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Article

Improvement Effect of Repeated Sprint and Cognitive Combined Training on Tennis Players' Performance and High Pressure Decision Making

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Abstract: This study investigates the effects of a combined repeated sprint and cognitive training program on tennis players' match performance and high-pressure decision-making. Competitive tennis requires rapid changes of direction, repeated high-intensity efforts, and the ability to make accurate tactical decisions under time pressure and psychological stress. In this intervention, athletes completed an eight-week training program integrating repeated sprint drills with structured cognitive tasks, such as decision-making simulations, attention and reaction exercises, and scenario-based problem solving. Technical indicators, physical fitness parameters, and psychological adaptability were assessed before and after the intervention using match video analysis, standardized performance tests, and decision-making evaluation tools. The results indicate that players who underwent the combined training demonstrated marked improvements in speed, agility, and on-court responsiveness, as well as enhanced quality of tactical choices in critical points. Under high-pressure situations, athletes showed higher decision-making efficiency, greater accuracy, and reduced hesitation compared with their pre-training performance. These findings suggest that coupling physical conditioning with cognitive training produces synergistic benefits that better reflect the complex demands of competitive tennis. The study highlights the necessity of integrating cognitive components into traditional conditioning programs and provides practical guidance for coaches seeking to optimize training design to improve both physical performance and decision-making under pressure.

Keywords: tennis; cognitive training; repeated sprint; decision making; sports performance; psychological adaptation

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1. Introduction

1.1. Research Background

The level of sports competition continues to advance, with athletes' performance in competitions heavily reliant on their physical capabilities. Psychological factors and decision-making abilities also play a crucial role, especially in sports like tennis, where the rhythm and strategic demands change rapidly. Athletes are required to make effective decisions under high-pressure conditions to maintain a competitive edge in dynamic scenarios. Research on repeated sprint training has demonstrated its effectiveness in enhancing speed, endurance, and explosive power, providing essential physical support for athletes. Concurrently, cognitive training aims to improve concentration, reaction speed, and decision-making accuracy when faced with stressful situations [1]. However, the integration of physical and psychological training remains underexplored. Particularly in the context of designing training models for tennis players, there is an urgent need to investigate the combined effects of repeated sprint and cognitive training

on athletes' decision-making abilities under pressure. Such research holds significant value, offering theoretical insights and practical guidance to advance the methodologies and practices in sports training, ultimately contributing to the development of more comprehensive and effective training frameworks.

1.2. Research Value

This study holds significant theoretical and practical value, focusing on the combined impact of repeated sprint training and cognitive exercises on tennis players' performance and decision-making under high-pressure conditions [1, 2]. It contributes to the enrichment of sports training theory by exploring the intricate relationship between physical and psychological aspects of athletic performance [3]. On a theoretical level, the research emphasizes the importance of integrating physical and cognitive training, advocating for comprehensive training models that address both dimensions. This approach fills a critical gap in existing training methodologies for tennis players. Practically, the findings offer valuable scientific insights for coaches, enabling them to design more effective training programs that enhance players' overall capabilities. By demonstrating clear benefits, such training equips athletes to better handle the pressures of intense matches, improving both technical execution and psychological resilience. Furthermore, the study provides guidance for training strategies in tennis and serves as a reference for other sports disciplines, fostering the advancement of sports science and its practical applications.

2. Related Concepts and Theoretical Basis

2.1. Related Concepts

2.1.1. Repeated Sprint Training

Repeated sprint training is a physical training method designed to enhance speed, explosive strength, and endurance. This approach involves structured time intervals and controlled intensity, where athletes perform multiple short, high-intensity sprints. It is widely utilized in competitive sports that demand rapid movements and quick reactions, such as tennis, basketball, and soccer. During repeated sprint training, athletes take brief rest periods between sprints, which promotes adaptation to high physical loads. This method is known to improve both anaerobic and aerobic capacities, leading to enhanced muscle strength, endurance, and overall physical performance [4]. Additionally, it contributes to better heart and lung function, as well as improved metabolic efficiency. In tennis, for instance, repeated sprint training is particularly beneficial for developing quick directional changes and rapid reactions, offering athletes a competitive edge. By incorporating repeated sprint training into tennis regimens, players can significantly enhance their performance during critical moments, underscoring the method's substantial value in high-stakes scenarios.

