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Optimization of Agility Training Programs for Badminton Athletes: A Systematic Review

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Abstract

Background and Goal of Study: Agility plays a crucial role in the performance of badminton athletes. However, the effectiveness of agility training programs is still debated within the sporting community. This study aims to systematically review agility training programs to improve understanding of the factors that influence badminton athletes' agility and seek optimal methods to improve their performance. Improving the effectiveness of agility training programs may contribute significantly to the overall performance of badminton athletes. **Materials and Methods:** This study adopted a systematic review approach to comprehensively collect, evaluate, and synthesize data from previous studies on optimizing agility training programs for badminton athletes. Through this approach, the study aimed to identify, assess, and integrate the results of various studies conducted on agility training programs in badminton. Utilizing extensive electronic databases such as PubMed, Scopus, and Web of Science, the study employed appropriate keyword search strategies to gather relevant literature. **Results:** Analysis of badminton athletes' training needs revealed several factors influencing agility, including speed, coordination, and flexibility. Evaluating the effectiveness of existing agility training programs revealed room for improvement, particularly in tailoring to individual needs and implementing more varied and structured training methods. **Conclusion:** This study highlights the importance of a deeper understanding of the factors that influence agility and the application of appropriate training programs to improve the performance of badminton athletes. The results of this study provide a foundation for developing more effective and targeted agility training programs, which can contribute to the improved performance of badminton athletes at various levels of competition. In addition, the findings also underscore the importance of an individualized approach in designing training programs to meet each athlete's unique needs.

Keywords: *Badminton; Agility; Training Program; Systematic Review; Optimization*

Introduction

In this modern era, badminton has become one of the sports that has received great attention, both in popularity and intensity of competition. Success in badminton is determined not only by physical

strength alone but also by the level of agility possessed by athletes. Badminton is one of the sports that requires a high level of agility. In badminton, agility is the main key to victory because it allows players to produce fast and accurate movements in a short time. Recognizing the importance of this aspect, many coaches and athletes strive to optimize agility training programs. However, these efforts often need help formulating an appropriate and effective training program. Therefore, this study aims to conduct a systematic review of badminton athletes' agility training programs to identify factors that influence the effectiveness of training programs and find optimal methods to improve athletes' agility.

According to (Hojka et al., 2016), agility in sports is the ability to produce fast, accurate, and coordinated movements in rapidly changing situations. In badminton, agility includes the ability to move quickly and requires good agility, coordination, and reaction. A study by (Nugroho et al., 2022) states that agility is important in achieving excellence in badminton. This shows how vital agility development is in improving the performance of badminton athletes.

Increased interest and competition in the sport of badminton have prompted the need for improvements in agility training programs. As its popularity continues to grow, the number of badminton athletes competing at local, national, and international levels is increasing. In this increasingly fierce competitive environment, every advantage, including a better level of agility, can make a significant difference in the outcome of a match. This aligns with research by (Özmen & Aydoğmuş, 2017), which found that agility development is an important strategy in improving athletes' performance in various sports, including badminton.

However, an effective and targeted training program is required to achieve optimal agility. Unfortunately, not all agility training programs deliver the expected results. Several factors can influence the effectiveness of a training program, including program design, training intensity, movement variation, and individual athlete factors. A study (Singh, 2020) found that exercise variety and complexity are important factors that influence the improvement of athletes' agility. Therefore, it is important to systematically review the various aspects that influence agility training programs to ensure their effectiveness.

This study aims to make a significant contribution to the development of more effective badminton training programs. By analyzing the factors that influence the effectiveness of agility training programs and identifying the optimal methods to improve athletes' agility, this study can provide useful guidance for badminton coaches and athletes in developing better training programs. A study by (Sonoda et al., 2018) confirmed the importance of a scientific approach in developing sports training programs. Therefore, systematic reviews like the one conducted in this study are expected to provide a solid foundation for developing more optimal agility training programs for badminton athletes.

Literatur Review

Definition of Agility in Sport

Agility is a physical ability that combines speed, agility, coordination, and the ability to change direction efficiently and effectively. In sports, agility is an important component that determines athlete performance, especially in sports requiring rapid direction and speed changes, such as badminton (Pambudi et al., 2022). Agility relies on the speed of physical movement and involves a fast decision-making process by athletes in responding to changing situations during the game (Slamet et al., 2022).

