ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202604_9(4).0022

Tennis Performance Enhancement Through Functional Integrated Training System

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Abstract

Tennis has evolved from a sport primarily dependent on technique and tactics into a comprehensive high-intensity intermittent activity that poses comprehensive challenges to athletes' physical, psychological, and cognitive capabilities. This paper aims to construct an evidence-based integrated training theoretical framework with the dual goals of enhancing sports performance and preventing injuries, by systematically reviewing recent empirical research on tennis-specific physical training. The article first analyzes the physiological metabolism and biomechanical demands of tennis, then demonstrates the mechanisms and empirical effects of functional training methods including core training, neuromuscular training, plyometric training, high-intensity interval training, as well as scientific monitoring and periodization. The review indicates that isolated development of single physical qualities can no longer meet the demands of modern tennis competition;instead an integrated training paradigm emphasizing movement quality, neuromuscular control, kinetic chain efficiency, and sport-specific relevance. This paradigm requires training design to simulate the energy metabolism characteristics, biomechanical patterns of technical movements, and psychological cognitive stress of tennis matches, while achieving individualization and optimization through scientific periodization and multi-dimensional monitoring. This paper ultimately proposes a set of actionable functional training principles and recommendations, aiming to provide coaches, athletes, and researchers with a logically rigorous, evidence-based guidance framework to promote the scientization of tennis physical training.

Keywords

Tennis; Sports performance; Functional training; Scientific monitoring.

1. Introduction

The competitive landscape of tennis has undergone profound changes over the past three decades. Innovations in racket technology, adjustments in court characteristics, and the evolution of training concepts have collectively shaped a modern style of play characterized by faster ball speeds, longer rallies, and more extreme on-court movement [1]. This evolution has elevated athletes' physical reserves to an unprecedented level of importance. Specifically, a high-level tennis match can last more than three hours, comprising hundreds of high-intensity sprints and strokes lasting 4 to 10 seconds each, with average heart rates exceeding 80% of maximum heart rate, interspersed with approximately 20 seconds of recovery intervals [2, 3]. This high-intensity intermittent exercise pattern imposes complex and demanding requirements on athletes' anaerobic power, aerobic recovery capacity, speed, agility, and neuromuscular endurance [4].

However, compared to team sports such as soccer and basketball, the scientization and systematization of tennis physical training have lagged relatively behind. For a long time, training practices have largely relied on coaches' experiential knowledge, lacking unified empirical guidelines [1]. This situation has led to many misconceptions in training: for example, overemphasizing long-distance steady-state running to develop endurance while neglecting the intermittent high-intensity aerobic capacity required for tennis; or blindly performing heavy traditional strength training to pursue absolute strength without effectively translating it into serve speed or forehand stroke power [4, 5]. The disconnect between training content and match demands not only limits the exploration of performance potential but may also increase injury risk due to inappropriate loading and movement patterns.

In the past two decades, the sports science community has shown increasing interest in tennis-specific physical training, yielding a large number of high-quality empirical studies. These studies have explored various training methods—from core stability to functional strength, from plyometric training to neuromuscular control—and their effects on tennis players' physical fitness and sport-specific performance. However, this scattered evidence has not yet been integrated into a systematic theoretical framework, making it difficult to provide clear guidance for practitioners. Based on this, this paper systematically integrates and theoretically constructs relevant research literature, not only addressing which training methods are effective but also deeply exploring why they are effective, how to apply them most effectively, and how different methods can work synergistically. The article will start with an analysis of tennis-specific demands, take movement patterns and kinetic chain optimization as the core, and use scientific monitoring and individualized periodization as safeguards, ultimately aiming for the dual goals of maximizing sports performance and minimizing injury risk.

2. Analysis of Tennis-Specific Demands

Any effective physical training program must begin with an understanding of the essence of the sport. Training that deviates from sport-specific demands is blind and inefficient. Therefore, before discussing specific training methods, it is necessary to deconstruct the multidimensional requirements that tennis matches impose on athletes' physical systems.

