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The effect of nutrition on badminton athlete performance: A systematic review
El efecto de la nutrición en el rendimiento de los atletas de bádminton: Una revisión sistemática

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Abstract. Background and Goal of Study: Athletic performance results from a complex interaction between training, genetics and nutritional intake. In sports such as badminton, which demand endurance, speed and strength, nutrition plays a crucial role in supporting performance and recovery. Although nutrition is recognised as an important factor, there is limited research on the specific effects of nutrition on badminton athlete performance. This study aims to systematically analyse the existing literature on the influence of nutrition on badminton athlete performance, focusing on macronutrients, micronutrients and supplementation. Materials and Methods: This study used a systematic review approach, following PRISMA guidelines. Databases such as PubMed, Scopus, and Web of Science were reviewed for articles published from 2010 to 2023, using keywords related to nutrition and badminton. Studies that met the inclusion criteria were evaluated based on the research design, population, type of nutrition intervention, and performance measures used. Data were extracted and analysed qualitatively. Results: Of the 130 articles identified, 61 met the inclusion criteria. Findings showed that optimal carbohydrate intake, adequate hydration and nutritional timing significantly improved stamina and recovery. Supplementation with creatine and beta-alanine was also shown to improve strength and endurance performance. However, the effects of micronutrients such as vitamins and minerals were more variable and dependent on the individual's nutritional status before the intervention. Conclusion: Nutrition plays a vital role in supporting the performance of badminton athletes. Carbohydrates, adequate hydration, and certain supplements such as creatine and beta-alanine can improve performance. However, nutritional recommendations should be individualised based on the athlete's needs and goals. Further research is needed to examine micronutrient-specific effects and personalised nutrition strategies in badminton.
Keywords: Nutrition, Badminton Athlete, Systematic Review.

Resumen. Antecedentes y objetivo del estudio: El rendimiento deportivo es el resultado de una compleja interacción entre el entrenamiento, la genética y la ingesta nutricional. En deportes como el bádminton, que exigen resistencia, velocidad y fuerza, la nutrición desempeña un papel crucial en el apoyo al rendimiento y la recuperación. Aunque se reconoce que la nutrición es un factor importante, la investigación sobre los efectos específicos de la nutrición en el rendimiento de los atletas de bádminton es limitada. Este estudio pretende analizar sistemáticamente la bibliografía existente sobre la influencia de la nutrición en el rendimiento de los atletas de bádminton, centrándose en los macronutrientes, los micronutrientes y la suplementación. Materiales y métodos: Este estudio utilizó un enfoque de revisión sistemática, siguiendo las directrices PRISMA. Se revisaron bases de datos como PubMed, Scopus y Web of Science en busca de artículos publicados entre 2010 y 2023, utilizando palabras clave relacionadas con la nutrición y el bádminton. Los estudios que cumplieron los criterios de inclusión se evaluaron en función del diseño de la investigación, la población, el tipo de intervención nutricional y las medidas de rendimiento utilizadas. Los datos se extrajeron y analizaron cualitativamente. Resultados: De los 130 artículos identificados, 61 cumplieron los criterios de inclusión. Los resultados mostraron que la ingesta óptima de carbohidratos, la hidratación adecuada y el momento nutricional mejoraron significativamente la resistencia y la recuperación. También se demostró que la suplementación con creatina y beta-alanina mejoraba el rendimiento de fuerza y resistencia. Sin embargo, los efectos de micronutrientes como las vitaminas y los minerales fueron más variables y dependieron del estado nutricional del individuo antes de la intervención. Conclusiones: La nutrición desempeña un papel vital en el apoyo al rendimiento de los atletas de bádminton. Los hidratos de carbono, una hidratación adecuada y ciertos suplementos como la creatina y la beta-alanina pueden mejorar el rendimiento. Sin embargo, las recomendaciones nutricionales deben individualizarse en función de las necesidades y los objetivos del deportista. Se necesitan más investigaciones para examinar los efectos específicos de los micronutrientes y las estrategias de nutrición personalizadas en el bádminton.
Palabras clave: Nutrición, deportista de bádminton, revisión sistemática.

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Introduction

Athletic performance results from a complex combination of training, genetics and various lifestyle factors, of which nutrition plays a critical role (Sorrenti et al., 2019). Nutrition is essential in supporting recovery, increasing energy, optimising metabolic function, and preventing injury (Papadopoulou, 2020). Among sports that require endurance, strength, and speed, badminton demands specific nutritional strategies to support peak performance (Na & Kim, 2022).

However, while the importance of nutrition in sports has long been recognised, studies on the specific effects of nutrition on badminton athlete performance are limited (Abdullah et al., 2022). Existing research is often more generalised, not specifically targeting the unique needs of badminton athletes playing at a competitive level (Turğut, Bozkuş, Özmekik, & Kocakulak, 2021). Therefore, there is a need to conduct a systematic review that can identify, evaluate and synthesise the current scientific evidence on the effect of nutrition on the performance of badminton athletes.

This systematic review aims to fill this knowledge gap by exploring how nutrition affects critical aspects of badminton athlete performance, such as stamina, strength, recovery and injury prevention. Specifically, this review

aims to answer the research question: "What types of nutrition affect the performance of badminton athletes, and how?"

In reviewing the existing literature, this study focuses on various aspects of nutrition, including the intake of macronutrients (carbohydrates, proteins, and fats) and micronutrients (vitamins and minerals), as well as hydration strategies, all of which have potentially significant effects on athletic performance (Roberts, Moulding, Forbes, & Candow, 2023). Previous studies have shown that a specifically tailored diet can improve muscle work capacity, reduce fatigue, and accelerate recovery after training or competition (Evans, McClure, Koutnik, & Egan, 2022).

However, existing research gaps suggest that there needs to be more consensus regarding specific nutritional recommendations for badminton athletes. For example, while some studies emphasise the importance of carbohydrates as the primary energy source (Podlogar & Wallis, 2022). Others suggest that protein has a more critical role in supporting muscle protein synthesis and recovery (Burd, Beals, Martinez, Salvador, & Skinner, 2019). Similarly, the importance of hydration and micronutrients such as iron and vitamin D has been recognised, but their practical application in badminton still requires further investigation (Ghazzawi et al., 2023).

