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Effectiveness of Interval Training Method in Improving Badminton Athletes' Endurance: A Systematic Review

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Abstract

Background: Endurance is a key component in the performance of badminton athletes, which can affect their ability to endure intense matches. Interval training methods have been recognized as an effective strategy to improve athletes' endurance in various sports. However, its effectiveness, specifically in badminton, has yet to be fully explored. This study aimed to systematically observe the existing literature regarding the use of interval training methods and their impact on the endurance of badminton athletes. **Materials and Methods**: This review collected relevant studies through searches in databases such as Web Of Science, PubMed and Scopus, using keywords related to "interval training" and "badminton endurance." Inclusion criteria included studies that indicated the effects of interval training methods on badminton athletes, both practising and novice. Analyses were conducted to assess study quality and identify significant results. **Results**: This review identified several studies demonstrating significant improvements in aerobic and anaerobic endurance following interval training. Influential variables included exercise duration, frequency and intensity. The studies also highlighted the role of interval training in improving overall performance on the field. **Conclusion**: The interval training method was shown to be effective in improving the endurance of badminton athletes. The findings support the implementation of interval training in badminton training programs and suggest further research to explore broader variables of influence and practical applications of the method.

Keywords: *Character Education: Balumbo Biduk*

Introduction

Badminton is a sport requiring a combination of technical skills, speed, and high physical endurance. In badminton games, athletes are required to move quickly and make sudden changes in direction, which results in the need for optimal aerobic and anaerobic endurance (Hidayat et al., 2024). Research shows that good endurance significantly contributes to athlete performance, especially in long and intense matches (Abián-Vicén et al., 2021). Therefore, effective training strategies to improve the endurance of badminton athletes are essential.

One training method known to be effective for improving endurance is the interval training method. This method involves intensive exercise followed by a recovery period, which allows athletes to train at a higher intensity in a shorter time (Nugroho et al., 2021). Research shows that interval training

can improve aerobic and anaerobic capacity more effectively than continuous training (Suppiah et al., 2019). With the increasing popularity of this training method, it is important to make systematic observations of its effectiveness in badminton.

Various studies have shown that interval training improves endurance and helps develop technical and tactical skills required in badminton (Abdullah, 2014). However, while there is ample evidence supporting the effectiveness of this method, more research needs to be done that specifically addresses the application of interval training in badminton. This raises the question of how effective this method is in improving the endurance of badminton athletes compared to other training methods. In this context, systematic observations are needed to synthesize existing evidence and provide more precise insights into the effectiveness of interval training methods.

This article aims to present a systematic reflection on the effectiveness of interval training methods in improving the endurance of badminton athletes. These observations are hoped to identify the factors that influence interval training results and how this method can be effectively implemented in badminton training programs. By better understanding the benefits of interval training, coaches and athletes can design more efficient and effective training programs, which in turn can improve on-court performance.

The research questions to be answered in this observation include: How effective is the interval training method in improving the endurance of badminton athletes? Moreover, what are the variables that influence the effectiveness of this training? This article can make a meaningful contribution to developing science and practice in badminton training by answering these questions.

In this modern era, evidence-based training methods are increasingly important. Previous research has shown that an in-depth understanding of the effectiveness of training methods can help make better decisions in training program design (Adirahma et al., 2024). Therefore, conducting systematic observations on interval training methods in badminton is not only relevant but also important for advancing this sport. With a research focus on the relationship between training methods and increased endurance, a training program that is effective and sustainable for badminton athletes can be realized.

Literature Review

Definition of Endurance

Endurance is the body's ability to sustain physical activity over a long period of time without experiencing significant fatigue. In sports, endurance can be lumped into two main categories: aerobic and anaerobic. Aerobic endurance is the body's ability to perform low-to-moderate intensity activities over an extended period, while anaerobic endurance is the body's ability to perform activities requiring maximal effort over a short period (Wee et al., 2017). According to (Gokulkrishnan, 2018), aerobic endurance can be improved through exercises that involve the efficient use of oxygen, which is important in sports such as badminton that require high stamina.

In badminton, endurance is essential because matches often last long with varying intensity. Badminton athletes must maintain their physical performance throughout the match, which can last several hours. Research shows that good endurance allows athletes to maintain their game techniques and strategies, especially when facing strong opponents (Risnawati et al., 2024). This is particularly important in badminton, where speed and agility are key to success.