According to (Apte et al., 2023) agility requires coordination between vision, brain, and body parts so athletes can respond quickly and accurately to stimuli. This suggests that agility involves more than just physical aspects; it also includes cognitive aspects that affect the athlete's ability to make decisions and react quickly.

Measuring agility in sports is often done through specialized tests designed to assess an athlete's ability to respond to rapidly changing situations. Tests such as the Illinois Agility Test and T-Test are commonly used to measure athlete agility in many sports, including badminton (Muthiarani et al., 2021). The results of these tests provide valuable information about an athlete's ability in aspects of agility that can be used to design appropriate training programs.

A study (Thieschäfer & Büsch, 2022) emphasized the importance of agility in all skill levels in sports, not only at the elite level but also at the beginner level. This suggests that agility is a critical component that must be developed early in an athlete's career.

On the other hand, factors such as age, gender, and general physical condition can affect an athlete's level of agility, so training programs should be individually tailored to maximize each athlete's agility potential (Pojskić et al., 2018) Therefore, a deep understanding of the principles of agility training is essential for coaches to develop agile and competitive athletes.

In a literature synthesis, (Subak et al., 2022) stated that agility is one of the best indicators of athletic success, showing a close relationship between agility ability and overall athletic performance. This confirms the importance of research and development of training programs that improve athletes' agility.

The Role of Agility in Badminton

Agility is one of the key physical aspects that affect the performance of badminton athletes. In badminton, agility is the athlete's ability to make quick and efficient changes in direction without losing speed, balance, or control (Gusliandi et al., 2020). This ability is crucial given the dynamics of badminton games that require quick responses to opponent attacks and the ability to maneuver quickly on the court—asserted that agility affects athletes' movement speed and their ability to make tactical decisions during matches (Wijayanti et al., 2021).

Furthermore, agility directly contributes to techniques and strategies in badminton games. Athletes with high agility can implement game strategies more effectively, such as a powerful smash, an accurate drop shot, or a tactical lob, because they can position themselves better in less time (Solanki & Gill, 2021). Agility allows athletes to adapt and react to rapidly changing game situations, thus increasing variability and uniqueness in their play. (Kuo et al., 2022) noted that this adaptability is an important factor in achieving higher levels of competition.

Research on professional badminton athletes showed that those who followed a structured agility training program showed significant improvements in their game performance, including speed, accuracy, and efficiency of movement (Hu & Wang, 2023). Training programs designed to improve agility can assist athletes in developing the ability to change direction quickly and maintain balance, which are key elements in badminton matches. (Makhlouf et al., 2018) Found that agility training significantly improved athletes' reaction speed and maneuverability on the court.

Agility is also closely related to strategic success in matches. A study by (Flaviani et al., 2023) showed that badminton athletes with higher levels of agility tended to make smarter game decisions and more accurate technique execution than those with lower levels of agility. This suggests that agility affects not only the physical aspects of the game but also the cognitive aspects, including decision-making and information processing during the game (Farisi, 2018).

Thus, the importance of agility in badminton must be considered. Athletes who want to improve their performance should consider integrating agility training regularly into their training program. As shown by (Young et al., 2015), training programs that target agility enhancement can make a significant

difference in athletes' performance, not only in movement speed and efficiency but also in the strategic and cognitive aspects of the game.

Factors Affecting the Agility of Badminton Athletes

Various factors, including physical, psychological, and environmental factors, influence badminton athletes' agility. An in-depth understanding of these factors is essential for developing effective training programs and improving athlete performance.

Physical factors play an essential role in determining an athlete's agility level. As one of the main components, strength directly affects an athlete's ability to perform fast and powerful movements on the field. According to (Lam et al., 2018), increasing muscle strength can significantly improve an athlete's agility performance, showing a positive correlation between muscle strength and agility. Flexibility also contributes to agility, allowing athletes to perform a broader and more efficient range of movements. (Yilmaz, 2022) regular flexibility training increases the range of motion, essential in achieving optimal positioning when playing badminton. Static and dynamic balance is essential for maintaining body stability and control during matches, facilitating quick and accurate transitions between movements (Ayuningtyas et al., 2021).

