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Training for High Level Performance in Women's Collegiate Volleyball: Part I Training Requirements

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summary

Volleyball played at a high level of competition is a physically demanding activity. To perform and compete at a high level requires that athletes be well prepared physically to meet the demands of the game. The purpose of this article is to discuss the physical requirements of collegiate women's volleyball and the need to emphasize specificity when designing a volleyball training program.

Movements of the Game

Volleyball is commonly described as a high speed, explosive, powerful sport. Repeated maximal or near-maximal vertical jumps, frequent change-of-direction sprints, diving to make a save, and repeated overhead movements when spiking or blocking are among the movements that make up the game (1, 4). Further-

more, the athlete generates high levels of force when spiking or performing an approach jump and absorbs a lot of force when diving, landing, or blocking a spike. To meet these physical demands requires a high level of conditioning (4). Due to the need to generate and to absorb high levels of force, the opportunity for injury exists. A well-designed strength and conditioning program plays an important role in reducing injury. An advantage that resistance training provides the athlete is the improved kinesthetic awareness that is developed through resistance training by strengthening the muscles and tendons and increasing muscle recruitment and coordination (11).

Energy Demands

The average play in volleyball lasts about 6 seconds, followed by an average rest period of 14 seconds, not including player substitutions or timeouts (4). This work:rest ratio suggests that athletes primarily use the adenosine triphosphate phosphocreatine system. There are about 50 rallies per game. As a result, energy-system training for volleyball should consist of 50 or more repeats lasting 5–10 seconds. These efforts should consist of jumping, running, and/or diving, involving

frequent changes of direction, followed by 10–15 seconds of rest (1).

Some of the training activities should last 20–45 seconds to prepare the players for the approximately 10% of rallies that exceed 15 seconds in duration. For example, a drill for an outside hitter could consist of a block jump, backpedaling for 4 m, a rapid spike approach, and a spike jump. A drill for a back line player could consist of a lateral movement for 3 m, dive and roll, and backpedal to the starting point. A setter could sprint to the net from a back line position, jump set, block jump, and sprint to the starting position (1).

The intensity and duration of training activities and the duration of recovery periods should be controlled in order to train the aerobic/anaerobic thresholds and to avoid stressing the lactic acid anaerobic metabolism too heavily. To tax the alactic anaerobic and aerobic systems but not the lactic acid anaerobic system requires that training consist of sets or repetitions with sufficient rest between sets to avoid an excessive buildup of lactic acid (1). If the training regimen is specific to the energy systems involved in the game and the movements used in

training are specific to volleyball, it is possible to overload the neuromuscular system so that the athlete is trained to jump higher, to run faster, and to change directions more quickly.

Specificity of Training

To best improve physical performance in sport requires the application of specificity and overload. *Specificity* means that the conditioning program mimics game movements as closely as possible. *Overload* means that training must provide a stimulus (weight, speed, height, duration) that is greater than normal and requires a greater than normal effort from the athlete (1). The most effective way to accomplish this is to perform exercises that are highly similar to actual movements of the game and also provide adequate overload to force the body to improve its capabilities. As a result, training should develop the abilities to jump and run short distances, dive, and change direction quickly—with minimal reduction in performance due to fatigue (1). It is important to remember, however, that exercise selection, similar to program design, should progress from general to specific. That is, as the off-season progresses, exercise selection should become more and more specific to the movements that occur during competition (7). Training for maximum force production should imitate game movements in pattern, velocity, contraction type, and contraction force, in a manner that is similar to the movements that make up the sport of volleyball (1).

As a result, exercise selection should be based on training movements, not muscle groups. The more similar the training activity is to the movements that make up the sport, the more carryover there will be from the weight room to the competition (7). Exercises such as squats and lunges are effective at increasing hip/leg strength and are performed in a movement pattern that is similar to movements seen in volleyball.

Because of this, squats and lunges are better choices for the athlete than, for example, leg extensions or leg presses (7).

To accomplish the goal of placing an emphasis on specificity of training, an emphasis is placed on standing, free-weight exercises that mimic the movement patterns seen on the court. Due to the biomechanical similarity between performing vertical jumps and performing cleans, jerks, and snatches, an emphasis is placed on including the weightlifting movements in our training program.

Also emphasized is the selection of standing free-weight, closed kinetic chain exercises, such as squats and lunges, as previously mentioned. These types of exercises can be selected based on the similarity of their movement patterns to those that make up the game of volleyball. Lower body exercises such as squats, lunges, and side lunges require movement patterns similar to those demonstrated by athletes during competition. The goal is to select and emphasize exercises that train the athlete in a manner similar to what she will encounter during competition.