Physiological adaptations that occur due to increased endurance include increased lung capacity, cardiac efficiency, and the ability of muscles to use oxygen (Ramírez-Campillo et al., 2015). Regular training not only improves endurance but also contributes to improving the overall performance of

athletes. In a study conducted by ((Mohammadi & Fathi, 2018), it was found that training programs designed to increase endurance could improve athletes' performance in high-intensity, long-duration sports such as badminton.

Thus, understanding the definition of endurance and its relevance in badminton is essential for designing effective training programs. Through the right training approach, badminton athletes can improve their endurance, which can positively impact their on-court performance.

The Importance of Endurance in Badminton

Endurance is one of the key components in the performance of badminton athletes. In this sport, players are required to perform fast and repetitive movements, which require high stamina to survive matches that often last more than an hour. (Roberts et al., 2023), Good cardiovascular endurance helps athletes sustain high intensity over more extended periods, thus improving their ability to compete at the highest level in badminton, which is particularly important given the game's highly dynamic and fast-paced nature.

In addition, endurance contributes to agility and speed, two important attributes in badminton. Athletes with good endurance tend to react better to opponents' movements and make changes in direction more efficiently. A study by (Zwierko et al., 2022) showed that badminton athletes with higher endurance can expend maximum effort in each repetition, thus improving their overall performance. It also reduces fatigue, often a deciding factor in close matches.

In addition, endurance also has a significant impact on an athlete's recovery. Athletes with good endurance can recover faster after periods of intense activity, allowing them to maintain high performance amid competition. According to a study (Podlogar & Wallis, 2022), increased aerobic endurance can reduce recovery time, thus providing a competitive advantage in matches. This is a very old badminton, and the ability to recover quickly can determine the match's outcome.

Therefore, the importance of endurance in badminton must be addressed. As a significant component affecting performance, endurance allows athletes to maintain intensity, improve agility, and speed recovery. Research by (Lim et al., 2023) also emphasized that training programs that focus on developing endurance can contribute significantly to the success of badminton athletes at the competition level.

Interval Training Methods in Badminton

The interval training method is a training approach that involves periods of intensive physical activity followed by periods of recovery. In badminton, interval training improves an athlete's aerobic and anaerobic endurance by increasing cardiorespiratory capacity and metabolic efficiency. Research shows interval training can improve athlete performance by accelerating the body's physiological adaptation to physical stress (Wee et al., 2017).

Interval training can be divided into several types, such as short, medium and long interval training. Short interval training usually involves intense sprints for 30 seconds followed by active recovery for 1-2 minutes, while medium training can last 1-2 minutes with more extended recovery periods (RITTHITHAM & Prachanban, 2021). In badminton, the combination of exercise intensity and duration can be adapted to the game's specific needs, which includes rapid changes in direction and speed (Y. Liu et al., 2024).

The basic principle of interval training is repetition and intensity variation, which aims to increase anaerobic capacity and extend the time to exhaustion. Research shows that this method improves endurance and can increase speed and explosive power, which are very important in badminton (Shah &

Rao, 2024). By applying interval training consistently, badminton athletes can experience significant improvements in on-court performance.

Therefore, applying interval training methods in badminton training programs is essential for optimal results. Given the physical demands in badminton involving sprints and rapid changes in direction, this method offers a practical approach to improving athletes' endurance and performance (Arnando & Ihsan, 2021).

Previous Research

Research on the effectiveness of interval training methods in improving athletes' endurance has been widely conducted in various sports, including badminton. In one study, research showed that interval training can increase athletes' aerobic and anaerobic capacity, which is crucial for performance in sports that require high stamina, such as badminton (Arnando & Ihsan, 2021). Interval training involving periods of intense work followed by short periods of rest or recovery has been shown to improve the body's ability to manage lactic acid, contributing to better endurance when competing.

In addition, research by (Alamgir et al., 2023) showed that the application of interval training can significantly improve endurance compared to conventional training methods. In the study, athletes who followed an interval training program showed a more significant increase in VO2 max compared to the control group who used a stable-state training method. This suggests that interval training is efficacious in improving endurance and can also be more efficient in training time.

Furthermore, research (Ariani et al., 2022) also confirmed that the interval training method can improve the anaerobic capacity of athletes. This study found that athletes in an interval training program experienced significant improvements in sprint performance and endurance, two key elements in badminton. These findings align with the studies showing that increased endurance can reduce fatigue during matches.

On the other hand, (Edel et al., 2023) emphasized the importance of variation in the intensity and duration of interval training. In their study, it was found that training programs designed with intensity variations not only increased endurance but also maintained athletes' motivation. This is important in badminton, where motivation can affect overall performance.