From a psychological perspective, motivation plays a vital role in encouraging athletes to achieve and maintain high levels of agility. According to (Mohammadi & Fathi, 2018), intrinsic motivation is associated with increased consistency and intensity in training, which is crucial for agility development. Concentration and mental resilience allow athletes to stay focused during changing match conditions and deal better with pressure, indirectly supporting increased agility (Burhaein et al., 2020).

Environmental factors, including adequate training facilities, support from coaches, and training program design, play a key role in optimizing badminton athletes' agility. Well-equipped and high-quality training facilities support the implementation of various specific exercises needed to improve agility (Putra & Lumintuarso, 2020). Coach support is essential in technical aspects, motivation, and developing appropriate mental strategies for athletes (Zaker & Parnabas, 2018). Scientifically designed and specific training programs for badminton are essential to develop targeted agility, according to a study conducted by (Martini et al., 2022), which emphasizes the importance of individualization in training programs.

Previous Studies on Agility Training Programs in Badminton

This research delved into various sources and literature that have explored the effect of agility training programs on the performance of badminton athletes. This approach identified effective training methodologies and highlighted gaps in existing research as a foundation for developing the current study.

Previous studies on agility training programs in badminton have explored various methods and approaches to improve athletes' agility. One frequently used form of training is coordination training, designed to enhance athletes' ability to control their body movements with precision and efficiency. These exercises often involve complex and repetitive movement patterns, such as footwork drills, shuttle run drills, and agility ladder drills. According to Research (Junior et al., 2017), coordination drills are an important component in training programs to improve the agility of badminton athletes as they help improve reaction speed, motor coordination, and movement control. This suggests that coordination training plays a crucial role in preparing badminton athletes for the fast and dynamic demands of the game.

In addition, strength training is also an integral part of a badminton athlete's agility training program. Strength training helps improve joint stability and muscle control, both critical to achieving optimal agility in the game. These exercises may include bodyweight exercises, additional weight, and balance exercises. A study by (Dong et al., 2018) found that strength training integrated with agility

training can significantly improve agility and balance in badminton athletes. This suggests that a combination of agility and strength training can provide optimal results in improving athlete performance.

In addition to coordination and strength training, plyometric exercises are often used in agility training programs for badminton athletes. Plyometric exercises aim to increase skeletal muscle strength and muscle contraction speed through explosiveness movements, such as jumps, jumps, and kicks. According to (Nugroho et al., 2022), plyometric training can improve the ability of badminton athletes to produce strength and speed of movement in dynamic game situations. This suggests that plyometric training can be a valuable addition to an agility training program to improve the performance of badminton athletes.

In addition to direct training to improve agility, psychological factors must be considered in training programs. Mental exercises like visualization and meditation can help athletes improve their focus, mental resilience, and emotional control during matches. A study (Erol, 2022) showed that mental training integrated with physical training can improve badminton athletes' mental agility, which can affect their performance on the court. Therefore, in designing an optimal agility training program, it is also important to consider the psychological aspects.

In developing an agility training program for badminton athletes, it is important to consider the various factors influencing agility, including coordination training, strength, plyometrics, and psychological aspects. Integrating all these elements in a training program can help achieve optimal agility and improve the overall performance of badminton athletes; this study seeks to fill a gap in the literature and contribute new insights towards developing more effective training programs.

Methods

Research Design

This study adopted a systematic review approach to comprehensively collect, evaluate, and synthesize data from previous studies on optimizing agility training programs for badminton athletes. Through this approach, the study aimed to identify, assess, and integrate the results of various studies conducted on agility training programs in badminton. By utilizing extensive electronic databases such as PubMed, Scopus, and Web of Science, the study employed appropriate keyword search strategies to gather relevant literature. This approach enabled the research to gain a more in-depth and systematic understanding of the effectiveness of various agility training methods, taking into account the quality and relevance of related studies. Through qualitative data analysis, this study aims to offer evidence-based recommendations to improve agility training programs for badminton athletes.

Study Selection Criteria

At this stage, the research will set inclusion and exclusion criteria to ensure the selection of studies that match the research focus. These criteria include study focus, population, language, publication timeframe, and quality of methods to optimize badminton athletes' agility programs.