2.1. Physiological Metabolic Demands

Tennis matches consist of alternating short periods of explosive exertion and relatively longer recovery periods, which determine the dual nature of its energy supply system. First, the anaerobic system dominates explosive actions. Each serve, powerful stroke, sprint, or retrieval primarily relies on the phosphagen and glycolytic systems to provide large amounts of energy in a very short time. Research shows that in a single match, athletes may perform more than 60 maximal sprints (2-5 meters) and complete hundreds of explosive strokes [2]. Therefore, athletes need to possess excellent maximal strength, explosive power, and speed. Second, the aerobic system supports continuous play and recovery. The ability to sustain matches lasting up to three hours and recover during intermissions (averaging about 20 seconds) heavily depends on the aerobic metabolic system, which is responsible for rapidly clearing anaerobic metabolites, promoting recovery, preparing for the next rally, and delaying fatigue accumulation [1]. Some scholars have pointed out that combined training incorporating high-intensity intervals is superior to sport-specific technical training alone in improving maximal oxygen uptake and anaerobic endurance, highlighting the importance of developing high-intensity aerobic capacity. Third, based on the above two points, elite tennis players must possess metabolic flexibility to switch rapidly between anaerobic and aerobic systems, and training must target both capacities while simulating their alternating pattern in match play.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202604_9(4).0022

2.2. Biomechanical and Movement Pattern Demands

The essence of tennis technical movements is the effective transmission of ground reaction forces to the racket through a coordinated kinetic chain [6]. First, the kinetic chain principle indicates that, taking the serve or forehand as an example, force generation begins with lower limb push-off, passes through the core for stabilization and rotational acceleration, transmits to the shoulder, upper arm, and forearm, and finally releases at the wrist and racket. Weakness or disruption at any link in the chain leads to force leakage, reduced efficiency, and compensatory overload on other links, increasing injury risk [6]. Second, the core musculature plays a critical role in this process, as it must maintain spinal and pelvic stability during high-speed rotation while actively participating in rotational force production, amplifying lower limb power and transmitting it to the upper limbs. Research has shown that elite junior players generally exhibit greater trunk flexor than extensor strength, indicating possible imbalances, and trunk rotational strength is significantly correlated with medicine ball throwing distance [7], directly pointing to the necessity of core training. Third, tennis movement encompasses a large amount of lateral movement, crossover steps, backward movement, and abrupt stops and starts, so training must cover the sagittal, frontal, and transverse planes. Deceleration ability is crucial for rapid direction changes, maintaining balance during strokes, and preventing lower limb injuries, yet it is often overlooked [8]. Effective deceleration depends on dynamic balance, eccentric strength, and reactive strength, and should become a training focus.

2.3. Neuromuscular and Perceptual-Cognitive Demands

High-level tennis is not only a physical contest but also a competition in neuromuscular control and decision-making speed. On one hand, plyometric actions such as serve take-off and baseline push-off rely on the stretch-shortening cycle of muscles; optimizing this cycle enhances movement explosiveness and efficiency. Research has confirmed that plyometric training can significantly improve young players' jumping height, sprint speed, and serve velocity [9]. On the other hand, good movement is not only about speed but also about moving correctly, which involves anticipating the trajectory of the incoming ball and the opponent's position and quickly initiating the most effective footwork. Interviews with coaches have categorized professional players' movement patterns into fast type, reading type, and efficient type, emphasizing the central role of perception and decision-making in movement quality [10]. Therefore, physical training cannot be completely detached from the tennis context; agility exercises incorporating decision-making elements should be designed.

