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The Impact of Core Strength on Volleyball Techniques and Key Elements of Scientific Training

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Abstract. As volleyball performance continues to improve, the role of core strength in athletes' on-court performance has gained increasing attention. However, the current specialized core strength training system for volleyball in China still requires further development. This study aims to explore the impact of sport-specific core strength on volleyball techniques, analyzing the underlying mechanisms and practical training strategies. The findings indicate that core strength enhances athletes' movement stability and explosive power while reducing the risk of sports-related injuries. Stable trunk control also improves the efficiency of offensive and defensive movements. A specialized core training program combining dynamic and static exercises, along with individualized and team-based approaches, better meets the demands of actual match scenarios. This research provides theoretical guidance for grassroots volleyball coaches in implementing scientific core strength training. Future studies could employ controlled experiments to quantify training outcomes and develop more refined, position- and age-specific core training programs tailored to different player roles and developmental stages.

Keywords: Volleyball, Core Strength, Training

1. Introduction

Volleyball originated in the United States in 1895 and was introduced to China in 1905. Since the 20th century, volleyball has become increasingly competitive, with international organizations established accordingly. At the end of the 20th century, major reforms were made to the rules of volleyball, leading to the subsequent development of various international competitions. As the level of competition continues to rise, physical requirements for athletes have also intensified, particularly in terms of core strength. Core strength refers to the ability of the core muscle groups in the human body to generate force. It is the fundamental ability that enables the body to maintain stability, transmit force, and control movements during physical activities and sports. It serves as the power transmission hub and the foundation for aerial stability in volleyball. The situation on the volleyball court is constantly changing, requiring athletes to quickly and accurately respond to the circumstances on the field. The completion of these actions has certain requirements for physical fitness, which necessitates the support of specialized core strength training. For example, powerful jump serves, diving for the ball, aerial spiking, jumping block, etc. Among these, especially in the volleyball spiking action, core strength plays a crucial role [1]. Enhancing an athlete's core strength

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can not only effectively help them strike the ball with greater force during spiking, making the hit ball more aggressive and creating an advantage for the team, but also better protect the athlete's safe landing after spiking and reduce the risk of spraining their ankle. The better an athlete's core strength is, the more stable and rapid they can complete various volleyball actions. At the same time, strong core strength can help athletes improve their control over their own movements. However, most coaches in China are overly eager for their athletes' technical progress or have overly traditional training concepts, resulting in unscientific core strength training and seriously affecting the success rate of developing reserve talents and the physical health of Chinese volleyball [2]. Although there has been a lot of experience in core strength training, most of it is specialized training for track and field events. At present, the systematic core strength training specifically for volleyball players is not yet fully developed. Therefore, this article aims to deeply study the impact of volleyball-specific core strength on volleyball technical movements, provide more complete scientific basis and practical guidance for volleyball training, and offer suggestions for volleyball-specific core strength training based on actual situations.

2. The influence of core strength on volleyball technical movements

2.1. Impact on explosive power and stability

Enhancing core strength is the key to improving the stability of volleyball movements. After jumping and serving, the body is in a suspended state without any support, and the core muscle group is the only organization that maintains body posture. When the core strength is insufficient, the body is prone to forward leaning, tilting, excessive backward leaning and other postures that are not under the control of the athlete, resulting in deviation of the hitting point, difficulty in controlling the trajectory and force of the spike. Only when the core strength is strong enough can the core stability be ensured, and athletes can maintain the standard posture of "expanding body and contracting abdomen" in the air, thereby ensuring the stability of each hitting action. The stability of the hitting point is also closely related to the core strength. The core strength determines how long the body can remain stable in the air, and thus determines whether the arm can lead the arm to the optimal position to complete the shot. When the core strength is insufficient, the body will sway slightly with the swing of the arms, which can lead to unstable hitting points. The aerial spike motion of jump serve follows the principle of power chain, where angular momentum is transmitted from the pelvis, torso, upper arm, and forearm to the hand in sequence [3]. The core strength is the most important intermediate link in this chain. When the core strength is weak, the force of kicking the ground cannot be transmitted to the arm through rotation, and the spiker will involuntarily rotate the arm to hit the ball, resulting in deformation of the action, decreased stability, and greatly reduced explosive power. The consistent speed of the spike action directly determines the explosive force of the spike. The core strength is strong, the power transmission is coherent, the spike action is more continuous, and the arm can also obtain a large amount of power in a very short time. The power transmitted to the ball in the moment of hitting the ball is naturally greater.