Through a systematic review approach, this study aims to provide a comprehensive analysis that can assist badminton coaches, nutritionists and athletes in designing effective nutritional strategies to improve performance. The aim is to identify, evaluate, and synthesise evidence from studies that have been conducted on this topic to offer reliable recommendations for players, coaches, and health professionals.

Literature Review

Introduction to Nutrition and Athletic Performance

The importance of nutrition in athletics cannot be underestimated, as it is crucial in supporting athletes' athletic performance, recovery, and general health. Proper nutrition helps athletes maximise their training potential, improve performance, reduce the risk of injury, and speed recovery (Close, Baar, Sale, & Bermon, 2019). Consumption of the right proportions of carbohydrates, proteins, fats, vitamins and minerals is essential for energy, cell growth and repair, and practical immune system function.

Carbohydrates are recognised as the primary fuel source for high-intensity exercise and competition, influencing muscle glycogen stores and energy availability during exercise (Leite & Rombaldi, 2014). On the other hand, protein is essential for post-exercise muscle recovery and repair and the synthesis of muscle proteins required for adaptation to exercise (Trommelen, Betz, & van Loon, 2019). Fat also plays a vital role as an energy source, especially during long-duration activities, demonstrating the complexity of nutrition in the context of athletic performance (Rahman, Ali, & Rahman, 2015). Vitamins and minerals, although required in smaller amounts than macronutrients, support a range of critical biological functions, including haemoglobin formation, regulation of energy metabolism, and protection against oxidative stress (Moon, Oh, & Kim, 2022). Deficiencies in these micronutrients can lead to reduced performance, fatigue and increased risk of injury (Angeline, Gee, Shindle, Warren, & Rodeo, 2013).

Nutritional strategies should be customised to meet the individual athlete's needs, considering the type of sport, intensity, duration of training, and athlete-specific goals (Guest, Horne, Vanderhout, & El-Sohemy, 2019). Comprehensive research and an in-depth understanding of the relationship between nutrition and athletic performance can assist in the development of practical nutritional recommendations and personalised nutritional strategies for athletes (Hannon et al., 2021).

Related to Nutrition in Athletes

Research on athlete nutrition is a critical area that involves essential aspects such as specific nutritional requirements, understanding of nutrition, and the impact of nutrition on athlete performance. (Karlic, Krammer, & Haslberger, 2022) Provides a comprehensive analysis of the relationship between nutrition and athletic performance, highlighting the importance of energy requirements, body composition evaluation, and nutrient and fluid requirements. This research also reviews the role of supplements and ergogenic aids that can influence athlete performance.

A study (Bird & Rushton, 2020) revealed that there needs to be more basic nutritional knowledge among elite young athletes, especially regarding dietary intake and supplementation. This suggests an urgent need for better nutrition education among athletes. (Eck & Byrd-Bredbenner, 2021) Their qualitative study found that although some athletes' eating behaviors and beliefs were in line with sports nutrition recommendations, other behaviors, such as supplement use and perceptions of processed foods, deviated from these recommendations.

Another study (Symond, Rahmi, & Rasyid, 2020) recommended the importance of evaluating the effectiveness of nutrition education on athletes' eating behaviors and the acceptability of the menus offered to them. This emphasizes the importance of education in shaping healthy eating habits among athletes. (Sasmarianto, Henjilito, Zulrafli, Kamarudin, & Nazirun, 2021) It emphasized the significance of nutritional status on athlete performance, underlining the importance of a deep understanding of nutritional needs for athletes, coaches, and sports management.

(Hull et al., 2016) discussed the role of sports nutritionists in optimizing athletes' diets and the importance of nutritional periodization, indicating the need for further research in this area. (Arazi & Hosseini, 2012) Highlighted low nutrition knowledge among Iranian collegiate athletes and its contribution to unhealthy eating patterns, indicating

the need for nutrition education interventions.

(Gao et al., 2022) highlighted the positive effects of a nutrition course on improving non-college athletes' nutrition knowledge and dietary behaviours. In conclusion, these references emphasize the importance of nutrition in athletic performance and clarify the need for more comprehensive research to improve athletes' nutritional understanding, eating habits, and overall performance. This body of literature indicates a direct correlation between good nutrition knowledge, healthy dietary practices, and improved athletic performance, strengthening the argument that nutrition education should be a key component of athlete training.

In conclusion, the literature confirms that nutrition is essential in supporting athlete performance. Adequate intake of carbohydrates, protein, hydration, micronutrients, and periodized dietary strategies are crucial elements that athletes and coaches must consider to achieve optimal performance.

Nutrition in the Context of Badminton

In badminton, nutrition supports athletes' performance, recovery, and overall health. Badminton requires a combination of speed, strength, endurance, and agility, so the nutritional needs of its athletes must be tailored to support these aspects. Below is a more in-depth discussion of nutrition in the context of badminton, accompanied by supporting citations.

1. Carbohydrates as the Main Energy Source

Carbohydrates are the primary energy source for badminton athletes, as they can be quickly converted into glucose used for fuel during high-intensity training and matches. Research shows that adequate carbohydrate consumption before, during, and after training can improve performance and speed recovery (Abián-Vicén, Bravo-Sánchez, & Abián, 2021; Firmansyah et al., 2024). Strategic carbohydrate intake is essential in badminton, where matches can last for long periods at varying intensities.

2. The Importance of Protein for Muscle Recovery and Growth

Protein plays a vital role in muscle recovery and growth, which is crucial for badminton athletes to maintain strength and prevent injury. A study by (Miyake et al., 2016) found that adequate protein consumption, especially after training, can accelerate muscle recovery and increase muscle protein synthesis, which is essential for training adaptation.

3. Hydration and Performance

Hydration is another important factor in athletic nutrition, especially in badminton. Dehydration, even at mild levels, can reduce performance and concentration and increase the risk of injury. Research by (Orrù et al., 2018) showed that optimal hydration status can maintain athletes' physical and cognitive functions, which are essential in badminton for quick decision-making and reactions to opponents.

4. Electrolytes and Energy Management

Electrolytes, such as sodium, potassium, and magnesium, play a role in many physiological processes that affect athlete performance, including muscle contraction and fluid balance. According to (Racinais et al., 2021; Ramos Espinoza, Narrea Vargas, & Castillo-Paredes, 2022) proper electrolyte intake, especially for athletes who train or compete in hot conditions, can prevent muscle cramps and maintain electrolyte balance.