Tabel 1. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Focus of Study	Only studies explicitly focus on developing, implementing, or evaluating agility training programs for badminton athletes. This includes research on the effects of agility training on performance, training methods, and comparisons between different types of agility training.	Studies that focus not directly on agility in badminton athletes, such as studies that focus only on aspects of general health, nutrition, or psychology without specifically linking them to agility or athletic performance.
Population	Studies involving professional and semi-professional badminton athletes of all ages and genders. Studies must provide sufficient demographic details of the sample under study.	Studies focusing on novice, amateur, or non-athlete athletes will be excluded to ensure that the review findings apply to professional or semi-professional athletic contexts.
Language	Articles published in English or a relevant local language, provided that an English abstract is available to facilitate the review process.	Articles that are not in English
Year of Publication	Articles published in the last 9 years (2015-2024)	Articles published more than 9 years ago
Methodological Quality	Articles with good methodological quality	Articles with low methodological quality or a high risk of bias may be excluded to ensure the validity of the research results.

The selection of studies based on the above criteria aimed to ensure that this systematic review produced a synthesis of the most relevant and high-quality evidence regarding optimizing agility training programs for badminton athletes. This rigorous selection process is important to build a solid evidence base for future training recommendations.

Data Search Strategy

A systematic search strategy was key in conducting a systematic review on optimizing agility training programs for badminton athletes. Firstly, major electronic databases such as PubMed, Scopus, Web of Science, and Science Direct were identified as the main sources of information for the literature search. The next step was to develop a list of relevant keywords and phrases based on the research topic. Boolean techniques were used to combine keywords and expand the search scope. After that, an initial search was conducted to assess the volume and relevance of the available literature, followed by filtering the search results by title and abstract to determine relevance to the research objectives. Full-text downloading and screening of the selected studies was conducted, followed by specialized software reference management. A search update plan was also developed to ensure up-to-date literature searches. This structured and transparent search strategy ensured comprehensive and relevant literature coverage, which provided the foundation for an in-depth analysis of the optimization of badminton athletes' agility training programs.

Data Analysis

In the data analysis using the PRISMA method, this study started with study identification through a predefined database search, following specific keywords to collect relevant literature on optimizing agility training programs for badminton athletes. After an initial screening process based on the title and abstract, studies that met the inclusion criteria were fully reviewed. Two researchers worked independently on data selection and extraction to ensure accuracy and reduce bias. Next, qualitative analyses were conducted to synthesize data from the selected studies, highlighting key themes, similarities, and differences. This process included the creation of a detailed PRISMA flow chart, visualizing the study selection process, the number of articles screened at each stage, and reasons for exclusion, leading to a better understanding of the existing data and identifying research gaps for future studies.