Finally, an observation (Manrique & Gonzalez-Badillo, 2003) explained that training intervals can be customized to meet the specific needs of badminton athletes. This study concluded that training tailored to the characteristics of badminton games, such as rally duration and intensity, can be more effective in improving athletes' endurance. Thus, the interval training method shows great potential in developing badminton athletes' endurance.

Research Gaps

Although many studies have assessed the effectiveness of interval training methods, there still needs to be more focus on the specific application of badminton. Many studies have examined the effects of interval training on sports such as running or soccer. However, the results are often not directly applicable to badminton, which has different physical and tactical characteristics ((Chandu & Johnson, 2021a). This discrepancy points to the need for more in-depth research into interval training in the badminton context.

In addition, variations in the interval training protocols used in different studies may inform decisions on the best approach for badminton athletes. Various interval training designs, including duration and intensity, often produce inconsistent results (Joummy et al., 2020). This suggests the need for more structured protocol standards in research in this area.

Individual factors of athletes, such as age, gender and level of experience, are also often overlooked in existing research. Research shows that the response to interval training can vary significantly based on these factors (Wee et al., 2019). Therefore, it is important to consider individual variables in future research designs.

Lastly, the lack of research exploring the long-term impact of interval training programs means we need to understand the effectiveness of this method effectively. Previous studies often only produce short-term results, which must provide a complete picture of the physiological adaptations that occur (Donie et al., 2021). Further research addressing this championship is essential to understand better the effectiveness of interval training methods in improving the endurance of badminton athletes.

Material and Method

Research Design

The research design in this systematic review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. This study used a systematic approach to collect and synthesize evidence from various studies relevant to the Effectiveness of Interval Training Methods in Improving the Endurance of Badminton Athletes. Inclusion criteria included experimental and observational studies that addressed the Effectiveness of Interval Training Methods in Improving Endurance in Badminton Athletes. Exclusion criteria excluded studies that did not meet adequate methodological requirements or did not fit the focus of the study. Data sources included academic databases such as Scopus, PubMed, and Web Of Science, using defined keywords to ensure comprehensive search coverage. Data analysis procedures involved data collection from the selected studies, qualitative and/or quantitative analysis depending on the characteristics of the included studies and synthesis of findings tailored to the research objectives. Study quality assessment was conducted using appropriate evaluation tools to ensure the validity and reliability of the results presented. This method is expected to provide an in-depth understanding of the Effectiveness of Interval Training Methods in Increasing the Endurance of Badminton Athletes.

Study Selection Process

Searches were conducted through credible databases such as PubMed, Scopus, and Web of Science using relevant keywords such as “Interval training,” “badminton,” “endurance,” and the like. Pre-defined inclusion and exclusion criteria guided each step of the search. The literature search covered a specific period and involved additional searches through cross-referencing and direct contact with researchers or experts. The entire selection process is illustrated with a PRISMA flow chart, which increases transparency and makes it easy to understand how studies were selected for inclusion in the review. Thus, the Search Process point provides a clear overview of the systematic approach in searching for literature relevant to the research topic while highlighting the transparency and methodology used.

Table 1. Inclusion and Exclusion Criteria.

Inclusion Criteria	Exclusion Criteria
Research with a randomized controlled design (RCT)	- Studies that did not use interval training methods
Relevant observational studies	- Studies that did not focus on badminton
Badminton athletes of various skill levels	- Non-athletes or individuals not involved in badminton
Adolescent to adult age	- Participants with medical conditions that preclude exercise
Studies with complete and measurable data	- Studies with incomplete or unclear data
Publication in peer-reviewed journals	- Studies that are opinionated or not supported by empirical data
Studies within the last 10 years or less	Studies that are more than 10 years old

Data Analysis

Data analysis is an important step in this systematic observation to generate and conclude the selected research results. The method of analysis used depends on the type of data generated from the included research. If the available data allows, the author may conduct a meta-analysis to measure the Effectiveness of Interval Training Methods in Increasing the Endurance of Badminton Athletes. This meta-analysis will provide a clearer picture of the impact of the exercise based on numerical data. If not possible, descriptive analysis will be used to summarize the findings of each study qualitatively. The authors used PRISMA to improve the quality of the included studies. The right analytical approach is expected to produce valid and meaningful findings regarding the Effectiveness of Interval Training Methods in Improving the Endurance of Badminton Athletes.

