novelty of this research lies in the application of HIIT within a university-level karate coaching education context, rather than elite athlete settings that dominate previous literature. The findings are expected to contribute theoretically to sport training science and practically to the development of efficient evidence-based conditioning models for martial arts courses in higher education.

B. Methods

This study employed a quasi-experimental method using a one-group pretest-posttest design, which was considered appropriate to examine the effectiveness of the High-Intensity Interval Training program on aerobic endurance improvement among Karate Specialization students. This design allowed the researcher to compare participants' aerobic endurance levels before and after the intervention within the same group. Similar experimental designs have been widely used in previous studies examining the effects of high-intensity interval training on karate athletes and aerobic capacity evelopment.

The participants consisted of 20 Karate Specialization students of PKO FIK UNIMED, selected using purposive sampling, with the criteria of being actively enrolled in the karate specialization course, physically healthy, and regularly participating in practical sessions.

The research approach used a field experimental approach, in which the intervention was conducted directly within the students' regular sports training environment to maintain ecological validity and practical relevance.

Data were collected using the Multistage Fitness Test (Bleep Test) to estimate maximal oxygen uptake, which served as the indicator of aerobic endurance. This instrument was selected because it is practical, valid, and commonly used in sports science studies

to measure aerobic fitness in athletes and students.

Before hypothesis testing, the data were examined using: Normality test (Shapiro–Wilk), Homogeneity test and Descriptive statistics. To determine the effectiveness of the intervention, the study used a paired sample t-test to compare pretest and posttest maximal oxygen uptake scores at a significance level of 0.05. This technique is widely recommended for one-group pretest-posttest designs involving interval data. The data analysis was conducted using SPSS version 25.

C. Result and Discussion

Result

The study involved 20 Karate Specialization students who completed the pretest and posttest measurements of aerobic endurance using the Multistage Fitness Test, expressed as maximal oxygen uptake values (ml/kg/min).

The descriptive analysis showed a clear increase in aerobic endurance after the High-Intensity Interval Training intervention.

Table 1. descriptive analysis

Variable	N	Mean	SD
Pretest	20	38.65	0.82
Posttest	20	42.67	0.92
Mean Gain	20	4.02	0.16

The mean score increased from 38.65 ml/kg/min in the pretest to 42.67 ml/kg/min in the posttest, indicating an average improvement of 4.02 ml/kg/min. The normality of the data was tested using the Shapiro–Wilk test.

Table 2. Normality Test

Variable	Sig.
Pretest	0.200
Posttest	0.200

Since all significance values were greater than **0.05**, the data were normally distributed and suitable for parametric testing. A paired sample t-test was conducted to determine whether the improvement in aerobic endurance was statistically significant.

Table 3. Paired Sample t-Test

Variable	Mean Difference	t-value	df	Sig. (2-tailed)
Posttest – Pretest	4.02	112.33	19	0.000

The analysis showed that the significance value was 0.000 < 0.05, indicating a statistically significant difference between pretest and

posttest scores.

Therefore, the hypothesis stating that High-Intensity Interval Training effectively improved the aerobic endurance of Karate Specialization students at PKO FIK UNIMED was accepted.

The findings demonstrated that the six-week High-Intensity Interval Training program produced a substantial improvement in maximal oxygen uptake among Karate Specialization students. This result suggested that structured interval-based training effectively enhanced the students' cardiorespiratory endurance and supported the physiological demands of karate-specific movement patterns.

The consistent gain scores across all 20 participants also indicated that the intervention was effective not only at the group level but also individually.

Discussion

The results of this study demonstrated that the High-Intensity Interval Training program significantly improved the aerobic endurance of Karate Specialization students at PKO FIK UNIMED, as indicated by the increase in the mean maximal oxygen uptake score from 38.65 ml/kg/min to 42.67 ml/kg/min, with a mean gain of 4.02 ml/kg/min. The paired sample t-test further confirmed that this improvement was statistically significant ($p < 0.05$). These findings indicate that the structured six-week HIIT intervention effectively stimulated physiological adaptations in the cardiovascular and respiratory systems, leading to improved oxygen utilization efficiency during exercise.