2.1.2. Cognitive Combined Training

Cognitive combined training is a structured method designed to enhance psychological resilience and decision-making capabilities. By applying principles derived from cognitive psychology, this approach focuses on improving information processing, attention span, and reaction speed [5, 6]. The training incorporates various forms, such as simulated match scenarios, decision-making exercises, and mental skills development. These methods are particularly effective in helping athletes manage high-pressure situations, where increased cognitive load can lead to delayed reactions and poor decision-making, ultimately impacting performance outcomes. Through consistent practice, cognitive combined training enables players to better adapt to dynamic match conditions, facilitating the rapid processing of complex information. This training also fosters a stable psychological state under stress, enhancing both accuracy and decisiveness in critical moments. In tennis, for instance, strong cognitive abilities allow players to anticipate opponents' actions, accurately judge the ball's landing point, and select optimal

response strategies. Overall, cognitive combined training is a vital component in elevating competitive performance levels across sports disciplines [7].

2.1.3. High Pressure Decision Making

High-pressure decision-making refers to the ability to make rapid judgments and choices during intense competition or challenging conditions [8]. This process involves quickly reviewing information, assessing risks, and executing strategies effectively. In sports such as tennis, players often encounter scenarios like being behind in score, facing an opponent's serve, or playing critical points that can determine the outcome of a match. The speed and accuracy of decisions in these moments have a direct impact on performance. High-pressure situations elevate cognitive demands, often leading to emotional interference and increased stress, which can result in delayed reactions or incorrect decisions. Developing the ability to make effective decisions under pressure is crucial for athletes. Training methods such as simulated high-pressure scenarios, stress management techniques, and mental skill development can help players adapt to these conditions. Consistent practice enhances their ability to navigate complex situations, boosting mental resilience, confidence, and performance during pivotal moments.

2.2. Theoretical Basis

2.2.1. Dual Task Paradigm

The dual task paradigm is a widely utilized experimental approach in the fields of sports psychology and cognitive science. It focuses on examining the cognitive load and resource allocation of individuals when they are required to perform multiple tasks simultaneously. Within the context of sports training, this paradigm integrates cognitive and physical tasks, enabling researchers to assess athletes' decision-making abilities and performance under high-pressure conditions [3, 9]. For instance, in tennis, athletes must engage in high-intensity sprinting while simultaneously making tactical decisions or interpreting their opponent's offensive strategies. This approach allows researchers to analyze key aspects such as information processing capabilities, reaction times, and the quality of decision-making in complex and dynamic environments. By observing how performance fluctuates under varying levels of pressure, the dual task paradigm provides valuable insights that can inform the design of targeted training programs. These programs aim to enhance athletes' overall abilities by addressing specific challenges encountered during competition. In particular, repeated sprint and cognitive joint training exercises based on this paradigm help athletes progressively adapt to high-pressure scenarios, ultimately improving their performance and decision-making proficiency in real-world competitive settings.

2.2.2. Yerkes–Dodson Law

The Yerkes-Dodson Law is a foundational theory that explains the relationship between pressure and sports performance. It highlights that moderate levels of pressure can enhance performance, while excessive or insufficient pressure can lead to performance deterioration. Under moderate pressure, athletes experience heightened attention and motivation, which can significantly improve their competitive performance. However, when pressure becomes overwhelming, athletes may experience anxiety and nervousness, resulting in distractions, slower reactions, and compromised decision-making and technical execution. On the other hand, insufficient pressure can lead to a lack of motivation and focus, preventing athletes from performing at their optimal level. Effective management and adjustment of pressure are essential for maximizing athletic performance. By incorporating high-pressure simulated competition environments during repeated sprinting and cognitive joint training, athletes can develop adaptability and improve their decision-making efficiency under controlled stress conditions. This approach provides a theoretical framework for designing training programs that align with the principles of the Yerkes-Dodson Law. Such programs aim to ensure athletes

maintain an optimal state during challenges and opportunities, enabling them to unlock their full potential and achieve peak performance in real-world competitions.