2.4. Empirical Correlates of Key Performance Indicators

Training ultimately serves match performance. Large-scale studies provide evidence for the association between physical fitness indicators and competitive level. First, a study of 902 elite junior German players aged 11-16 found that serve velocity and upper limb strength were the strongest predictors of national youth rankings, with national-level players significantly outperforming regional-level players [11]. Second, vertical jump height, 5-20 meter sprint speed, and sport-specific endurance have also been shown to be highly correlated with match performance [12]. These indicators should be core components of physical testing and training effect evaluation.

In summary, tennis-specific demands constitute a multidimensional complex system. A scientific physical training system must simultaneously address these metabolic, mechanical, neurological, and cognitive challenges, and ultimately translate training effects into improvements in key performance indicators. Functional training is an ideal paradigm for addressing these challenges, as will be elaborated in the following sections.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202604_9(4).0022

3. Theoretical Foundations of Functional Training

Before discussing specific training methods, it is necessary to clarify the definition, core philosophy, and compatibility of functional training with tennis.

3.1. Definition and Core Philosophy of Functional Training

Functional training is not a fixed set of exercises but a training philosophy: training should improve an individual's ability to perform tasks safely and effectively in a specific environment [13]. For tennis players, the specific environment is the tennis court, and the tasks include rapid movement, explosive stroking, sudden stops and changes of direction, etc. Based on this philosophy, functional training emphasizes the following principles: First, movement pattern priority—training should center around fundamental human movement patterns rather than isolating individual muscles, because every action on the tennis court results from the coordination of multiple joints and muscle groups. Second, multiplanar integration—tennis occurs in the sagittal, frontal, and transverse planes, so training must encompass all planes to simulate the complexity of real matches. Third, equal emphasis on force production and force reduction—training should target both concentric contractions and place high importance on eccentric contractions and dynamic stability. Fourth, proprioception and balance—maintaining body posture under unstable or dynamic conditions is the foundation of efficient movement and precise stroking. Fifth, sport-specific relevance—all training should ultimately aim to enhance sport-specific performance, meaning that training effects should transfer to the tennis court.

This philosophy stands in stark contrast to traditional bodybuilding-style training, which often involves single-joint, single-plane exercises on fixed machines, and although it may increase muscle girth, its contribution to complex movement performance is limited [14].

3.2. Compatibility of Functional Training with Tennis

The characteristics of tennis determine the necessity of functional training. Tennis requires athletes to perform multiplanar explosive movements at high speeds, repeatedly executing high-intensity intermittent outputs. Traditional training may develop isolated physical qualities that are difficult to integrate effectively in dynamic match play [4]. Functional training, by simulating movement patterns in match play, directly optimizes neuromuscular control and improves kinetic chain efficiency, thereby enabling the transfer of physical fitness to sport-specific skills. For example, medicine ball rotational throwing exercises simulate the trunk rotational force pattern of forehand strokes or serves, simultaneously training lower limb push-off, core rotation, upper limb whip-like action, and the coordination of the entire chain—a typical characteristic of functional training.

4. Key Components of Functional Training

Functional training encompasses a variety of specific training methods. In tennis physical training, the following components are particularly important, as they are interrelated and complementary, together forming the core of an integrated training system.

4.1. Core Training

Core training is the foundation of functional training, but here the emphasis is on the function of the core in dynamic movement—resisting movement and transmitting force. First, the limitations of traditional core training are evident in early research findings that 8 weeks of core training significantly improved core endurance in intermediate tennis players but did not increase serve velocity [5]. This suggests that isolated core endurance training may be insufficient to improve complex technical movements requiring whole-body coordination, and that serve velocity improvement also requires upper and lower limb strength coordination and

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202604_9(4).0022

joint mobility. Second, anti-movement core training emphasizes the ability of the core musculature to resist external forces that would otherwise cause unintended trunk movement. A 2025 randomized controlled study showed that anti-movement core training was significantly superior to traditional dynamic core training in activating the transversus abdominis, internal and external obliques, and erector spinae, and exhibited higher neuromuscular efficiency [15], making this training more closely aligned with tennis match demands. Third, rotational explosive power training is indispensable because the core is not only a stabilizing platform but also a force amplifier. Existing research has found that trunk isokinetic rotational strength is highly correlated with medicine ball throwing distance [7]. Finally, the value of instability training lies in the fact that training on unstable surfaces can further challenge the core musculature. A 2025 analysis indicated that core training using unstable equipment was superior to traditional training on stable surfaces in improving trunk strength and sprint performance [16], an adaptation that can better transfer to sports scenarios requiring dynamic stability.