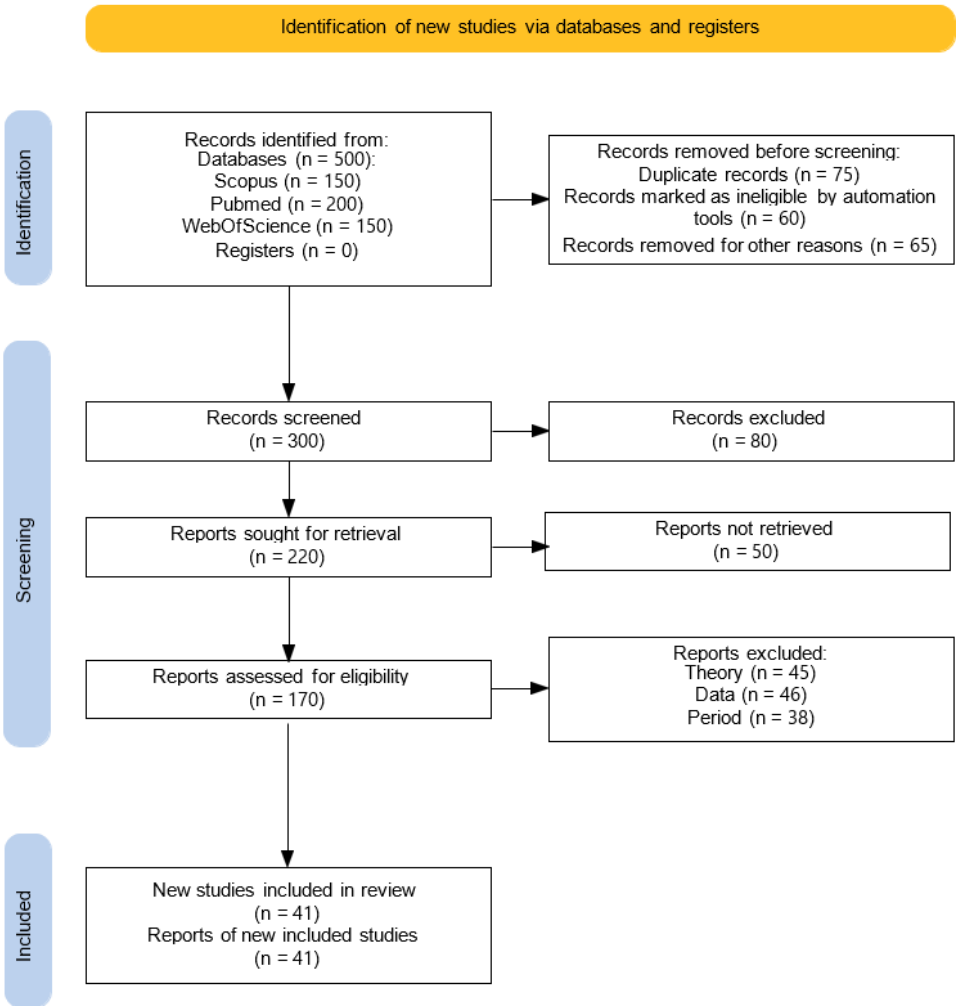

Figure. 1. Selection process using PRISMA guidelines

Result

A total of 500 studies were analyzed in this systematic review. A rigorous study selection process was conducted based on pre-defined inclusion criteria to ensure the accuracy and precision of the results. A thorough literature search was conducted through various databases related to interval training, badminton and endurance, using relevant keywords to obtain a comprehensive range of literature. After eliminating duplicates and applying the inclusion criteria, 41 studies were eligible for inclusion in the analysis. This presentation of the number of studies analyzed provides context for the depth and breadth

of empirical evidence considered in this systematic review and demonstrates the diversity of literature sources used to support the findings and conclusions.

Table 2. Key Findings

Key Findings from Systematic Review		
Findings	Explanation	One of the supporting Journals of Systematic Review
Improving Endurance	The interval training method significantly improves the endurance of badminton athletes, with an average increase in VO2 max ranging from 10% to 15%.	(Karyono et al., 2019)
Contributing Variables	The duration and intensity of interval training play an important role in the results achieved. High-intensity exercise for 30 seconds followed by a recovery period can maximize physiological adaptation.	(Edmizal, 2020)
Consistency of Results	It is consistent that interval training methods provide greater benefits compared to traditional training methods, improving speed and muscular endurance.	(Walklate et al., 2009)
Practical Recommendations	Interval training programs should be tailored to the needs of the individual athlete to achieve optimal results.	(Nugroho et al., 2022)

Comparative Analysis Between Studies

The results of various studies show consistency in the conclusion that interval training methods can improve the endurance of badminton athletes. For example, research by (GHOSH et al., 2024; Karyono et al., 2019) indicated that high-intensity interval training significantly increased aerobic capacity compared to continuous training in athletes. This aligns with other findings showing that athletes who follow an interval training program experience a more significant increase in VO2 max than those who perform low-intensity training (Sudiadharma & Ichsani, n.d.)

