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Application of Rapid Telescopic Compound Training Method in Athletes' Explosive Training

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Abstract: *As modern competitive sports increasingly demand greater explosive power from athletes, plyometric training has gained widespread adoption across numerous sports as an effective method for enhancing explosive strength. This paper examines the origins and working principles of plyometric training, explores its application in explosive power development across different sports, and analyzes the practical implementation of variables such as training intensity, volume, and frequency within training programs. Finally, it outlines future research directions for plyometric training, including enhancing athletes' long-term performance and integrating it with diverse training methodologies. This multi-perspective theoretical examination of RCT contributes to developing more scientific, safer, and efficient training protocols for athletes.*

Keywords: *Rapid Contraction-Tension Training; Explosive Power; Athletes*

1. Introduction

Today, an increasing number of coaches and researchers are incorporating rapid stretch-shortening cycle training into their programs to enhance athletes' performance. This method has also become a frequently used approach in rehabilitation training for athletes. Compared to traditional strength development, plyometric training differs significantly by aiming to achieve maximum force output in muscles within extremely brief timeframes. Its concept originates from the field of physical conditioning, seeking to enhance strength, power, and athletic function through rapid, forceful movements during both the stretching and contraction phases of muscle activity. Researchers in Norway and other countries define it as the stretch-shortening cycle (SSC). The core objective of SSC training is to integrate the elastic components within muscles and tendons with the stretch reflex process, thereby amplifying muscle force display in subsequent movements. Generally, SSC comprises three phases: the eccentric phase, the transition from eccentric to concentric, and the final concentric phase. Starting from the practical application of RSC training in athletes' explosive power development, this study comprehensively explores the physiological mechanisms of this training method and conducts in-depth research on its application in explosive power training across various sports disciplines. The objective is to provide coaches with a solid theoretical foundation and reference materials for practical implementation.

2. Rapid Stretch-Shortening Cycle Training

2.1 Origins of Rapid Stretch-Shortening Cycle Training

Plyometric compound exercises originated in Europe as a training method, initially serving solely as jumping drills. Beginning in the 1970s, Eastern European athletes gradually showcased their prowess on the international stage, drawing attention to this distinctive "jumping exercise." The term "Plyometrics" derives from Latin, translating to "measurable growth." Verkhoshansky, a seminal figure in the Soviet Union during the 1960s, is revered as the founder of training methods for enhancing explosive power skills. It was during this era that he proposed his renowned theory of super-maximal force. In 1975, Wilt introduced the super-maximal training concept to the United States, where it gained widespread adoption and popularization. Subsequently, numerous scholars conducted detailed experimental studies and theoretical analyses. By the mid-1980s, German scientists Gohoff and Schmidt-Hohlfelder began deep investigations into the origins and training methods of "reflexive power," achieving remarkable scientific results. Subsequently, scholars from numerous countries entered this field, giving rise to diverse academic schools of thought. Since the 1970s, the Finnish Komi research team has conducted comprehensive and in-depth studies on the operational mechanisms of the stretch-shortening cycle (SSC),

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fatigue progression pathways, and recovery mechanisms. Extensive academic exploration has taken place in countries like France and Germany, yielding rich subsequent research outcomes [1]. In China, scholars such as Wei Bing and Li Shuhong have offered unique perspectives on the origins of this specialized training method. They share the view that as early as the 1930s, Jesse Owens' coach, Snyder, employed methods and tools similar to the principles of plyometrics during Owens' initial training sessions [2]. The author posits that super-maximal training constitutes a distinct training theory or methodology. In China's early sports era, professional sports literature consistently employed the term “super-maximal exercise,” as seen in Tian Maijiu's Sports Training Science and Wang Ruiyuan's Sports Physiology. Ultimately, theoretical interpretations developed by experts across diverse nations and disciplines—as exemplified by Professor Wang Anli and Researcher Sun Wenxin from Beijing Sport University—converge on the prevailing view: Rapid Tension-Relaxation Composite Training“ fully captures the unique characteristics of super-long training. Therefore, this paper adopts “Rapid Tension-Relaxation Composite Training” or “Rapid Tension-Relaxation Composite Exercise” to replace the traditional term ”super-long exercise."