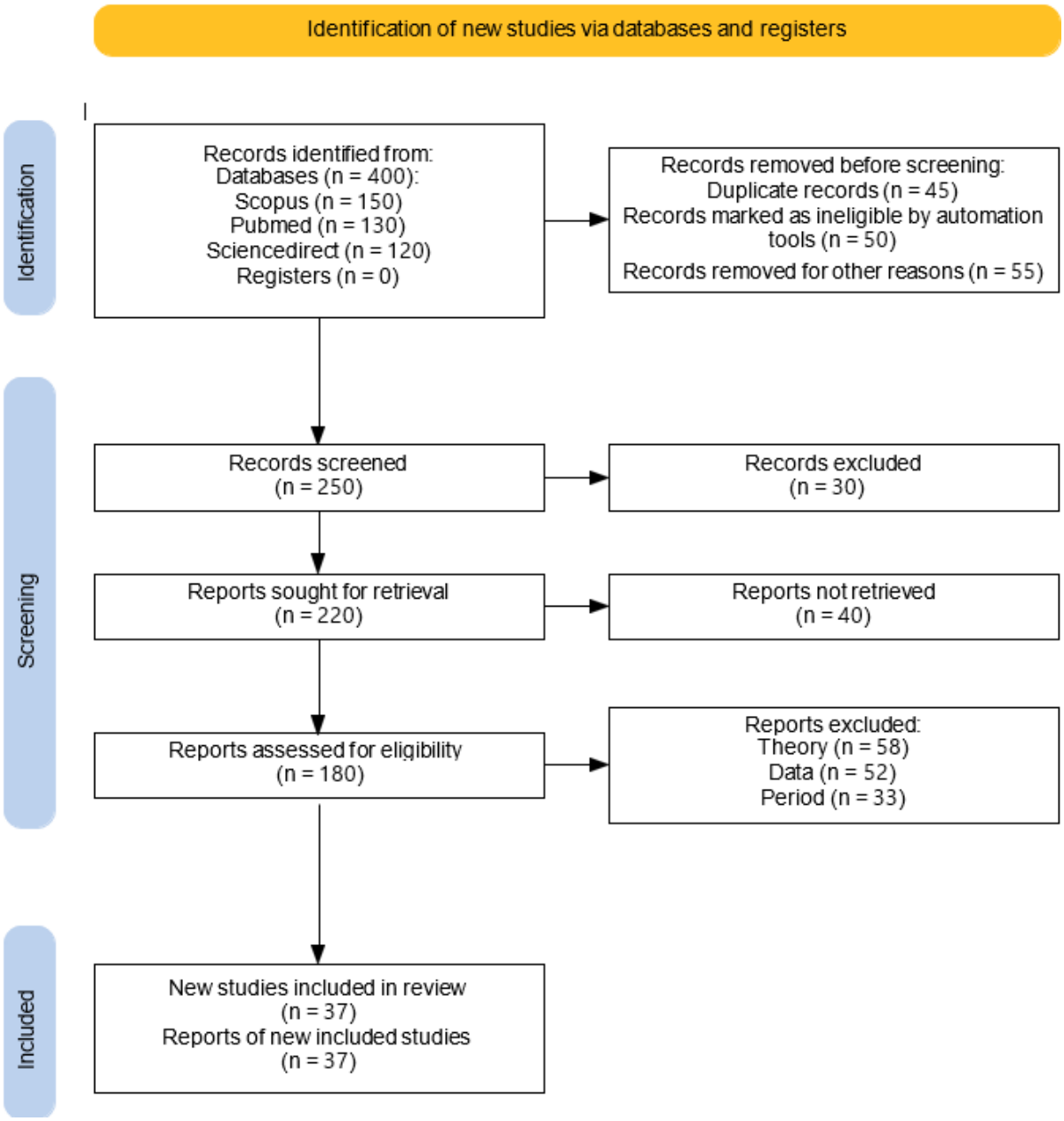

Figure. 1. Selection process using PRISMA guidelines

Results

Research Findings

The literature included reputable scientific journals, research books, and conference documents relevant to badminton athletes' agility training programs. These sources were selected based on the quality of the research methodology, the accuracy of the data, and their relevance to the focus of the study.

Table 2. Findings in the Research

Key Findings from Systematic Review		
Findings	One of the supporting Journals of Systematic Review	Explanation
Initial analysis of the athlete's needs.	(Ihsan et al., 2024)	The training needs of badminton athletes are very diverse, including physical, technical, and mental aspects. To achieve optimal performance in badminton, a well-rounded workout that covers various aspects of skill and physical condition is required.
Evaluation of the training program.	(Liu et al., 2020)	There needs to be a significant gap in its effectiveness, especially in agility development. The importance of agility training in badminton has been widely recognized, but there is still a need to optimize the training methods used to develop agility.
Statistical analysis of athlete performance.	(Jaworski et al., 2020)	Significant improvements in various aspects of agility following an optimized training program. Focused and structured agility training can improve badminton athletes' reaction time, movement speed, and coordination.
Feedback from athletes and coaches.	(Jaworski et al., 2020)	Feedback from athletes and coaches also made a valuable contribution to the understanding of the effectiveness of the Exercise program. Most athletes reported significant improvements in agility skills and overall performance.

Based on these findings, it is recommended that badminton athletes' agility training programs be more focused and structured, with an emphasis on exercises that are specific and relevant to the demands of the sport. Additional steps should also be taken to ensure that training programs consider individual needs and are responsive to athletes' ongoing feedback.

Gaps in the Current Exercise Programs

Training programs that tend to be monotonous can lead to boredom and decreased athlete motivation. When athletes become accustomed to a certain type of training, their adaptability is hampered. Therefore, it is important to identify deficiencies in the various exercises currently provided.