Evidence from other sports also supports the value of core training: 6 weeks of core stability training improved functional movement screen scores and trunk endurance in adult tennis players [17]; a martial arts study showed that core training significantly enhanced airborne rotational movement performance [18]; and core training in swimmers improved in-water body stability, thereby enhancing propulsion efficiency [19]. These principles are equally applicable to tennis.

4.2. Neuromuscular Training

Neuromuscular training includes plyometric training and also encompasses balance, proprioception, dynamic stability, and landing technique training, aiming to optimize communication between the brain and muscles, improving movement control efficiency and safety. First, regarding the effects of comprehensive neuromuscular training, 6 weeks of neuromuscular training safely and effectively improved speed, agility, core strength, single-leg function, and balance in competitive junior tennis players [20]. Second, critical research on training sequencing showed that scheduling neuromuscular training before sport-specific training led to significant improvements in speed, agility, countermovement jump, medicine ball throw, and serve velocity; when scheduled after sport-specific training, most indicators showed no improvement or even declined [21]. This indicates that the neuromuscular system's ability to learn and adapt is greatly diminished in a fatigued state, so high-quality neuromuscular training should be placed at the beginning of the training session when athletes are fresh. Third, for injury prevention in females, a modified FIFA 11+ neuromuscular training program significantly improved countermovement jump height and single-leg squat quality in female court sport athletes, with within-group improvements in 20-meter sprint performance [22], suggesting that incorporating such standardized protocols into training for female junior tennis players offers dual benefits of performance enhancement and injury risk reduction.

4.3. Plyometric Training

Plyometric training utilizes the stretch-shortening cycle of muscles, producing greater force and power through rapid eccentric contraction followed by explosive concentric contraction, which is crucial for all explosive actions in tennis. First, regarding comprehensive physical fitness improvement, 8 weeks of plyometric training resulted in significant improvements in countermovement jump, standing long jump, 20-meter sprint, agility test, medicine ball throw, and serve velocity in 12-13 year old tennis players [9]. Second, regarding direct improvement of serve velocity, a comparison of resistance training and plyometric training on serve velocity found that only the plyometric training group showed significant improvement, while the resistance group showed no significant change [23], indicating that developing reactive strength and rapid force production capacity is more directly effective for improving serve

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202604_9(4).0022

velocity than simply increasing maximal strength. Third, regarding improvement of change of direction and agility, plyometric training, particularly lateral and multi-directional jumping exercises, effectively enhances lower limb stiffness and lateral force production capacity, thereby improving change-of-direction performance [12].

4.4. Optimization of Warm-up Strategies

Warm-up is an integral component of training, and its quality directly determines the performance level of subsequent training or competition. On one hand, regarding the advantages of neuromuscular warm-up, an 8-week study comparing neuromuscular warm-up and dynamic warm-up in young male tennis players showed that the neuromuscular warm-up group had significantly greater improvements in key explosive power indicators such as 5-meter and 10-meter sprint, countermovement jump, overhead medicine ball throw, and serve velocity [24]. The researchers recommended using a neuromuscular warm-up lasting 20-35 minutes incorporating these elements. On the other hand, the structure of an optimized warm-up should include: (1) whole-body activities to increase heart rate and body temperature; (2) dynamic stretching and mobility exercises; (3) activation exercises targeting the core and scapular girdle; (4) neuromuscular and plyometric exercises; (5) progressively accelerated sport-specific movement exercises; (6) technical stroking exercises. This structured warm-up systematically activates athletes' physiological and psychological systems.