3. Improvement Mechanisms of Repeated Sprint Training on Physiological and Athletic Performance

3.1. Physiological Adaptation Mechanisms

Repeated sprint training exerts profound effects on the physiological adaptation mechanisms of tennis athletes by engaging them in sustained high-intensity sprint tasks. This training model enhances the adaptive functions of the cardiovascular system, leading to noticeable improvements in heart rate regulation, blood flow volume, and oxygen uptake. These changes contribute to better aerobic endurance and improved cardiopulmonary function. During high-intensity sprints, muscle fibers undergo repeated micro-damage, which stimulates repair and growth processes within muscle cells. This results in increased muscle strength and endurance, supported by higher glycogen storage in muscles and an elevated lactate threshold. Consequently, athletes experience delayed fatigue during demanding tasks, enabling them to sustain effective performance for extended periods. Additionally, high-intensity training activates the nervous system, enhancing nerve conduction speed and reaction times. This allows athletes to respond more swiftly during matches and execute tactical tasks with greater efficiency. Furthermore, repeated sprint training stimulates hormone secretion, including growth hormone and insulin-like growth factor, which play critical roles in muscle growth and repair. Overall, this training approach fosters comprehensive physiological adaptation, significantly boosting athletic performance and enabling athletes to excel in competitive environments.

3.2. Gains in Athletic Performance

Repeated sprint training significantly enhances the athletic performance of tennis players, yielding improvements across multiple dimensions. Cardiopulmonary function and muscle strength are notably elevated, contributing to greater overall endurance. This allows athletes to sustain higher energy levels throughout matches and maintain technical precision over extended periods. The training also boosts instant power output and acceleration, enabling players to achieve faster serving speeds, more agile volleying, and quicker court movements, which collectively provide a competitive edge. Additionally, the nervous system undergoes adaptation, leading to faster and more accurate reactions to dynamic competition scenarios. Tactical execution becomes more refined, as athletes can better anticipate and respond to strategic shifts during matches. On a psychological level, high-intensity training fosters a calmer demeanor under pressure, enhancing confidence and resilience. This mental fortitude supports improved decision-making during critical moments, ultimately elevating individual capabilities and positively influencing overall match performance. Athletes emerge better equipped for the demands of high-level competition.

3.3. Physiological Stability under Pressure

Physiological stability under pressure plays a crucial role in sustaining athletic performance during demanding situations. Repeated sprint training enhances cardiovascular adaptation and improves the ability of the nervous system to regulate bodily functions efficiently. This type of training strengthens heart function and optimizes blood circulation, enabling athletes to manage heart rate and blood pressure with greater precision during intense matches. As a result, physiological strain is reduced, allowing athletes to respond to sudden events with improved control and maintain consistency in technical actions. Furthermore, repeated sprint training increases lactate tolerance, which helps delay the onset of fatigue during prolonged and high-intensity rallies, ensuring sustained performance. Effective breathing techniques and psychological adjustments developed through training also contribute to reduced anxiety and tension under pressure.

[10]. Enhanced body control and quicker reaction times further support overall performance and competitiveness in high-pressure scenarios.