5. Micronutrients and Athlete Health

Although required in smaller amounts, micronutrients, such as vitamins and minerals, play an essential role in supporting athletes' metabolic function, recovery, and immune system. Studies by (Kontele & Vassilakou, 2021) show that deficiencies in certain micronutrients can affect athletic performance and long-term health. For badminton athletes, adequate micronutrient intake is essential to support high-intensity training and recovery.

Gaps in the Literatur

Research on the effect of nutrition on athlete performance has significantly developed in the last decade. However, most studies have focused on endurance and strength sports, leaving sports with unique characteristics, such as badminton, less explored (Ng & Lam, 2002). Despite the general recognition that nutrition plays a critical role in athletic performance, the specificity of the sport of badminton needs to be improved in the existing literature. This creates a critical gap, as badminton requires a specialized combination of speed, strength, and endurance, which may require different nutritional strategies (Vicente-Salar, Santos-Sánchez, & Roche, 2020).

Furthermore, while several studies have examined the effects of carbohydrates and hydration on athletic performance, few studies have specifically targeted the effects of micronutrients such as vitamins and minerals on injury recovery and resilience among badminton athletes (Wardenaar et al., 2017). This suggests a need for more focused research on micronutrients, which could provide valuable insights into how nutrition can improve certain aspects of badminton athletes' performance.

Another gap identified is the lack of longitudinal studies that evaluate the long-term effects of nutritional interventions on badminton athletes. Most existing studies are cross-sectional or experimental with short durations, which only partially capture long-term nutritional strategies' potential benefits or side effects (Sta, Kowalski, & Krupa-kotara, 2023) This is important as long-term nutritional strategies can significantly affect athlete health and performance. Finally, there needs to be more research that integrates a multidisciplinary approach, which considers the physiological aspects of nutrition and the psychological and social factors that influence athletes' nutritional decisions and behaviors (Langan-Evans, Cronin, Hearris, Elliott-Sale, & Morton, 2022). Integrating these approaches is essential to develop nutritional recommendations that are both biologically effective and psychosocially practical and sustainable.

Related Theories and Models

In the context of research on nutrition's influence on badminton athletes' performance, various theories and models have been developed to understand the relationship between nutrient intake and physical performance enhancement. One frequently cited model is the Nutrient Periodisation Model, which suggests that athletes' nutritional intake should be adjusted based on their training cycle to maximize performance and recovery (Stellingwerff, Morton, & Burke, 2019). This model recognizes that athletes' nutritional needs change depending on their training phase, whether the preparation, competition, or recovery phase.

In addition, Metabolic Adaptation theory highlights how long-term adaptation to diets rich in specific nutrients, such as carbohydrates or fats, can affect energy metabolism and athletic performance (Burke et al., 2021). This research suggests that athletes can optimize fuel use by adapting their diet to training and competition needs.

Another relevant theory is the Nutrient Recovery Window Concept, which emphasizes the importance of timing post-exercise nutrient intake to maximize muscle protein synthesis and glycogen recovery (Hecht, Bank, Brian Cook, & Mistovich, 2023). This concept is based on evidence that there is an optimal period after exercise when the body is more efficient at absorbing and utilizing nutrients for muscle recovery and growth.

Finally, the Nutrition and Exercise Synergy Model explains how strategic combinations of nutrient intake and specific types of exercise can result in significant performance improvements (Oharomari, Ikemoto, Hwang, Koizumi, & Soya, 2021). This model suggests that integrating a targeted nutritional approach with a specifically designed exercise program can optimize physiological adaptations to exercise.

These models and theories provide a framework for understanding how nutrition can be optimized to support athletic performance. Recent research has shown that applying these principles in badminton athletes' training and nutritional management can improve performance, endurance, and recovery. Through the practical application of these theories, athletes and coaches can design more effective nutrition programs to support individual needs and training goals.

Material & Method

Research Design

The design of this study followed a systematic review approach by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The study was designed to identify, evaluate and synthesise all relevant empirical studies examining the relationship between nutritional intake and performance in badminton athletes. This approach was chosen for its ability to provide a comprehensive and objective synthesis of evidence based on predefined inclusion and exclusion criteria. The main objective of this design was to collect and analyse data from published studies to answer the specific research question of how and in what capacity nutrition affects badminton athlete performance. The research process involved systematically searching the literature in several major electronic databases and other sources, using relevant keywords and predefined search strategies. The study selection process will be conducted in stages, starting with an initial screening based on the title and abstract and then a full eligibility assessment of the full text. This approach ensures that only studies that fulfil strict criteria and are relevant to the research question will be included in the analysis.

Inclusion Criteria

Table 1.

Criteria	Description
Inclusion	Study Type: Include only randomized controlled trials (RCTs), quasi-experimental studies, and observational studies (cohort and case-control studies) that have a control group. Studies must report specific nutritional interventions and athletic performance measurements as outcomes.
	Study Population: The population should consist of badminton athletes, both professional and amateur, with no restrictions on age, gender, or level of competition.
	Nutritional Interventions: Studies that evaluate the effects of nutritional supplementation (e.g., protein, carbohydrates, electrolytes), specialized diets (e.g., increased intake of certain foods, vegetarian diets), or hydration plans. Interventions can be acute (single dose or <24 hours before performance is measured) or chronic (>24 hours, including long-term nutrition programs).
	Outcome: Outcomes should directly measure athletic performance, such as strength, speed, endurance, recovery time, or specific performance in a game or practice.
	Language: Studies published in English
	Publication Time: 2010-2023
Exclusion	Study Type: Review, meta-analisis, komentar, or relevant empirical studies.
	Study Population: Studies involving non-athletes or athletes from other sports. Studies on individuals with specific health conditions (e.g., diabetes, obesity) unless the focus is on badminton athletes with those conditions.
	Nutritional Interventions: Studies that focus on pharmacological supplementation or non-nutritional medical interventions. Studies that were not specific about the type of nutrient or did not provide details on the dosage and duration of the intervention.
	Outcome: Studies that only report physiological or nutritional biomarkers with no direct relationship to athletic performance. Studies where the outcome is only subjective perception or satisfaction without objective performance measurement.
	Data Quality: Studies with unclear methodology, incomplete data, or significant risk of bias.
	Articles that are not available in English

Study Selection Process

In the Study Selection Process, researchers applied a multi-stage strategy to ensure the selection of accurate and relevant studies. First, a literature search was conducted in reputable databases such as PubMed, Scopus, and Web of Science, using related keywords such as "badminton athlete nutrition," "badminton supplementation and performance," and "athlete diet and physical fitness." Initial screening involved reviewing study titles and abstracts to determine their eligibility based on relevance to the researchers' research questions. Studies selected through the initial screening were then examined in full text to verify the fulfilment of the strict inclusion criteria. The researchers resolved disagreements between reviewers through joint discussion or consultation with a third reviewer to reach a consensus. The entire selection process is illustrated with a PRISMA flow chart, which increases transparency and makes the selection process easier to understand.