5. Empirical Support of Functional Training for Tennis Performance

The previous chapter outlined the key components of functional training and cited relevant research demonstrating their effectiveness in improving basic physical fitness indicators. However, the core question is: can these improvements in physical fitness truly translate into improvements in tennis technique? This chapter directly addresses this question.

5.1. Empirical Comparison Between Functional Training and Traditional Resistance Training

In terms of basic physical fitness indicators, functional training demonstrates significant advantages. A 12-week study comparing functional training and traditional training in adolescent tennis players showed that the functional training group had significantly greater improvements in indicators reflecting whole-body strength and power, such as wall squat, push-up, medicine ball throw, and standing long jump [25]. More importantly, this training approach yielded more advantageous long-term gains, possibly because traditional training encounters a neural adaptation plateau more quickly, whereas functional training continuously provides new stimuli through more complex movement patterns.

In terms of movement quality and injury prevention potential, a key benefit of functional training is the improvement of movement quality. A study comparing 12 weeks of functional training and traditional resistance training on functional movement screening in adolescent tennis players found that the functional training group showed significantly greater improvements across various indicators [26]. An 8-week study in prepubertal tennis players yielded even more striking conclusions: the functional training group showed significant improvements in all motor performance tests and functional movements; in contrast, the traditional training group showed declines in functional movements, while the control group showed no significant changes [14]. The researchers suggested that prepubertal children should prioritize developing fundamental movement patterns and correcting muscle imbalances caused by unilateral loading in tennis, rather than engaging prematurely in high-intensity, isolated muscle group strengthening [14]. For adult athletes, a study in untrained girls also found that 12 weeks of functional strength training was superior to traditional strength training in improving functional movement screen scores, flexibility, muscle strength, and power, while reducing the proportion of movement patterns associated with high injury risk [27].

5.2. Direct Transfer of Functional Training to Sport-Specific Skills

The most compelling evidence comes from the direct effects of training on tennis technique itself. Regarding hitting depth and accuracy, a study divided 18 young male players into two groups: a control group performing traditional physical training and an experimental group performing additional functional physical training. After 12 weeks, the experimental group showed significant improvements in average hitting depth and accuracy, while the control group showed only slight non-significant improvements [28]. This indicates that functional training can directly optimize the most critical output on the tennis court—hitting quality.

A study incorporating 28 randomized controlled trials concluded that functional training can enhance athletes' physical and technical performance [29].

Regarding serve velocity, plyometric training has been shown to significantly improve serve velocity [9, 23], and this indicator is one of the strongest predictors of national youth rankings [11].

Regarding movement and agility, multi-directional movement exercises and change-of-direction training within functional training can effectively improve tennis-specific movement ability, with research confirming that functional training significantly improves 5-20 meter sprint and agility test performance [12].

5.3. Application Prospects of High-Intensity Functional Training

High-intensity functional training is a high-intensity variant of functional training, typically conducted in a circuit training format combining multi-joint, whole-body movements with adjustable intensity and flexible rest intervals [30]. Its distinction from high-intensity interval training lies in high-intensity functional training's emphasis on multi-modal movements, whereas high-intensity interval training may involve only single-mode intervals [30].

In terms of efficiency and comprehensiveness, high-intensity functional training has garnered attention for its ability to simultaneously stimulate strength, endurance, power, and metabolic systems within a relatively short time. A study describing the physiological profile of high-intensity functional training athletes found that they exhibited excellent performance in peak oxygen uptake, lactate threshold, maximal anaerobic power, maximal strength, and jumping power, reflecting the comprehensive adaptations brought about by this training [31].