This finding is consistent with the study by (Wijianto, 2024), which reported that HIIT significantly improved endurance in karate athletes after a six-week intervention program.

The similarity of findings suggests that interval-based high-intensity training is highly compatible with the intermittent movement patterns and energy demands of karate. In karate, athletes repeatedly perform explosive attacks, defensive movements, and rapid repositioning, all of which require efficient aerobic recovery between bouts. Therefore, improvements in aerobic endurance directly support better training sustainability and technical execution.

The present results also support the findings of (Hadi & Yudhistira, 2023), who found that HIIT significantly enhanced anaerobic endurance, agility, and muscle power in kumite athletes. Although the previous study focused on competitive athletes, the current study extends this evidence to the university learning context, showing that HIIT is also effective among sports coaching students. This extension is important because students in coaching education programs have different training goals compared to elite athletes, emphasizing both physical development and pedagogical application.

In addition, the findings align with the systematic review and meta-analysis by Yue et al., 2025 which concluded that HIIT significantly improves aerobic and anaerobic capacity across Olympic combat sports, including karate, taekwondo, judo, and boxing. The meta-analysis emphasized that repeated exposure to high-intensity work intervals with

short recovery periods stimulates mitochondrial density, stroke volume, and peripheral oxygen extraction, which ultimately increases maximal oxygen uptake. This physiological mechanism explains the consistent increase in posttest scores observed in the present study.

From a theoretical perspective, the current findings strengthen the training adaptation theory that exercise specificity and interval density are critical determinants of aerobic development in combat sports learners. Unlike continuous endurance training, HIIT provides a stimulus pattern that closely resembles karate's intermittent nature, making the adaptation more sport-specific and functionally transferable.

The new finding of this research lies in the confirmation that HIIT is not only effective for competitive karate athletes but also highly effective for Karate Specialization students in higher education coaching programs. This leads to a practical theoretical proposition that: HIIT can be positioned as an evidence-based conditioning model for university-level karate coaching curricula to improve aerobic endurance efficiently within limited academic training time.

This proposition may serve as a new applied training framework in sports coaching education, particularly for martial arts specialization courses that require efficient physical conditioning models integrated with academic schedules.

D. Conclusion

This study concluded that the implementation of High-Intensity Interval Training significantly improved the aerobic endurance of Karate Specialization students at PKO FIK UNIMED. This conclusion was consistent with the research objective stated in the introduction, namely to provide an effective and efficient training solution for overcoming the suboptimal aerobic endurance observed among karate specialization students. The increase in the mean maximal oxygen uptake score from 38.65 ml/kg/min in the pretest to 42.67 ml/kg/min in the posttest demonstrated that the six-week interval-based training program successfully enhanced the students' cardiorespiratory capacity.

The findings also confirmed the proposed solution presented in the introduction that a structured HIIT model was more suitable than conventional endurance training for the intermittent physiological demands of karate. Therefore, the study strengthened the assumption that sport-specific interval conditioning is highly effective in improving aerobic performance within university-level martial arts education settings.

From an applied perspective, the results of this study have strong prospects for implementation in the sports coaching curriculum, particularly in karate specialization courses, as an evidence-based physical conditioning model that can be integrated into limited academic training schedules. The efficiency of the training duration and the significant physiological gains make HIIT a practical approach for lecturers, coaches, and students in improving endurance performance.

For future research development, it is recommended that further studies involve control group designs, larger sample sizes, longer intervention periods, and additional physiological variables, such as heart rate recovery, blood lactate, anaerobic capacity, and karate-specific performance outcomes. Further investigations may also explore the integration of HIIT with technical-tactical karate drills to develop a more

comprehensive and sport-specific conditioning framework for higher education coaching programs.

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F. Conflict of Interest

Author declare this article no. conflict of interest

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