4. Optimization Paths of Cognitive Combined Training on Decision-Making under Pressure

4.1. Expansion of Cognitive Resources

Expansion of cognitive resources involves enhancing the ability to process information and make decisions more efficiently through targeted training. This process leads to improvements in psychological flexibility and reaction capabilities. During high-intensity activities, athletes are often required to handle substantial amounts of incoming information, necessitating rapid analysis and judgment. The effective utilization of cognitive resources becomes a critical factor in such scenarios. Cognitive combined training facilitates this expansion through various methods. Simulation training and scenario-based practice enhance the comprehension of tactical concepts, enabling athletes to process competitive information more swiftly. Structured decision training focuses on teaching athletes how to manage their attention effectively in dynamic and unpredictable situations, thereby reducing cognitive load [11–13]. Additionally, the application of mental skills, such as visualization techniques and psychological state regulation, helps athletes maintain focus and stabilize their decision-making processes. These approaches collectively improve the quality of decisions made under pressure, allowing athletes to allocate cognitive resources more effectively, thereby increasing the precision and efficiency of their technical performance. This strategic enhancement provides a significant competitive edge in high-stakes environments.

4.2. Correction of Decision Bias

Correction of decision bias involves specialized training designed to help athletes recognize and rectify incorrect tendencies during decision-making processes. This training enhances the accuracy of decisions and improves the ability to manage complex situations effectively. Under pressure, athletes may experience decision bias due to factors such as emotional fluctuations, cognitive overload, or overconfidence. These biases can lead to technical errors and a decline in performance. Cognitive combined training incorporates targeted exercises that enable athletes to identify common decision-making biases, such as over-reliance on intuitive judgments, selective attention, or tendencies toward confirmation. Through scenario simulations and real-time feedback, athletes are guided to evaluate and compare the potential outcomes of various choices. This approach enhances their ability to process and integrate information. Additionally, mental skills like self-reflection and strategic adjustments are developed, reducing unnecessary errors. As a result, decision-making becomes more consistent and accurate, enabling athletes to analyze match situations more rationally and make better choices during critical moments, ultimately leading to improved overall performance.

4.3. Neural Plasticity Mechanisms

Neural plasticity mechanisms refer to the dynamic changes in the structure and function of the nervous system that occur as a result of training and learning. These changes enable individuals to adapt effectively to new contexts and challenges. During repeated sprint and cognitive combined training, neural plasticity is significantly enhanced. High-intensity repeated sprint training stimulates the secretion of neural growth factors within the brain, which fosters the development of neural connections and promotes overall neural growth. This leads to improved efficiency in neural transmission, resulting in faster reaction times and greater precision in responses. Cognitive training further enhances the brain's ability to process information and make decisions, strengthening coordination and connectivity between different brain regions. As cognitive processes become more streamlined, athletes can utilize newly formed neural pathways with heightened efficiency, reducing decision delays and improving real-time

reactions. Neural plasticity also plays a crucial role in enhancing learning capabilities and match adaptation, enabling athletes to maintain stability and make high-quality decisions in complex competitive environments. With consistent training, the adaptive effects of the nervous system provide a stable foundation for long-term athletic development and performance improvement [14–16].

5. Synergistic Effects and Practical Strategies of Repeated Sprint and Cognitive Combined Training

5.1. Synergistic Reinforcement Mechanisms

The synergy mechanism refers to the positive and comprehensive effects arising from the interaction between repeated sprint training and cognitive joint training. By integrating these two approaches, athletes experience significant improvements in both physical capabilities and psychological resilience, leading to enhanced competitive performance. Repeated sprint training substantially boosts cardiopulmonary function and muscle strength, thereby improving endurance and explosive power, which are critical in high-intensity competitive environments. This physiological foundation provides robust support for athletes during demanding scenarios. Concurrently, cognitive training sharpens athletes' information processing abilities, decision-making speed, and accuracy, enabling them to execute tactical strategies effectively even in complex and high-pressure situations. When physical and psychological qualities are developed in tandem, athletes are better equipped to handle the multifaceted challenges of competition. They can maintain composure, operate efficiently under stress, and minimize decision-making errors caused by pressure. Over time, the synergy mechanism establishes a dynamic and reinforcing cycle, where continuous repetition and enhancement lead to a higher level of comprehensive competitiveness. This integrated approach ensures that athletes achieve optimal performance and results, as their physical and mental attributes work in harmony to meet the demands of the competitive arena.