Regarding the influence of load selection, a 12-week high-intensity functional training study in healthy active populations compared the effects of low-load and moderate-load conditions. The results showed that both loads significantly increased lean body mass and maximal strength, but the low-load group showed greater reductions in body fat percentage [32]. This provides coaches with flexibility: if the goal is fat loss with muscle maintenance, low-load high-repetition high-intensity functional training can be prioritized; if the goal is maximal strength and muscle growth, moderate loads can be used.

Regarding integration into tennis training, high-intensity functional training can serve as an effective supplement for developing comprehensive metabolic capacity and whole-body strength endurance within tennis training. Its multi-modal movement characteristics can align with tennis-specific demands. However, high-intensity functional training typically induces high fatigue levels and should be appropriately scheduled within the training cycle to avoid conflict with key technical training or match days.

In summary, a large body of empirical research consistently demonstrates that functional training not only enhances tennis players' basic physical fitness but also directly optimizes stroke technique and on-court movement ability. The core mechanism is that, by simulating movement patterns in competition, functional training improves neuromuscular control and

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202604_9(4).0022

optimizes kinetic chain efficiency, thereby enabling the physical fitness developed in the gym to truly translate into competitive advantages on the court.

6. Implementation Safeguards for Functional Training

Even the most perfect training methodology cannot guarantee long-term success without scientific organization, monitoring, and adjustment. This chapter discusses how to integrate functional training into a long-term, dynamic, and individualized training system.

6.1. Training Periodization

Periodization refers to the process of systematically planning training variables to achieve optimal competitive condition at specific times. For tennis players, periodization is particularly complex because they need to maintain a relatively high competitive level throughout the year to cope with dense competition schedules.

First, regarding the effects of periodized training, a review indicated that periodized resistance training programs can significantly improve tennis players' strength and hitting velocity [4]. Compared to non-periodized training, periodization better coordinates the development of different physical qualities, manages fatigue, and avoids plateaus.

Second, caution regarding functional overreaching and non-functional overreaching is noteworthy. A case study of a 30-day high-intensity training period in three elite tennis players of different rankings showed that all players ultimately improved their performance, indicating functional overreaching [33]. However, the study also found that the responses of various monitored markers were inconsistent and varied more in higher-ranked players. The study emphasized that no single physiological or psychological marker reliably predicts impending non-functional overreaching, and the risk of misjudgment is high.

Third, periodization strategies recommend adopting reverse periodization or block periodization approaches, that is, focusing on developing foundational physical fitness during the preparatory period, and transitioning to blocks focused on maintaining strength, developing power, speed, and sport-specific endurance during the pre-competition and in-season periods, with training volume reduced and intensity increased, more closely aligned with competition schedules. Dedicated time for recovery and regeneration must also be arranged.

6.2. Multi-Dimensional Monitoring System

Based on the above cautionary points, establishing a multi-dimensional monitoring system is crucial for achieving individualization and precision in training.

Monitoring content should include the following aspects. First, performance indicators: regularly test key performance indicators such as serve velocity, vertical jump, 20-meter sprint, 1RM or velocity in specific strength exercises, etc. [11, 12], with performance decline being the most direct warning signal. Second, subjective perceptions: use daily questionnaires to collect subjective feedback on RPE, sleep quality, muscle soreness, fatigue, stress levels, etc., which is the lowest-cost and highly effective monitoring tool. Third, physiological indicators: when conditions permit, monitor resting heart rate, heart rate variability, salivary cortisol, etc., but understand their individual variability and fluctuations, and avoid isolated interpretation. Fourth, movement quality monitoring: regularly conduct functional movement screening or similar assessments to monitor changes in movement patterns and early detect potential asymmetries or compensatory patterns [26, 34].

Data-driven decision-making is the ultimate purpose of monitoring. When subjective fatigue remains consistently high, performance tests stagnate or decline, and heart rate variability shows abnormal decreases, coaches should decisively adjust the training plan, increase

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202604_9(4).0022

recovery time or reduce load, preventing functional overreaching from progressing to non-functional overreaching.