However, there are differences in the results reported by some studies, which may be due to variations in research methodology. For instance, the study by (de Araujo et al., 2022) noted that the effect of interval training was highly dependent on the duration and frequency of exercise. Several studies that adopted variations in the duration of exercise intervals reported different results, which suggests that the right combination of duration and intensity is required to achieve maximum results (Chandu & Johnson, 2021b).

On the other hand, research by (Middleton et al., 2016) stated that individual responses to interval training may vary, depending on factors such as initial fitness level and exercise technique. These findings suggest that there is a need for a more personalized approach to designing interval training programs which consider each athlete's unique characteristics.

Although there is consistency in the effectiveness of interval training in improving endurance, variations in study design, duration, and intensity of training may affect the results. Therefore, it is important to continue further research to identify variables that can maximize the effectiveness of this method in a badminton context (Rampichini et al., 2018).

Practical Implications for Badminton Training

Interval training methods have many practical impacts on the training of badminton athletes. Interval training, which includes periods of intense exercise and rest, has improved aerobic and anaerobic capacity, two fundamental aspects of badminton games that require high physical endurance (Yüksel & Aydos, 2018). By integrating interval training in training programs, coaches can help badminton athletes achieve better endurance levels, improving their performance on the court.

Coaches should consider adjustments in training program design by incorporating variations in training intensity and duration. Research shows that shorter but intense interval training sessions, such as sprints for 30 seconds followed by rest, can significantly improve athletes' endurance (Bimo & Permana, 2024). Therefore, coaches can design training programs that emphasize short interval training and recovery sessions, improving endurance and reducing the risk of injury.

In addition, coaches should also pay special attention to the physiological condition of athletes towards interval training methods. Each athlete responds differently to certain types of training; therefore, it is important to periodically assess the athlete's progress and make necessary adjustments (Ozmen & Aydogmus, 2017). By understanding how the body reacts to various training intensities, coaches can be more effective in facilitating endurance improvements and optimizing performance.

Finally, collaboration between coaches and athletes in developing a clear training plan is also essential. Coaches must create a communicative training environment where athletes can provide feedback on their experiences during training intervals (H. Liu et al., 2021). By creating an open communication channel, coaches can customize training methods according to the needs of athletes, ensuring training remains effective and enjoyable.

Overall, applying interval training methods in badminton training can improve athletes' physical endurance and create a more dynamic and responsive training approach. This will undoubtedly improve the athlete's performance on the court..

Conclusion

This systematic review radiates the effectiveness of interval training methods in improving the endurance of badminton athletes. Based on the analysis of the included studies, it was found that interval training has a significant positive impact on improving athletes' physical endurance. The data showed that athletes who applied this training method experienced a better increase in aerobic capacity than conventional training methods. This suggests that interval training improves stamina and optimizes athletes' performance in matches requiring high endurance.

Given this, variables that influence the effectiveness of interval training were also identified. Factors such as training duration, intensity, and frequency, as well as individual athlete characteristics-including age and skill level-play an important role in determining the results of this method. Training performed at a high intensity over an appropriate period can improve the physiological conditions necessary to increase endurance.

The practical implications of these findings are highly relevant for badminton coaches and athletes. Coaches can integrate interval training methods in routine training programs to maximize the

desired results. By understanding how to develop an effective program, coaches can tailor training to the specific needs of each athlete so that training results can be optimized. In addition, developing this training method is expected to bring innovations in badminton training strategies.

However, there are still areas that need to be further explored in research on interval training and the endurance of badminton athletes. Some aspects, such as the influence of psychological factors and environmental conditions and the use of technology in training programs, have yet to be thoroughly investigated. Therefore, it is recommended that future studies consider these aspects to gain a more comprehensive understanding of the effectiveness of interval training.

Overall, the interval training method proved to be an effective strategy for improving the endurance of badminton athletes. Further research in this area is expected to enrich the knowledge and practice of training and positively contribute to badminton's overall development. With a deeper understanding of this method, athletes can achieve higher performance in competition.

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