Data Analysis

In this study, data from the selected studies will be extracted and analysed to determine the effect of nutrition on athlete performance. Information on study design, sample, type of nutrition provided, duration of intervention, and key outcomes such as improved physical performance will be collected. Qualitative analyses will be conducted to synthesise findings from different studies, assess the consistency of results, and identify patterns or relationships. For quantitative analysis, a meta-analysis will be performed if data allows, using a random effects model to accommodate heterogeneity between studies. PRISMA flowcharts will visualise the study selection and inclusion process, ensuring transparency and ease of understanding for the reader.

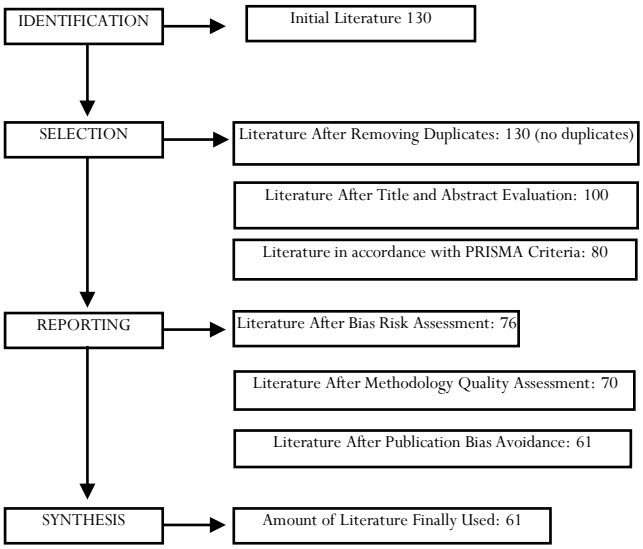

Figure 1.

Result

Research Findings

Table 2.
Findings in Research

By Type of Nutrition		
Nutrition	Result	One of the supporting Journals of Systematic Review
Carbohydrate	Carbohydrates are the primary energy source, supporting high-intensity training activities and recovery. Adequate carbohydrate consumption can increase muscle glycogen stores, which are essential for performance and endurance during badminton matches..	(Alghannam, Gonzalez, & Betts, 2018; Contreras, Perez Garcia, Ramos-Jiménez, Torres, & Chavez-Guevara, 2023)
Protein	Protein is essential for muscle recovery and muscle growth. Studies show that athletes who consume adequate amounts of protein have faster recovery and increased muscle mass, contributing to strength and endurance.	(Heaton et al., 2017)
Hydration	Fluid loss of 2% of body weight can reduce physical and cognitive performance. Adequate hydration is essential for maintaining blood volume, body temperature regulation, and muscle function.	(Dube, Gouws, & Breukelman, 2022)
Electrolytes	It is essential to maintain fluid balance and muscle function. Low electrolytes, such as sodium and potassium, can lead to fatigue, cramps, and reduced performance..	(Maughan & Shirreffs, 2019)
Vitamin dan Mineral	Micronutrients such as iron, vitamin D, and calcium play a role in energy metabolism, bone health, and muscle function. Deficiencies can lead to decreased performance and a higher risk of injury..	(Anugrah et al., 2024; Maughan & Shirreffs, 2019)
By Dosage and Time of Consumption		
Nutrition	Results	One of the supporting Journals of Systematic Review
Carbohydrate	Consumption of 30-60 grams per hour during high-intensity activity is necessary to support stamina. Carbohydrates should be consumed 3-4 hours before competition to ensure energy availability.	(Perez-Schindler, Hamilton, Moore, Baar, & Philp, 2015), (Hills & Russell, 2018)
Protein	A dose of 20-25 grams is recommended immediately post-workout to support recovery and muscle protein synthesis.	(Moore, 2019)
tra	Drinking 500ml of water two hours before physical activity is essential to ensure sufficient initial hydration.	(Bonoy, Mbame, André, Ngarsou, & Doukoya, 2022)
Electrolytes	It is essential to consume electrolytes, especially sodium and potassium, before and after exercise to replace those lost through sweating. A small amount of 500-700 mg of sodium per hour of exercise is recommended..	(Medina Corrales et al., 2020; Tiller et al., 2019)
Vitamin dan Mineral	Iron should be taken at individualized doses based on the athlete's iron status, with iron supplements of 100-200 mg per day recommended for the deficient. Vitamin D is recommended at 2000-6000 IU/day, especially during months with little sunlight. Calcium, essential for bone	(Tiller et al., 2019), (Yoon, Kwon, & Kim, 2021), (McClanahan et al., 2002)

health, is recommended at 1200-1500 mg/day.

The influence of nutrition on the performance of badminton athletes cannot be ignored. From carbohydrates acting as the primary fuel to micronutrients supporting essential physiological functions, every aspect of nutrition is critical in optimising athlete performance. Athletes need to follow a nutritional plan that is balanced and tailored to individual needs, as variations in response to nutrition can significantly affect final results. Through a holistic approach to nutrition, athletes can reach their full potential, strengthening the basis for consistent and sustainable performance.

While scientific evidence shows that nutrition plays a vital role in supporting the performance of badminton athletes, it is essential to recognise that individual needs can vary. Specific and personalised nutritional adjustments in an athlete's diet should consider age, gender, training intensity, and health conditions. A holistic approach to nutrition, which integrates scientific knowledge with a deep understanding of individual needs, will maximise an athlete's performance potential.