Each athlete has different needs and skill levels. Gaps in the current training program may be related to more customization or differentiation in training to meet individual needs. For example, athletes with different skill levels may require a different focus in training.

Badminton involves physical aspects such as speed and agility and requires high technical skills. The gap in training programs may lie in more integration between physical and technical training. This may result in athletes needing help to apply the skills acquired in training to matches.

An effective training program requires constant monitoring and constructive feedback from the coach. The lack of effective monitoring and feedback mechanisms may result in athletes being unable to improve and optimize their performance.

In addition to physical and technical aspects, agility in badminton is also related to psychological factors such as concentration, mental resilience, and stress management. Gaps in training programs may lie in the need for more attention to developing athletes' psychological aspects.

By understanding and identifying the gaps in current training programs, this study can provide valuable insights to develop more holistic and effective training programs to improve badminton athletes' agility.

Discussion

Correlation between Factors Affecting Agility and Training Programs

The correlation between factors affecting agility and training programs is one of the key aspects to consider in research on optimizing badminton athletes' training programs. In this discussion, we will explore the relationship between factors such as physical fitness, playing techniques, and mental stability and the effectiveness of training programs.

Physical fitness, such as strength, speed, and flexibility, can provide a strong foundation for developing athlete agility. Training programs focusing on improving these aspects are expected to influence agility levels directly. However, it is important to evaluate the extent to which training programs can integrate exercises that suit the physical needs of badminton athletes.

Furthermore, game technique factors such as stroke skills, movement coordination, and strategy in play can also affect agility. The discussion will cover the extent to which training programs pay attention to these technical aspects and how their implementation on the court can effectively improve agility.

Finally, mental stability, including concentration, motivation, and stress management, is important in an athlete's agility. Evaluation of the extent to which training programs assist in developing athletes' mental aspects will be an important part of this discussion.

Considering the complex interactions between these factors, this discussion will provide a deep insight into how training programs can be optimized to achieve maximum agility in badminton athletes.

Evaluation of the Effectiveness of Existing Exercise Programs

In evaluating the effectiveness of existing training programs, this study critically reviewed the success of existing training programs in improving agility in badminton athletes. The analysis was conducted by considering factors influencing agility, such as training technique, intensity, duration, and variety of training. In this context, the research findings highlighted the training program's success in addressing key aspects that affect agility but also identified some weaknesses that need improvement.

Specifically, the research found that training programs focused more on developing strength and reaction speed tended to be more effective in improving agility than programs focused solely on basic technique. Nonetheless, the evaluation also revealed that some athletes might need help adjusting to the training program's high training intensity or lack of variety. Therefore, suggestions for the development of the training program include: 1) Adjusting the intensity, 2) Increasing the variety of exercises, 3) Emphasizing training techniques that strengthen specific aspects of agility.

This evaluation provides valuable insights for coaches and trainers in tailoring training programs to maximize the potential of badminton athletes to achieve optimal agility.

Implications of Results for Building an Optimal Exercise Programs

The implications of the results for the development of optimal training programs are crucial in improving and enhancing the quality of training programs for badminton athletes. Based on the findings from this study, several aspects can be highlighted to guide the development of more effective training programs.

Firstly, in evaluating the effectiveness of existing training programs, this study identified some weaknesses that may be present in current training programs. For example, the focus of training on certain aspects of agility may not be optimal or suited to the needs of badminton athletes. The implication is that developing a more holistic and integrated training program that includes different types of exercises to improve all aspects of agility may be required.

Secondly, the results of this study also highlight the factors that influence the agility of badminton athletes. A deep understanding of these factors is essential in constructing an optimal training program. For example, if research shows that flexibility is a key factor in achieving optimal agility, then training programs should include exercises designed to improve athletes' flexibility.

Furthermore, the implications of the research results for the construction of optimal training programs also highlight the importance of adaptation and flexibility in such programs. Developing individually tailored training programs is important based on the findings that training needs can vary between athletes. This may involve a more structured approach in assessing each athlete's needs and abilities and developing a training program tailored to their characteristics and needs.