2.2 Working Mechanism of Rapid Tension-Relaxation Composite Training

2.2.1 Muscle Stretch Reflex

The muscle stretch reflex is another mechanism of the stretch-shortening cycle, with the most common example being the knee-jerk response elicited by lightly striking the quadriceps tendon with a rubber band. In human movement control, the central nervous system relies on sensory receptors such as muscle spindles and tendon organs to execute actions through sensory feedback mechanisms. Muscle spindles and tendons share a complex and profound interrelationship, playing a pivotal role in neurohumoral regulation. Muscle spindles are highly sensitive to stretching. Structurally arranged in parallel with muscle fibers, they are affected by the stretching effects when skeletal muscles are stretched. This influence transmits stimuli via sensory nerve fibers to the spinal cord, reflexively prompting the stretched muscle to actively contract, thereby enhancing its strength. This mechanism is known as the stretch reflex [3]. As a proprioceptor, the muscle spindle exhibits extreme sensitivity to the speed and magnitude of muscle stretching. When detecting rapid yet relatively weak muscle stimulation, the spindle reflexively generates a pronounced response. This response heightens muscle activity, ultimately increasing muscular force.

2.2.2 Elastic Components of Muscle

The elastic components within muscles primarily refer to connective tissue, which can be further classified into series elastic components (SEC) and parallel elastic components (PEC) based on their arrangement [4]. As a crucial element in the fast-twitch training model, the SEC stores elastic potential energy when stretched, thereby increasing force production. The parallel elastic component (PEC) enhances passive force through unstimulated muscle stretching. Through in-depth examination of prior foreign literature, Dr. Chen Xiaoping explicitly proposed that the muscle-tendon complex structure is fundamentally the result of muscle and elastic elements intertwining. Within this structure, a specialized protein called the muscle spindle attaches to the muscle cell membrane. When muscles undergo passive stretching, the frequency of nerve impulses transmitted by the muscle spindle and tendon spindle increases. Naturally, the tendon spindle also possesses self-protective properties. When muscle fibers exhibit excessive tension, it may lead to injury. In such situations, the tendon spindle forms a protective mechanism for the body, limiting muscle movement to reduce the likelihood of injury during exercise [5].

3. Application of the Rapid Twitch-Slow Twitch Composite Training Method in Sports

3.1 Application of Rapid Twitch-Slow Twitch Composite Training in Basketball

As a dynamic sport, basketball's intense competition and rich visual appeal have drawn vast audiences, playing an indispensable role in its sustained popularity [6]. In today's wildly popular ball sports, winning requires exceptional physical conditioning—superior lower-body explosiveness and outstanding core control. This is especially true for basketball centers, who must repeatedly jump for rebounds, block opponents' shots defensively, and score via jump shots offensively. All these techniques demand the ability to generate maximum force in minimal time. These technical movements demand athletes possess exceptional lower-body explosiveness. Undoubtedly, plyometric training has become the primary method for developing this ability, with common exercises including box jumps and drop jumps.

After implementing training interventions for SCBA players at Shandong Sport University, Lu Changqing conducted in-depth research and discovered that combining resistance strength training with plyometric exercises significantly enhances lower-body explosive power. This approach demonstrated

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remarkable improvements in skills such as the running one-legged jump and full-court fast-break layups, with particularly pronounced gains observed in the T-shuttle run test [7].

Jing Lanxiang et al. proposed that training strategies employing super-long resistance can significantly shorten the support phase duration of the Stretch-Shortening Cycle (SSC), reduce recovery time, and enhance the energy transfer from eccentric to concentric contraction within the muscle-tendon complex. This mechanism elevates lower-body muscular explosive capacity [8].

Thus, the application of RSC training in basketball is widespread and yields favorable training outcomes. As a sport emphasizing explosive power, basketball demands rapid muscle recruitment and elastic potential energy, granting RSC training a unique position in enhancing basketball explosiveness.