2.2. Impact on injury prevention

Athletes face a high risk of injury during frequent rapid movements, sudden stops, and jumps on the field, such as rotator cuff injuries, lumbar strain, knee joint injuries, etc [4]. In volleyball, serving, dribbling, dunking, and blocking all require shoulder involvement. According to statistics, rotator cuff injuries account for 51.43% of shoulder injuries among volleyball players [5]. The rotator cuff

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is composed of four different muscles, namely the supraspinatus muscle, infraspinatus muscle, teres minor muscle, and subscapularis muscle. The tendons of these four muscles merge into one near the starting and ending points of the humerus, wrapping around the shoulder joint and providing stability to the shoulder joint. When the core strength is not strong enough, athletes do not stay in the air for enough time, and the time to complete movements is not fast enough, which can lead to incorrect shoulder use and burden on the rotator cuff. Increasing core training can enhance the stability of the spine and pelvis, and reduce injuries caused by improper movements. Strengthening core strength can protect one's own safety and control ability, effectively absorb the injuries caused by frequent rapid jumps and emergency stops, and thus reduce the occurrence of sports injuries.

2.3. Impact on sports performance

The improvement of core abilities can promote athletes to perform better, not only improving the accuracy and explosiveness of attacks, but also enhancing the disguised speed and low center of gravity stability of defense. For example, athletes who have undergone core stability training have significantly improved arm swing speed, power transmission, and movement efficiency in volleyball jump serve compared to athletes who have undergone regular core strength training. This is because core stability training for volleyball players is more in line with the sports structure, and athletes have gradually mastered the most effective joint-based serving method [6]. In high-intensity and high-pressure competition, it can help athletes flexibly change positions to cope with different tactics, making the running process smoother.

3. Application of core strength training

Spike is the most active and effective offensive and scoring technique in volleyball matches, and it is also the action that requires the most explosive power. To quickly generate great explosive power in a short period of time, it cannot be done without the support of core strength. Previously, training methods were mostly focused on traditional core training modes, lacking specialized core training methods for volleyball. The core training of volleyball should not only be limited to the general flat support level, but should be combined with various technical movements of volleyball, and dynamic and static exercises should be combined to produce the core training of volleyball.

3.1. Personalization and teamwork

Due to the complexity of volleyball movements and individual differences in basic situations, it is necessary to develop individual training plans based on each athlete's different positions, characteristics, and weak points. Developing personalized training plans requires a combination of past situations, physical fitness test results, and technical analysis reports to accurately identify weak areas and areas for improvement. For example, in the study of personalized physical training design and effect evaluation for excellent volleyball counter attacking athletes, through the analysis of an excellent volleyball counter attacking athlete, it was found that after 7 weeks of training using personalized physical training, there were significant changes in all aspects of physical fitness levels [7]. Personalized training can better consider the recovery period, physical condition, and training status of athletes, and can reasonably arrange the training intensity and frequency suitable for the athletes themselves, scientifically formulate training plans, and better protect the physical health of athletes. The main advantage of core strength team training is to improve participation persistence, facilitate movement correction, and reduce waist compensation injuries; Simulate real motion scenes

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by leveraging collaboration and adversarial manufacturing of external disturbances. In principle, the core focuses on the control of the trunk by the nerves. A team environment can promote concentration, improve the recruitment efficiency of the core muscle group, train the stability of the trunk when the body is disturbed, and the training effect is easier to transfer to actual exercise. However, it should be noted that if the competition only focuses on the duration and ignores the action standards, it can easily cause injuries, and some injured or sick individuals may need personalized adjustments.

3.2. Composite specialization

Composite specialized training is a deep combination of core strength training and volleyball specific movements, with the goal of achieving synchronous improvement of core stability and specialized technical movements through multi-dimensional comprehensive exercises [8]. Arrange a reasonable training plan based on the unstable factors on the simulated field according to the different positions of athletes. For example, some unstable factors can be added on the basis of simulating a spike, allowing athletes to coordinate their core strength to make the spike more natural and smooth on the field. For example, using a medicinal ball to simulate ball control exercises such as "run-up jump rotation", or using a balance pad to complete serving squats and defensive saves exercises [9]. Thus strengthening the core's control over actions in unstable environments. It is also possible to design some core strength training for two or more people to cooperate. In the process of training core strength, team cooperation can be increased to make team members cooperate more seamlessly, which is more conducive to practical combat. Specialized training not only supports athletes' performance and coordination on the field, but also reduces the load on their knee and ankle joints caused by landing after takeoff, effectively protecting their safety.

3.3. Combining dynamic and static exercises

Dynamic exercise refers to a training method in which the core muscle group drives the body to produce significant displacement or joint activity during the contraction process. Muscle contraction mainly alternates between centripetal and centrifugal contractions, and muscle length constantly changes during exercise, such as dynamic lateral plank support, Spider Man plank support, bicycle plank support, etc. [8]. Focus on the parts that require quick power, such as dunking and swinging the arm, jumping and serving, etc. [8] The coordinated hip extension, trunk rotation, and shoulder acceleration required during the serve process, especially during jump serve, reflect the goals of dynamic core training. Its ability to generate and transmit rotational force is the fundamental determinant of serving speed [8]. So the dynamic core training has greatly improved the speed of serving. Static exercise refers to a training method in which the core muscle group maintains a specific posture without significant displacement of the body during isometric contraction. Muscle contraction is mainly characterized by isometric contraction, where muscles continue to exert force but their length remains relatively unchanged, and joints do not produce significant movement, such as anterior plate support, static lateral plate support, and lower abdominal plate support. Emphasis is placed on maintaining stable body posture, such as maintaining aerial posture for jumping and blocking, and posture for defensive preparation movements [8]. The stiffness of the torso formed through equidistant training is a prerequisite for safely and effectively transmitting power to the limbs. So static core exercises mainly improve the speed of dunking [9].