The dosage and timing of nutrient consumption play an essential role in maximising the performance of badminton athletes. Although the dosage and timing of nutrient consumption are based on scientific evidence, it is necessary to remember that individual needs may vary based on age, gender, training intensity, and health conditions. Therefore, an individualised approach is always recommended (Moore, Sygo, & Morton, 2022).

Given the complexity of the relationship between nutrition, dosage, timing of consumption and athletic performance, it is imperative to take a holistic and customised approach. Collaboration between the athlete, coach and sports nutritionist is crucial in designing a nutrition programme that is not only supported by scientific evidence but also tailored to the athlete's specific needs and goals. Implementing an optimised nutritional strategy, considering the correct dosage and timing of consumption, can provide a significant competitive advantage for badminton athletes.

Discussion of Findings in the Context of Previous Research

In research on the influence of nutrition on the performance of badminton athletes, different types of nutrients have been the main focus of evaluation for their effects on improving athlete performance, recovery, and health. Carbohydrates, as the primary energy source, support athlete performance by extending the duration of training and competition by maintaining optimal blood glucose levels (Moore et al., 2022). Protein is essential for muscle repair and growth and has been shown to accelerate post-exercise muscle recovery, particularly in endurance and strength sports (Demonbreun, Biersmith, & McNally, 2015). Long-term energy source fat is also essential for endurance athletes, supporting efficient energy use and maintaining a healthy body weight (Yun, Lee, & Jeong, 2020).

In addition to macronutrients, vitamins and minerals play critical roles in supporting athletes' physiological functions, including energy metabolism, muscle contraction, and recovery. For example, iron, essential for oxygen transport, can affect aerobic capacity and performance (kızıltoprak, 2021). Calcium and Vitamin D are essential for bone health, which is crucial for badminton athletes in preventing injuries (Wuyun, Hu, He, Li, & Yan, 2019).

Nutritional supplements, such as beta-alanine and creatine, have been researched for their ergogenic effects, with creatine showing improvements in repeated sprint performance and muscle strength (Glaister & Rhodes, 2022). While beta-alanine aids in improving exercise capacity by reducing muscle fatigue (Stecker, Harty, Jagim, Candow, & Kerksick, 2019).

Based on the available evidence, it is clear that nutrition significantly influences badminton athletes' performance. However, it is essential to note that the effectiveness of nutritional interventions may vary based on the athlete's individuality, including gender, age, fitness level, and training specificity. Therefore, a personalized approach to nutrition, which considers each athlete's unique needs and goals, is likely to provide the most significant benefit to improving the performance and health of badminton athletes. Recognizing the complexity of the interaction between nutrition and sports performance, further research is needed to optimize nutritional strategies for badminton athletes.

Discussion

Nutrition acts as fuel for athletes and as the foundation for recovery, adaptation to training, and, ultimately, performance enhancement. Analysis of the findings from the reviewed studies showed that proper consumption of nutrients, in terms of type, quantity, and timing, significantly impacts badminton athletes' performance. Macro-nutrients such as carbohydrates, protein, and certain micronutrients were found to contribute to improved stamina, muscle strength, and recovery time. This underlines the importance of a structured nutritional strategy in athletic training.

The interpretation of these results must be understood in the broader context of the existing literature. Previous studies have shown that nutrition is critical in endurance and strength sports. Still, its application to badminton, which requires a combination of speed, strength, and stamina, has yet to be widely explored. Therefore, our findings provide new insights suggesting that sports nutrition principles can and should be adapted to support the specific needs of badminton athletes. For example, the optimal timing of protein consumption to support muscle

protein synthesis and post-exercise recovery is particularly important, given the frequency and intensity of athletes' training.

From a practical standpoint, the implications of these findings are significant. Coaches and athletes can use this information to design more effective nutrition programmes, which focus on what is consumed and when consumed to maximise performance. This includes adjustments to daily diets and nutritional strategies before, during and after competition. For example, integrating carbohydrates with a high glycaemic index in the post-workout recovery window can accelerate muscle glycogen replenishment. At the same time, high-quality protein consumption can support muscle recovery and growth.

However, it is essential to recognise the limitations of this systematic review. One of the main limitations is the variation in the design of the studies reviewed, which includes differences in sample size, duration of nutritional interventions, and performance measurement methods used. This variability makes data synthesis challenging and may affect the strength of conclusions that can be drawn. In addition, most of the studies reviewed focused on young and healthy athlete populations, which limits the ability to generalise findings to a broader population of athletes, including master athletes or athletes with specific medical conditions.

These limitations highlight the need for further research designed with more rigour. Future studies should investigate the specific effects of certain types of nutrients on different performance parameters in a more extensive and diverse sample of badminton athletes. In addition, experimental studies with tighter control over confounding variables, such as training intensity and baseline nutritional status, will help understand the underlying mechanisms of how nutrition affects performance.

Suggestions for future research also include further exploration of how specific nutrient combinations can maximise adaptation to training and recovery. For example, studies on the timing of nutrient consumption and its interaction with exercise type may provide insights into how to optimise nutritional protocols. It is also relevant to consider individualised factors such as gender.

Conclusions

This study evaluated the influence of nutrition on the performance of badminton athletes, revealing that proper nutrition plays a significant role in improving athletes' performance and recovery. Key findings suggest that carbohydrates, protein, hydration, and certain micronutrients, such as vitamins and minerals, can improve strength, stamina, recovery, and concentration during training and matches when consumed in the right amounts and at the correct times. However, there are variations in individual responses to nutritional strategies, emphasising the importance of a customised approach.

Limitations in the data and methodology of the reviewed studies underscore the need for further research with more rigorous designs and more diverse samples. This will help strengthen the evidence on specific nutritional strategies and their effect on badminton performance.

In conclusion, this review confirms the importance of nutrition as a critical component of badminton athletes' training, leading to recommendations for evidence-based nutrition practices. This paves the way for further research to optimise nutritional strategies to support athletes' peak performance.