In addition, it is also important to include periodic evaluation and adjustment in the construction of an optimal training program. Research findings may indicate that certain strategies or exercises are more effective than others or that changes may be needed over time to maintain optimal levels of agility. As such, constructing an optimal exercise program should include mechanisms to evaluate and adjust the program on an ongoing basis based on the latest findings and developments.

Overall, the results of this study provide valuable guidance for developing optimal training programs for badminton athletes. By taking into account the weaknesses of existing training programs, factors affecting agility, diverse training needs, individual adaptation, and continuous evaluation, more effective training programs that meet the needs of athletes can be developed, improving the overall performance and achievement of badminton athletes.

Comparison with Previous Research

In the comparison with previous research, we will evaluate the contribution of this study to the existing scientific literature in the context of optimising agility training programmes for badminton athletes. This study expands our understanding of the factors that influence agility as well as the effectiveness of training programmes in improving athlete performance. For example, previous research by (Wong et al., 2019) highlighted the importance of hand-eye coordination training in improving agility

in badminton athletes. However, this study adds a new dimension by considering other aspects such as flexibility, speed, and strength that also play a crucial role in agility. This enriches the scientific literature by broadening the scope of our understanding of the complexity of agility training.

In addition, this study also critically evaluates the effectiveness of existing exercise programmes, identifying their strengths and weaknesses. As suggested by (Chen et al., 2022), some exercise programmes may lack attention to certain aspects necessary to improve overall agility. In this context, this study provides additional insights by providing concrete recommendations to optimise these programmes.

As such, this study not only confirms previous findings but also goes a step further by providing a more comprehensive understanding of how training programmes can be adjusted and improved to achieve better results in developing agility in badminton athletes. By integrating these findings with previous research, we can strengthen the theoretical and practical foundation for the development of more effective training programmes.

Potential for Further Development and Application

The potential for further development and application of this research is enormous in optimizing agility training programs for badminton athletes. Firstly, the findings from this study can assist in designing more effective and targeted training programs to improve agility in badminton athletes. By analyzing the factors that influence agility and evaluating the effectiveness of existing training programs, we can identify areas for improvement and develop more efficient methods.

Furthermore, the results of this study can be used as a basis for further development in badminton sports training. By strengthening our understanding of the factors that influence agility and implementing the findings of this study, we can improve the overall quality of coaching badminton athletes. The steps taken based on this study can also help coaches and trainers develop a more individualized approach tailored to the needs of each athlete.

In addition, potential further developments also include in-depth follow-up research on certain aspects that may have yet to be fully covered in this study. For example, additional research could explore the effects of variations in training intensity or the use of technology in improving the agility of badminton athletes. Thus, this study can be a starting point for future studies that are more specific and focused on optimizing badminton athletes' agility training programs. Overall, the potential for further development and application of this research promises significant improvements in the future performance and coaching of badminton athletes.

Conclusions

In this study, we conducted a systematic review of badminton athletes' agility training programs to identify factors that influence their effectiveness and offer recommendations for further optimization. Through careful analysis, we concluded some important findings that can serve as a guide for badminton coaches, researchers, and practitioners.

In looking at the training needs of badminton athletes, we found that an effective agility training program should include aspects such as speed, agility, coordination, and quick reactions. In evaluating the effectiveness of existing training programs, we found that there is still room for improvement, especially in terms of tailoring training programs to athletes' individual needs and characteristics. These findings highlight the importance of a personalized and evidence-based approach in designing effective agility training programs.

This study contributes to building a more optimal badminton agility training program. By understanding the factors influencing agility and effective training programs, coaches and practitioners can adapt their training approaches to improve athlete performance. The importance of using scientifically proven and tested methods in designing training programs is also emphasized to ensure that the training efforts produce maximum results.

While this study provides valuable insights, some areas still require further research. For example, more research could be conducted to explore the effectiveness of the various agility training methods and better understand the individual factors influencing the response to training. In addition, further research involving long-term observation of the implementation of the recommended exercise program could provide additional insight into the long-term effectiveness of the proposed approach.

Overall, this study significantly contributed to the understanding of optimizing agility training programs for badminton athletes. By taking into account the findings we presented, badminton coaches and practitioners can take concrete steps to improve their training programs, which will positively impact athlete performance and achievement. Applying an evidence-based approach and developing our knowledge of agility training will be key to advancing the sport of badminton to greater heights.

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