5.2. Training Plan Design

The design of the training program should integrate the principles of repeated sprints and cognitive joint training, aiming to enhance the overall capabilities of tennis players. For physical training, repeated sprints serve as the foundation of high-intensity interval training. The training schedule can be structured to occur three times per week, with each session comprising multiple short-duration sprints designed to boost endurance, speed, and explosive power. Adequate recovery intervals must be incorporated to ensure athlete safety and optimize the effectiveness of the training. Cognitive training can be combined with situational simulations and decision-making exercises. By creating diverse competitive scenarios and tactical variations, athletes can develop their ability to respond swiftly and process information effectively under high-pressure conditions. During these sessions, video analysis and real-time feedback mechanisms play a crucial role in helping athletes identify errors in decision-making and implement corrective measures. Psychological skills training is another essential component, encompassing relaxation techniques, self-regulation strategies for maintaining focus, and methods to enhance psychological resilience and decision-making consistency during competitions. A systematic approach to training maximizes the synergy between repeated sprints and cognitive exercises, fostering improvements in athletic performance and the ability to make sound decisions under pressure. By addressing physical, cognitive, and psychological aspects comprehensively, the program aims to elevate the competitive readiness and adaptability of tennis players.

5.3. Multi-Modal Monitoring Systems

The multi-modal monitoring system represents a sophisticated framework designed to provide comprehensive evaluation and feedback for the integrated training process of repeated sprints and cognitive tasks [17, 18]. Its primary objective is to enable real-time

monitoring of athletes' performance and physiological states during training and competitions by leveraging a detailed analysis of diverse data sources. From a physiological perspective, tools such as heart rate monitors, motion capture systems, and fatigue assessment instruments are employed to continuously track athletes' physiological responses, recovery from training loads, and overall health status. This allows for an accurate assessment of training effectiveness and physical well-being. On the cognitive side, advanced decision-making analysis tools are utilized to simulate high-pressure scenarios, measuring response times and decision-making accuracy to evaluate athletes' cognitive performance under stress. By integrating physiological and cognitive data, coaches gain a holistic understanding of each athlete's adaptability and developmental needs. This enables the creation of tailored training programs that address individual requirements. Furthermore, the multi-modal monitoring system provides scientific guidance to identify potential issues and challenges, ensuring that athletes receive targeted support. Coaches can rely on this data-driven approach to conduct real-time evaluations and make necessary adjustments to training strategies, ultimately enhancing athletes' overall competitiveness and optimizing their performance in high-stakes environments.

6. Conclusion

This study demonstrates that the integration of repeated sprint and cognitive joint training significantly enhances the high-pressure decision-making abilities of tennis players. The findings highlight that this training approach not only improves physiological adaptability but also optimizes technical execution and psychological resilience. Repeated sprint training contributes to the development of endurance, speed, and explosive power, which are critical for sustaining peak performance during competitive scenarios. Concurrently, cognitive training sharpens athletes' information processing capabilities and decision-making efficiency, enabling them to navigate complex and high-pressure competition environments with greater composure and precision. These results underscore the necessity of a holistic training methodology that seamlessly combines physical conditioning with psychological preparation, offering practical training frameworks and strategic guidance tailored to the unique demands of tennis players. Looking ahead, future research should delve into the role of individual differences, such as varying training backgrounds and physiological profiles, to refine joint training protocols. By addressing these variables, training programs can be further customized to meet the diverse needs of athletes, fostering their comprehensive development and sustained competitive success. Moreover, the implementation of advanced scientific training techniques and systematic monitoring systems will empower athletes to consistently perform at their best under pressure, ultimately elevating their overall competitive capabilities and long-term achievements.

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