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4. Precautions for core strength training

4.1. Adequate warm-up and relaxation

Perform low to moderate intensity warm-up activities before training, activate the heart, lungs, and muscles, combine static and dynamic stretching, and combine the whole body with targeted areas. Prepare for formal training and avoid unnecessary injuries. Research has shown that effective warm-up can reduce the injury rate of athletes by 30% [10].

After the training, it is also important to relax. Athletes can use the foam shaft to roll and relax muscles or stretch and relax in pairs to promote blood circulation and relieve fatigue. Research has shown that 0.7% of relaxed individuals experience pre fainting symptoms, while 1.7% of those who passively recover experience pre fainting symptoms. The proportions of nausea were 1.3% and 2.0%, respectively. The incidence of acute muscle spasms is 1.0% and 1.3%, respectively, indicating that the probability of adverse events occurring in fully relaxed individuals is lower than that in passively relaxed individuals [11].

4.2. Prioritize training action quality

The quality of movements is superior to the increase in load, which is an important principle of core strength training. The core training focuses on the control of the trunk by the nerves, rather than simply increasing the load. If the movement is deformed, the activation of the deep core muscle group is insufficient, and the waist compensates for the force, increasing the load will only increase the risk of injury and the training effect will deteriorate. The load should be gradually increased under the premise of stable and standardized posture. All core training exercises should maintain the natural curvature of the lumbar spine, and try to avoid hunchback, hunchback collapse, or excessive forward tilt of the pelvis. The quality of movements in core training mainly includes trunk stability, pelvic control, spinal neutrality, and respiratory coordination. If the above steps lose control and cause movement deformation, insufficient activation of deep core muscle groups, compensatory force from the waist, and increased load, it will only increase the risk of injury and deteriorate the training effect. Mastering the principle of "three sided flatness", the body should be kept in a straight line when viewed from the side, back, and horizontal plane. Only stable posture and muscle groups can exert force correctly. Taking a flat support as an example, the head, torso, and legs should be kept straight to avoid sagging or arching the hips. The importance of ensuring the quality of movements is to avoid waist injuries as much as possible, achieve precise stimulation of core muscle groups, and improve training efficiency; Strengthen trunk stability and strength transmission ability, improve athletic performance, reduce ineffective compensatory fatigue, and achieve core true function, rather than simply pursuing the appearance of abdominal muscles.

4.3. Principle of gradual progress

Core strength training should follow the principle of gradual progress, from easy to difficult, from low load to high load, from stable to unstable, from static to dynamic, gradually increasing the difficulty and load of training [6]. From a practical perspective, it is necessary to arrange phased training reasonably. During the preparation period, attention should be paid to basic stability, using low to moderate intensity, multiple static supports and dynamic control training to activate deep muscle groups and solidify the foundation of movement control [9]. In the initial stage, the method of decimal conversion should be adopted. As the core strength of athletes increases, the training

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intensity gradually increases. Gradual progression is beneficial for reducing the risk of injury, establishing correct movement patterns, promoting coordinated development of deep and surface core muscle groups, improving neuromuscular control ability, and enhancing power transmission efficiency. To ensure the sustainable development of core scientific forces.

5. Conclusion

This article focuses on the research of the core strength of volleyball, sorting out the role of core strength in volleyball players' explosive power, physical stability, sports injury prevention, and performance on the court. It explores the implementation paths of personalized training team training, compound specialized training, and dynamic static combination training for core strength training, and proposes training precautions such as warm-up and relaxation, ensuring movement quality, and gradual progress. Research has shown that strong core strength is the key to the transmission of technical movements such as volleyball spikes and jump shots. Stable trunk control can improve the efficiency of offensive and defensive movements, as well as reduce sports injuries to the waist, shoulders, and ankles. In response to the current situation of traditional volleyball training concepts and incomplete specialized core training systems, this article combines core training with volleyball specific movements and proposes training ideas that are suitable for the characteristics of volleyball projects. This can provide practical reference for grassroots volleyball coaches to carry out core strength training.

However, this study only analyzes the training strategies of volleyball core strength from a theoretical perspective. Future research can combine sports testing to conduct comparative experiments, quantify the improvement effects of different core training programs on volleyball skills, further explore differentiated core training programs for volleyball players in different positions and age groups, and continuously improve the volleyball core strength training system.

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