Reference

Abdullah, K. H., Gazali, N., Abd Aziz, F. S., Syam, E., Muzawi, R., Rio, U., … Nazirun, N. (2022). Six decades of publication performances and scientific maps on sports nutrition. *Journal Sport Area*, *7*(1), 1–22. https://doi.org/10.25299/sportarea.2022.vol7(1).8126

Abián-Vicén, J., Bravo-Sánchez, A., & Abián, P. (2021). AIR-BT, a new badminton-specific incremental easy-to-use test. *PLoS ONE*, *16*(9 September), 1–13. https://doi.org/10.1371/journal.pone.0257124

Alghannam, A. F., Gonzalez, J. T., & Betts, J. A. (2018). Restoration of muscle glycogen and functional capacity: Role of post-exercise carbohydrate and protein co-ingestion. *Nutrients*, *10*(2). https://doi.org/10.3390/nu10020253

Angeline, M. E., Gee, A. O., Shindle, M., Warren, R. F., & Rodeo, S. A. (2013). The Effects of Vitamin D Deficiency in Athletes. *The American Journal of Sports Medicine*, *41*(2), 461–464. https://doi.org/10.1177/0363546513475787

Anugrah, S. M., Kusnanik, N. W., Wahjuni, E. S., Muhammad, H. N., Sulistyarto, S., Purwanto, B., … Sari, E. (2024). Herbal Supplements That Have the Potential to Accelerate Recovery of Exercise-Induced Muscle Damage: Systematic Review. *Retos*, *51*, 840–848. https://doi.org/10.47197/RETOS.V51.100616

Arazi, H., & Hosseini, R. (2012). a Comparison of Nutritional Knowledge and Food Habits of Collegiate and Non-Collegiate Athletes. *Sportlogia*, *8*(2), 100–107. https://doi.org/10.5550/sgia.120802.en.100a

Bird, S. P., & Rushton, B. D. (2020). Nutritional knowledge of youth academy athletes. *BMC Nutrition*, *6*(1), 4–11. https://doi.org/10.1186/s40795-020-00360-9

Bonoy, L., Mbame, J.-P., André, H., Ngarsou, P., & Doukoya, J. (2022). Physical performance, haematological and behavioural parameters of five mineral water in rats. *Scientific Journal of Sport and Performance*, *2*(1), 1–8. https://doi.org/10.55860/rmek4399

Burd, N. A., Beals, J. W., Martinez, I. G., Salvador, A. F., & Skinner, S. K. (2019). Food-First Approach to Enhance the Regulation of Post-exercise Skeletal Muscle Protein Synthesis and Remodeling. *Sports*

Medicine, *49*(s1), 59–68. https://doi.org/10.1007/s40279-018-1009-y

Burke, L. M., Whitfield, J., Heikura, I. A., Ross, M. L. R., Tee, N., Forbes, S. F., … Sharma, A. P. (2021). Adaptation to a low carbohydrate high fat diet is rapid but impairs endurance exercise metabolism and performance despite enhanced glycogen availability. *Journal of Physiology*, *599*(3), 771–790. https://doi.org/10.1113/JP280221

Close, G. L., Baar, K., Sale, C., & Bermon, S. (2019). Nutrition for the prevention and treatment of injuries in track and field athletes. *International Journal of Sport Nutrition and Exercise Metabolism*, *29*(2), 189–197. https://doi.org/10.1123/ijsnem.2018-0290

Contreras, M. M., Perez Garcia, A. I., Ramos-Jiménez, A., Torres, R. P. H., & Chavez-Guevara, I. A. (2023). Applications of Maximum Fat Oxidation and FATmax in the evaluation of sports performance inendurance-athletes: a narrative review. *Retos*, *47*, 806–813. Retrieved from https://recyt.fecyt.es/index.php/retos/index

Demonbreun, A. R., Biersmith, B. H., & McNally, E. M. (2015). Membrane fusion in muscle development and repair. *Seminars in Cell & Developmental Biology*, *45*, 48–56. https://doi.org/https://doi.org/10.1016/j.semcdb.2015.10.026

Dube, A., Gouws, C., & Breukelman, G. (2022). Effects of hypohydration and fluid balance in athletes' cognitive performance: a systematic review. *African Health Sciences*, *22*(1), 367–376. https://doi.org/10.4314/ahs.v22i1.45

Eck, K. M., & Byrd-Bredbenner, C. (2021). Food choice decisions of collegiate division i athletes: A qualitative exploratory study. *Nutrients*, *13*(7), 1–10. https://doi.org/10.3390/nu13072322

Evans, M., McClure, T. S., Koutnik, A. P., & Egan, B. (2022). Exogenous Ketone Supplements in Athletic Contexts: Past, Present, and Future. In *Sports Medicine* (Vol. 52). Springer International Publishing. https://doi.org/10.1007/s40279-022-01756-2

Firmansyah, A., Prasetya, M. R. A., Al Ardha, M. A., Ayubi, N., Putro, A. B., Mutohir, T. C., … Hanief, Y. N. (2024). The Football Players on Plyometric Exercise: A Systematic Review. *Retos*, *51*, 442–448. https://doi.org/10.47197/RETOS.V51.100800

Gao, Z., Wang, S., Peng, L., Sun, L., Qiu, P., Bai, B., … Wang, Q. (2022). Comparison of the Effects of Different Forms of Nutrition Education on Adolescent Male Soccer Players. *International Journal of Environmental Research and Public Health*, *19*(21). https://doi.org/10.3390/ijerph192113803

Ghazzawi, H. A., Hussain, M. A., Raziq, K. M., Alsendi, K. K., Alaamer, R. O., Jaradat, M., … Jahrami, H. (2023). Exploring the Relationship between Micronutrients and Athletic Performance: A Comprehensive Scientific Systematic Review of the Literature in Sports Medicine. *Sports*, *11*(6). https://doi.org/10.3390/sports11060109

Glaister, M., & Rhodes, L. (2022). Short-Term Creatine Supplementation and Repeated Sprint Ability—A Systematic Review and Meta-Analysis. *International Journal of Sport Nutrition and Exercise Metabolism*, *32*(6), 491–500. https://doi.org/10.1123/ijsnem.2022-0072

Guest, N. S., Horne, J., Vanderhout, S. M., & El-Sohemy, A. (2019). Sport nutrigenomics: Personalized nutrition for athletic performance. *Frontiers in Nutrition*, *6*(February), 1–16. https://doi.org/10.3389/fnut.2019.00008