3.2 Application of RSC Training in Volleyball

Volleyball, as a skill-and-strategy-dominated net-based competitive sport, lacks the highly distinctive physical confrontation techniques seen in basketball. However, it exhibits unique spectator appeal and competitive characteristics during rapid offensive-defensive transitions involving technical actions like passing, setting, spiking, serving, and blocking. Following the adoption of the “rally-point system” in volleyball, matches have become increasingly intense, demanding athletes possess sufficient physical reserves to cope. During rapid offensive-defensive transitions, athletes must master consecutive jumping techniques to successfully execute the critical tasks of blocking and spiking. This necessitates exceptional second-jump ability and relatively swift movement speed. Consequently, both the level of second-jump capability and the speed of movement are closely tied to explosive power. The rapid stretch-shortening cycle (RSC) training method is a technique designed to maximize potential within extremely limited time frames, specifically targeting the enhancement of individual explosive power. This training method guides movement execution based on changes in speed and direction during muscle contraction phases. By performing stretching and compression exercises at different body positions, it aims to enhance internal energy reserves. For high-speed extension compound training, focusing on volleyball players' game-winning patterns, the primary exercises are jump-based drills. Examples include various forms of single-leg and double-leg jumps, as well as common depth jumps and box jumps.

Li Zhiyuan's perspective emphasizes that athletes with a long-stretch–short-cycle, rebound-style jumping ability dominate the main attack position. Therefore, greater emphasis should be placed on developing this type of jumping capacity. For secondary attackers, deeper focus should be given to their squat jump technique, alongside strengthening hip-centered thigh muscles and explosive power training [9].

Wei Shuo proposes that when team members engage in rapid expansion compound training, they must focus on minimizing ground interaction time, strive to shorten vibration duration, and ensure targeted ground response. Considering volleyball players' speed, their short-distance acceleration, braking, deceleration, and subsequent re-acceleration—coupled with relatively low elasticity—significantly impact their movement rate, frequency, and timing. Ultimately, these factors determine the quality of their shots. To ensure high-quality training, athletes must also comprehensively consider factors like physical condition and mental state when selecting exercises. For enhancing agility, rapid expansion compound training plays an indispensable key role [10].

In summary, rapid extension-contraction compound training is widely applied in volleyball. As a sport dominated by lower-body explosiveness, we should leverage its unique methods—such as extending and shortening training cycles—to enhance athletes' performance. This approach integrates practical application with traditional training techniques.

3.3 Application of Rapid Tension-Relaxation Composite Training in Track and Field Training

Track and field, as a physically demanding sport with high technical specificity, places significant demands on athletes' physical qualities—particularly explosive power—in events like sprinting, shot put, long jump, and high jump. Sprinting, the most representative track event, imposes especially stringent requirements on athletes' strength, speed, and explosive power. Rapid Tension-Relaxation Composite Training stands out as the most effective method for developing explosive power. By enhancing the reflexive regulation of muscles by the central nervous system, it induces a synergistic effect within the athlete's nervous system, ultimately boosting explosive power. Consequently, an increasing number of coaches are integrating this approach into daily training regimens, combining traditional strength training with Rapid Tension-Relaxation Composite Training to continually refine novel training methodologies.

Sun Zhijian and his team conducted classification experiments on hurdlers, discovering that using jump depth training as a testing method significantly enhances athletes' explosive power, thereby substantially improving their competitive performance. Detailed research reveals this training strategy

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not only greatly increases physical strength but also aids in precisely regulating muscle activity. Furthermore, prolonged use of this technique yields particularly remarkable results in growth rate and explosive power [11].

Xu Lifeng, focusing on adolescent athletes, supplemented conventional training with super-long training. Comparing the effects between an observation group and a control group, the control group underwent traditional sprint training methods. The observation group, after traditional training, received super-long exercises at varying intensities, ultimately achieving more pronounced improvements in their 100m times [12].

4. Application of Rapid Stretch-Shortening Cycle Training in Athletes' Explosive Power Development

Different sports possess distinct characteristics and training methods. As a crucial form of training to enhance an athlete's explosive power—whether upper-body or lower-body—rapid-cycling compound training is applicable to virtually any sport and athlete. Activities like middle-distance running, rugby, baseball, and sprinting all demand athletes generate maximum muscular force within extremely brief intervals. For instance, baseball catchers must instantly generate lateral explosiveness to throw the ball into unguarded territory. In basketball, centers require consecutive vertical jumps to compete for offensive rebounds, succeeding only by outjumping opposing players. Using basketball players as an example, this program has developed a comprehensive training plan covering intensity, volume, frequency, and methodology. It focuses on compound training for lower-body rapid extension-contraction and explosive power development. We should note that coaches must assess the athlete's specific sport, playing position, and training condition to design an appropriate program. Combining position-specific demands and individual athlete conditions, design a safe and effective SSC training plan.