6.3. Individualization and Long-Term Development Perspective

Respecting individual differences is a fundamental requirement of scientific training. There are large individual differences in training responses, and the same program may yield different physiological, psychological, and technical responses across athletes. Monitoring data provide a basis for individualized adjustments, for example, some athletes may need more recovery time while others can tolerate higher training frequency.

Long-term athlete development requires training to align with age and developmental stages. Pre-puberty should focus on motor skills, coordination, foundational strength, and experience in various sports, avoiding premature specialization and high-intensity unilateral training [14]. As puberty progresses, the load and complexity of strength, power, and sport-specific physical training should gradually increase. Research indicates that the association between technique and ranking may be stronger than that of physical fitness in early adolescence, but the role of physical fitness becomes increasingly important with age [1], requiring coaches to adopt a developmental perspective.

7. Conclusion and Comprehensive Training Recommendations

Through systematic integration and in-depth analysis of relevant empirical research, the scientific contours of modern tennis physical training can be clearly delineated. The conclusion is clear: tennis performance enhancement has entered the era of integrated training. Isolated pursuit of maximal strength, absolute speed, or endurance mileage cannot address the complex, multidimensional challenges imposed by tennis matches. The key to success lies in constructing a comprehensive training system that takes sport-specific demands as the blueprint, optimizes movement patterns and kinetic chain efficiency as the core, neuromuscular control and power development as support, and scientific periodization and multi-dimensional monitoring as safeguards.

Based on the full text argumentation, the following comprehensive training recommendations are proposed for coaches and athletes:

First, prioritize demand analysis. Before designing any training program, deeply understand the physiological metabolic, biomechanical, and neurocognitive demands of tennis matches. Establish serve velocity, upper limb power, lower limb power, linear and multi-directional speed, and high-intensity intermittent aerobic capacity as core training targets and evaluation indicators.

Second, construct functional core training. Abandon core training that merely prolongs support time, and shift training focus to: (a) anti-movement core capacity using tools such as elastic bands; (b) rotational explosive power, such as medicine ball rotational throws in various positions; (c) progressive instability surface exercises to challenge deep stabilizing muscles. Treat core training as the hub connecting upper and lower limb strength.

Third, adopt the functional training philosophy. Use multi-joint, multiplanar compound movements as the main training content, prioritize movement quality as the first line of defense for injury prevention and performance enhancement. When designing training, always consider how the movement helps players move or generate force on the court.

Fourth, systematically develop neuromuscular and power capabilities. Use plyometric training as the core content for enhancing serve velocity and movement explosiveness. Simultaneously incorporate broader neuromuscular training, especially for youth and female athletes. Strictly adhere to the prioritization principle, placing these high-quality training components at the beginning of training sessions.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202604_9(4).0022

Fifth, optimize energy system training. Aerobic training should simulate match patterns, using high-intensity interval training or combined training with sport-specific techniques, rather than long-distance steady-state running. Consider high-intensity functional training as a supplementary tool for developing comprehensive metabolic capacity and whole-body strength endurance, selecting appropriate loads based on goals.

Sixth, implement structured warm-ups. Use neuromuscular warm-ups incorporating neuromuscular activation elements, lasting approximately 20-35 minutes, to maximize performance output in subsequent training or competition.

Seventh, implement scientific periodization and individualized monitoring. Develop long-term, periodized training plans that coordinate the development of different qualities with competition schedules. Establish a multi-dimensional monitoring system encompassing subjective perceptions, objective performance tests, and optional physiological indicators. Respect individual differences, use data to drive decisions, adjust training loads promptly, and ensure athletes' long-term healthy development.

The scientific exploration of tennis physical training continues. Future research needs to further explore the optimal combinations and dose-response effects of different training methods in elite adult players, as well as the application of emerging technologies in individualized training. However, based on the current solid evidence base, practitioners can already construct refined and scientific training systems that transcend empiricism.

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