Hannon, M. P., Flueck, J. L., Gremeaux, V., Place, N., Kayser, B., & Donnelly, C. (2021). Key Nutritional Considerations for Youth Winter Sports Athletes to Optimize Growth, Maturation and Sporting Development. *Frontiers in Sports and Active Living*, *3*(January), 1–9. https://doi.org/10.3389/fspor.2021.599118

Heaton, L. E., Davis, J. K., Rawson, E. S., Nuccio, R. P., Witard, O. C., Stein, K. W., … Baker, L. B. (2017). Selected In-Season Nutritional Strategies to Enhance Recovery for Team Sport Athletes: A Practical Overview. *Sports Medicine*, *47*(11), 2201–2218. https://doi.org/10.1007/s40279-017-0759-2

Hecht, C., Bank, N., Brian Cook, & Mistovich, R. J. (2023). Nutritional Recommendations for the Young Athlete. *Journal of the Pediatric Orthopaedic Society of North America*, *5*(1), 599. https://doi.org/10.55275/jposna-2023-599

Hills, S. P., & Russell, M. (2018). Carbohydrates for soccer: A focus on skilled actions and half-time practices. *Nutrients*, *10*(1). https://doi.org/10.3390/nu10010022

Hull, M. V., Jagim, A. R., Oliver, J. M., Greenwood, M., Busteed, D. R., & Jones, M. T. (2016). Gender differences and access to a sports dietitian influence dietary habits of collegiate athletes. *Journal of the International Society of Sports Nutrition*, *13*(1). https://doi.org/10.1186/s12970-016-0149-4

Karlic, H., Krammer, U., & Haslberger, A. (2022). Nutritional supplements for athletes and personalization; a short review. *Functional Food Science*, *2*(10), 224. https://doi.org/10.31989/ffs.v2i10.993

kızıltoprak, hasan. (2021). The Evaluation of Corneal and Lenticular Parameters in Iron Deficiency Anemia. *Beyoglu Eye Journal*, *6*(3), 173–179. https://doi.org/10.14744/bej.2021.65477

Kontele, I., & Vassilakou, T. (2021). Nutritional risks among adolescent athletes with disordered eating. *Children*, *8*(8), 10–12. https://doi.org/10.3390/children8080715

Langan-Evans, C., Cronin, C., Hearris, M. A., Elliott-Sale, K. J., & Morton, J. P. (2022). Perceptions of Current Issues in Female Sport Nutrition From Elite Athletes, Practitioners, and Researchers. *Women in Sport and*

Physical Activity Journal. https://doi.org/10.1123/wspaj.2022-0004

Leite, C. F., & Rombaldi, A. J. (2014). Effect of carbohydrate intake and physical exercise on glycogen concentration. *Revista Brasileira de Cineantropometria e Desempenho Humano*, *17*(1), 62–72. https://doi.org/10.5007/1980-0037.2015v17n1p62

Maughan, R. J., & Shirreffs, S. M. (2019). Muscle Cramping During Exercise: Causes, Solutions, and Questions Remaining. *Sports Medicine*, *49*(s2), 115–124. https://doi.org/10.1007/s40279-019-01162-1

McClanahan, B. S., Ward, K. D., Vukadinovich, C., Klesges, R. C., Chitwood, L., Kinzey, S. J., … Frate, D. (2002). Bone mineral density in triathletes over a competitive season. *Journal of Sports Sciences*, *20*(6), 463–469. https://doi.org/10.1080/02640410252925134

Medina Corrales, M., Garrido Esquivel, A., Flores Cruz, M., Miranda Mendoza, F. J., García Dávila, M. Z., Hernández Cruz, G., & Naranjo Orellana, J. (2020). Utilidad de la RMSSD-Slope para cuantificación de carga interna de entrenamiento en jugadores élite de bádminton. Estudio de caso (Utility of the RMSSD-Slope for internal training load quantification in elite badminton players. Case study). *Retos*, *2041*(40), 60–66. https://doi.org/10.47197/retos.v1i40.78348

Miyake, E., Yatsunami, M., Kurabayashi, J., Teruya, K., Sekine, Y., Endo, T., … Kyung, H. J. (2016). A prospective epidemiological study of injuries in Japanese national tournament-level badminton players from junior high school to university. *Asian Journal of Sports Medicine*, *7*(1), 5–10. https://doi.org/10.5812/asjsm.29637

Moon, J. H., Oh, C. M., & Kim, H. (2022). Serotonin in the regulation of systemic energy metabolism. *Journal of Diabetes Investigation*, *13*(10), 1639–1645. https://doi.org/10.1111/jdi.13879

Moore, D. R. (2019). Maximizing Post-exercise Anabolism: The Case for Relative Protein Intakes. *Frontiers in Nutrition*, *6*(September), 1–13. https://doi.org/10.3389/fnut.2019.00147

Moore, D. R., Sygo, J., & Morton, J. P. (2022). Fuelling the female athlete: Carbohydrate and protein recommendations. *European Journal of Sport Science*, *22*(5), 684–696. https://doi.org/https://doi.org/10.1080/17461391.2021.1922508

Na, K., & Kim, T. (2022). 배드민턴 스포츠의 영양학적 효과에 대한 고찰 TT - A Study on the Nutritional Effects of Badminton Sports. 스포츠사이언스, *40*(3), 459–467. Retrieved from https://kiss.kstudy.com/Detail/Ar?key=3993884

Ng, G. Y. F., & Lam, P. C. W. (2002). A study of antagonist/agonist isokinetic work ratios of shoulder rotators in men who play badminton. *Journal of Orthopaedic and Sports Physical Therapy*, *32*(8), 399–404. https://doi.org/10.2519/jospt.2002.32.8.399

Oharomari, L. K., Ikemoto, M. J., Hwang, D. J., Koizumi, H., & Soya, H. (2021). Benefits of exercise and astaxanthin supplementation: Are there additive or synergistic effects? *Antioxidants*, *10*(6), 1–12. https://doi.org/10.3390/antiox10060870

Orrù, S., Imperlini, E., Nigro, E., Alfieri, A., Cevenini, A., Polito, R., … Mancini, A. (2018). Role of functional beverages on sport performance and recovery. *Nutrients*, *10*(10), 1–21. https://doi.org/10.3390/nu10101470

Papadopoulou, S. K. (2020). Rehabilitation nutrition for injury recovery of athletes: The role of macronutrient intake. *Nutrients*, *12*(8), 1–17. https://doi.org/10.3390/nu12082449