4.1 Training Intensity

Training intensity serves as an indicator to evaluate the degree of physiological stimulation from exercise load. Specifically, it refers to the rapid adaptation training intensity targeting muscle and connective tissue in youth athletes [13]. The difficulty of SSC training primarily depends on the specific execution and standards of the movements, allowing for flexible variation. For instance, light jumping exercises similar to skipping rope involve relatively low intensity, while high-intensity drills akin to deep jump training can exert significant pressure on muscles and joints. However, during the design phase of lower-body rapid adjustment exercises, several key factors may influence training intensity. These factors may include, but are not limited to, contact points, movement rhythm, height, and weight. Among all considerations, contact points are paramount. Compared to single-leg or combined single-leg rapid extension-contraction training, combined double-leg rapid extension-contraction training generates ground reaction forces at the leg contact points that exert significantly greater pressure on lower-body muscles and joints. This pressure is analogous to weight-based feedback: athletes with greater body weight experience increased stress on their musculoskeletal tissues. For instance, in training that combines deep jumps followed by acceleration runs, the jump height is the primary consideration for coaches. Training with different body weights and contact points yields varying effects on athletes, including differing impacts on lower-body muscles and joints. This scenario primarily simulates the running motion during a defensive rebound followed by a fast break counterattack.

4.2 Training Volume

Training volume typically refers to the time and quantity expended in completing a given exercise, serving as one of the primary components of a training program. In plyometric training, volume is usually expressed through the number of repetitions and sets completed within a single session. Allerheiligen[14] posits that volume is typically represented by the number of foot contacts and the distance covered. Performing 3 sets of 10 repetitions each yields a volume of 30. Applying this concept to 4 repetitions yields a total volume of 120 feet. The number of foot contacts depends on the athlete's intensity, technical proficiency, body weight, and duration. The scale and intensity of the entire program (intensity, agility drills, plyometric training) also influence the volume of plyometric training. Table 1 summarizes a series of studies by Chu et al.[15], who recommend measuring volume using the number of deep-foot contacts per unit time. When performing compound exercises involving high-speed lower-body extension, the exercise frequency is generally maintained between 60 and 100 repetitions. However, as exercise quality improves, it may be possible to gradually increase the exercise intensity, but the total volume should be controlled within 180 repetitions.

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Table 1: Training Volume Adjustments Based on Athlete Training Level (Units: Foot Contacts)

Season	General Athletes	Elite Athletes	High-Level Athletes	Intensity
Off-Season	60-100	100-150	120-200	Low–Medium
Pre-Season	100-150	150-300	150-450	Medium–High
Mid-Season	Specialized Training	Specialized Training	Specialized Training	Moderate
Major Competitions	Recovery and Adjustment	Recovery and Adjustment	Recovery and Adjustment	

4.3 Training Frequency

Training frequency refers to the number of times an athlete performs plyometric training per week. Currently, research literature on plyometric training frequency is limited. Many scholars argue that studying recovery time between sessions is more valuable than investigating training frequency itself. Consequently, research indicates that a 48-72 hour interval between two plyometric training sessions serves as a standard recovery time guideline for typical plyometric training programs [16]. Based on this guideline, scheduling one session per week is generally appropriate. However, it is important to note that the periodic arrangement of RCT training should vary according to different sports, positions, daily training volume, and intensity, especially considering individual athletes' physical conditions. Taking basketball players as an example, scheduling one RCT session per week during the season is suitable, while two to three sessions per week can be arranged during the off-season.

4.4 Training Methods

Training methods refer to the approaches and techniques employed during athletic training to cultivate athletes' competitive abilities and accomplish training objectives. Over a century of development in modern high-level competitive sports, training methods have evolved from simple to complex, and from segmented to holistic. From the introduction of methods like fartlek running and interval training in the 1940s, the field has progressed to contemporary approaches such as blood flow restriction training, velocity-based strength training (VBT), and multi-modal plyometric training. Increasingly, these methods integrate modern technology to more effectively adapt to athletes at different stages, meeting the diverse needs for developing various competitive abilities. The following section outlines three training methods corresponding to different intensity levels of plyometric training, allowing athletes to select based on their needs.

4.4.1 Single-Leg Jump

Single-Leg Box Jumps serve as an entry-level, low-intensity exercise with high feasibility, requiring only a 45cm-high jump box (or any stable, elevated surface). The athlete faces the box, placing one foot on top—ideally with the entire sole—while the other foot remains on the ground. When an athlete jumps, they push off with the foot on the box,The other foot then lands and performs the same action,alternate feet in a continuous cycle. Each set should consist of 16–20 repetitions, with 6–8 sets being optimal.

4.4.2 Lateral Obstacle Jump

As an advanced training exercise, lateral hurdle jumps offer moderate intensity and require only a marker cone or obstacle. Athletes begin standing beside the obstacle in a comfortable, upright stance with feet shoulder-width apart. The athlete should from a ready position with knees and hips bent, jump laterally toward the same side of the obstacle, landing on the opposite side. Immediately repeat the jump. Each set should consist of 10-15 repetitions, with 6-8 sets total. During the exercise, ensure knees and hips are bent upon landing, maintain the original starting position, and immediately generate power to repeat the movement. The intensity can be increased by gradually raising the obstacle height or performing single-leg jumps, transitioning from moderate to moderately high intensity.

4.4.3 Vertical Jumps + Lateral Sprinting

Vertical jump training has become one of the most popular exercises in SSC training in recent years. Its flexibility, simplicity, and wide range of variations have made it a favorite among many physical training experts, leading to the development of numerous different training movements. This exercise incorporates a lateral sprint component after the vertical jump, instantly converting the elastic potential energy gained during the vertical jump into kinetic potential energy. This enhances muscle elasticity and continuously adapts neuromuscular function.

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This exercise requires a 45cm-high jump box. Athletes position themselves comfortably on the box with legs straight, eyes forward, and feet shoulder-width apart. After preparing, they step off the box with both feet landing simultaneously, immediately sprinting to their right. Training intensity can be progressively increased by having a partner direct the lateral sprint direction upon landing. Each set consists of 6-8 repetitions, with 4-6 sets forming one cycle. For subsequent cycles, gradually increase the box height or sprint distance based on the athlete's individual condition. It is crucial to minimize ground contact time upon landing to prevent excessive stress on lower-body joints and muscles.

5. Prospects for Rapid Stretch-Shortening Cycle Training Effects

In recent years, research on plyometric training has primarily focused on enhancing athletic performance, neuromuscular adaptation, and integration with other training methods. Regarding performance enhancement, Maria Zisi's research team [17] found that plyometric training with weighted vests effectively improves sprinters' start reaction time and first-step acceleration during the sprint phase, though its long-term training effects remain unexplored. Future research should focus on the long-term effects of plyometric training on athletes' physical adaptations. In summary, as a highly effective training method, the efficacy of plyometric training has been recognized by researchers. Future efforts should integrate technological approaches to further enhance athletes' long-term performance and optimize athletic outcomes.

6. Conclusion

With the rise of sports science in the 21st century, coaches and researchers have increasingly explored the fundamental principles and physiological adaptations behind Rapid Telescopic Compound Training. However, different sports disciplines yield varying performance benefits. Team sports like basketball and volleyball require athletes to maintain agility and tactical awareness during high-intensity intervals, while maintaining keen rebounding instincts in crowded court environments. Traditional endurance sports like track and field have utilized super-isometric training since the last century. Yet evolving training theories reveal that prolonged High intensity may not be optimal, particularly for speed-and power-demanding events where excessive endurance training could suppress athletes 'explosive capabilities. This has made balancing strength, speed, and endurance in personalized training programs a critical focus of contemporary sports science. Thus each athlete's physiological characteristics and sport-specific demands determine the precision and emphasis of their training regimens, coachs also need to redesign rapid telescopic compound training according to the actual situation of athletes.

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