Perez-Schindler, J., Hamilton, D. L., Moore, D. R., Baar, K., & Philp, A. (2015). Nutritional strategies to support concurrent training. *European Journal of Sport Science*, *15*(1), 41–52. https://doi.org/https://doi.org/10.1080/17461391.2014.950345

Podlogar, T., & Wallis, G. A. (2022). New Horizons in Carbohydrate Research and Application for Endurance Athletes. *Sports Medicine*, *52*(s1), 5–23. https://doi.org/10.1007/s40279-022-01757-1

Racinais, S., Ihsan, M., Taylor, L., Cardinale, M., Adami, P. E., Alonso, J. M., … Bermon, S. (2021). Hydration and cooling in elite athletes: Relationship with performance, body mass loss and body temperatures during the Doha 2019 IAAF World Athletics Championships. *British Journal of Sports Medicine*, *55*(23), 1335–1341. https://doi.org/10.1136/bjsports-2020-103613

Rahman, S. S., Ali, M. A., & Rahman, M. N. (2015). Effects of Mixed Dietary Fats on the Distribution of Triglycerides in Different Tissues of Exercised Trained Swiss Albino Mice. *Oalib*. https://doi.org/10.4236/oalib.1102113

Ramos Espinoza, M. A., Narrea Vargas, J. J., & Castillo-Paredes, A. (2022). Nutrición y ejercicio físico, una considerable propuesta de ayuda no farmacológica ante el COVID-19. *Federación Española de Docentes de Educación Física*, *45*, 538–557. Retrieved from https://dialnet.unirioja.es/servlet/articulo?codigo=8406699

Roberts, M. D., Moulding, B., Forbes, S. C., & Candow, D. G. (2023). Evidence-based nutritional approaches to enhance exercise adaptations. *Current Opinion in Clinical Nutrition & Metabolic Care*, *26*(6). Retrieved from https://journals.lww.com/co-clinicalnutrition/fulltext/2023/11000/evidence_based_nutritional_approaches_to_enhance.5.aspx

Sasmarianto, Henjilito, R., Zulrafli, Kamarudin, & Nazirun, N. (2021). Understanding the needs of nutrition intake on athletes. *Journal Sport Area*, *6*(2), 244–253. https://doi.org/10.25299/sportarea.2021.vol6(2).65

09

Sorrenti, V., Caudullo, G., Lucignano, F., Fortinguerra, S., Zusso, M., Giusti, P., & Buriani, A. (2019). Chapter Eighteen - Personalized sports nutrition: Role of nutrients in athletic performance. In D. Barh & I. I. Ahmetov (Eds.), *Sports, Exercise, and Nutritional Genomics* (pp. 411–431). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-816193-7.00018-X

Sta, W., Kowalski, O., & Krupa-kotara, K. (2023). *The Assessment of Body Composition and Nutritional*. 1–16.

Stecker, R. A., Harty, P. S., Jagim, A. R., Candow, D. G., & Kerksick, C. M. (2019). Timing of ergogenic aids and micronutrients on muscle and exercise performance. *Journal of the International Society of Sports Nutrition*, *16*(1). https://doi.org/10.1186/s12970-019-0304-9

Stellingwerff, T., Morton, J. P., & Burke, L. M. (2019). A Framework for Periodized Nutrition for Athletics. *International Journal of Sport Nutrition and Exercise Metabolism*, *29*(2), 141–151. https://doi.org/10.1123/ijsnem.2018-0305

Symond, D., Rahmi, H., & Rasyid, R. (2020). *Effectiveness of Various Factors on Athlete Physical Fitness in Sports Centre West Sumatera, Indonesia*. (3). https://doi.org/10.4108/eai.9-10-2019.2297180

Tiller, N. B., Roberts, J. D., Beasley, L., Chapman, S., Pinto, J. M., Smith, L., … Bannock, L. (2019). International Society of Sports Nutrition Position Stand: Nutritional considerations for single-stage ultra-marathon training and racing. *Journal of the International Society of Sports Nutrition*, *16*(1). https://doi.org/10.1186/s12970-019-0312-9

Trommelen, J., Betz, M. W., & van Loon, L. J. C. (2019). The Muscle Protein Synthetic Response to Meal Ingestion Following Resistance-Type Exercise. *Sports Medicine*, *49*(2), 185–197. https://doi.org/10.1007/s40279-019-01053-5

Turğut, M. , Bozkuş, T., Özmekik, M. , & Kocakulak, Ş. (2021). Examination of Nutritional Knowledge Levels and Nutritional Attitudes of Badminton Athletes. *Pakistan Journal of Medical and Health Sciences*, *15*(12), 3550–3552. https://doi.org/10.53350/pjmhs2115123550

Vicente-Salar, N., Santos-Sánchez, G., & Roche, E. (2020). Nutritional ergogenic aids in racquet sports: A systematic review. *Nutrients*, *12*(9), 1–20. https://doi.org/10.3390/nu12092842

Wardenaar, F., Brinkmans, N., Ceelen, I., Van Rooij, B., Mensink, M., Witkamp, R., & De Vries, J. (2017). Micronutrient intakes in 553 dutch elite and sub-elite athletes: Prevalence of low and high intakes in users and non-users of nutritional supplements. *Nutrients*, *9*(2). https://doi.org/10.3390/nu9020142

Wuyun, G., Hu, Y., He, Z., Li, Y., & Yan, X. (2019). The Short Tandem Repeat of the DMT1 Gene as a Molecular Marker of Elite Long-Distance Runners. *International Journal of Genomics*, *2019*. https://doi.org/10.1155/2019/7064703

Yoon, S., Kwon, O., & Kim, J. (2021). Vitamin D in athletes: focus on physical performance and musculoskeletal injuries. *Physical Activity and Nutrition*, *25*(2), 20–25. https://doi.org/10.20463/pan.2021.0011

Yun, H.-Y., Lee, T., & Jeong, Y. (2020). High-Fat Diet Increases Fat Oxidation and Promotes Skeletal Muscle Fatty Acid Transporter Expression in Exercise-Trained Mice. *Journal of Medicinal Food*, *23*(3), 281–288. https://doi.org/10.1089/jmf.2019.4651

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