The ability to spike the ball at high velocities is also of value to the volleyball athlete. This ability can be enhanced by increasing strength and power in both the trunk (discussed below) and the chest/shoulder girdle area using a variety of resistance training and upper body plyometric activities. Resistance training exercises such as bench press, standing bench press, shoulder press, and pullovers all can be used to assist in this area. Plyometric activities using a light medicine ball, mimicking the arm movement during a spike, also can contribute to this ability. In terms of upper body injury, the most common upper-extremity injury site in the volleyball athlete is the shoulder. The muscles of the shoulder and rotator cuff are of major concern due to their role in stabi-

lizing the shoulder and due to the high forces produced while spiking and blocking (4). A variety of rotator cuff exercises can be performed to strengthen and protect the shoulder joint and the rotator cuff.

Lateral Movements

Another area of emphasis in the training program is lateral movements. Most strength training movements occur in a sagittal plane. For example, exercises such as cleans, squats, and forward lunges all occur in this plane. However, most athletic events, including volleyball, are a mixture of straight-ahead and lateral movements. Examples of lateral movement in volleyball include a middle blocker sliding laterally to make a block or a defensive specialist diving laterally to make a save. If athletes train only in the sagittal plane, they are not prepared adequately for optimal lateral movement capabilities. To address this need for lateral movement, athletes should perform a variety of lateral training movements, both in the weight room and in plyometric/agility training. Examples of lateral resistance training movements include lateral squats, side lunges, and arch lunges. Lateral plyometric drill examples include lateral box jumps, lateral hurdle hops, and lateral bounds.

Value of Dumbbell Training

If the goal of the training program is to enhance athletic performance, dumbbells should make up a significant portion of the training program. The balance and body control required to perform dumbbell exercises are extremely high, which makes them a great choice when training athletes. All of these aspects transfer very well to the demands of volleyball competition (8).

Trunk Training

Many people think of training the trunk as abdominal training only. Although abdominal training is an important aspect of trunk training, a strong low back is also important for athletic perfor-

mance (6). Athletic movements such as twisting, jumping, and running all create strenuous forces on the back. An inadequately trained back can lead to weakness and impaired movement capabilities. Over time, this can lead to decreased athletic performance, injury, and pain.

When training the core, functional training often is ignored and in its place, are programs and exercises that aim to improve the muscular appearance of the trunk. This is unfortunate, because closed kinetic chain exercises require more balance and coordination and are more sport specific than typical “six-pack ab” exercises. Therefore, it is important to perform a portion of trunk exercises from a standing position, because this is the position from which the athletes compete.

It is also important to remember that whereas trunk training when training for appearance should be performed in a slow and controlled manner, trunk exercises when training for sport should include fast, explosive movements. This is because sports movements typically involve explosive, ballistic, and well-coordinated muscular actions. Power exercises are performed at a higher rate of speed due to the speed-specific adaptations that are seen during resistance training, and this concept applies to the trunk as well (6).

Volleyball also involves frequent rotational movement in the trunk, such as when serving and spiking. Many training programs tend to neglect rotational training. Because rotational movement occurs during competition, it is critical to include rotational movement in the training program (8). Athletes need to be trained for the rotational component of the sport, and the only way for this to occur is by emphasizing rotational movements in training.

Training to Improve Vertical Jump

Vertical jump ability is critical for success in volleyball (11). Jumping ability is im-

portant when performing the jump set and jump serve, as well as when blocking and spiking. As a result, improving vertical jump performance is a critical portion of the volleyball training program.

Although jumping ability is related to power production, it is important to remember that the effect of strength and speed on power is multiplicative. This means that the best gains in power will occur when there are increases in both strength and speed. Focusing only on strength or speed of movement will limit increases in power. In sports that require a high power output, the emphasis during the early phase of training should be on maximal increases in strength. Following this emphasis on strength development, there should be a transition to an emphasis on power and speed development (11).

To a large degree, jump performance is dependent on the force produced at the hip, knee, and ankle joints, although vertical jump performance training should not be limited to the lower body, because it has been shown that the arms contribute an average of 10% to the takeoff velocity during vertical jumping (11). As a result, improving explosive strength in the legs, hips and arms should result in improved vertical jump performance.

Research has shown that vertical jump performance increases after participation in a resistance training program (5). With a well-designed strength training program, the athlete will be able to produce greater force in the trained musculature. For example, it was found that a 7-week program of periodized parallel squats led to a significant increase in hip and thigh power. Performing squats twice per week for 7 weeks, the subjects improved their vertical jump an average of 3.3 cm. This increase in vertical jump height in the squat group was expected because the dynamic nature of the parallel squat enhances neuromuscular efficiency, such as the stretch reflex (5).

However, evidence suggests that a program using squats as the primary exercise for improving lower body power may result in less-than-ideal adaptation. A monotonous, low-repetition, heavy strength training (powerlifting) program over periods of weeks and months may result in overtraining. One of the limiting aspects of powerlifting is that as performance improves, power output decreases. This reduction in power output occurs because as the athlete grows stronger and the single repetition maximum (1RM) increases, movement speed decreases, sometimes substantially. In powerlifting, movement speed does not play a role in the success of the lift. Although this type of training allows the athlete to train with very heavy weights, it lacks the typical explosive movements of many sports (5).

Weightlifting-style movements (cleans, jerks, snatches, and associated training exercises) can be termed *explosive*. In both the clean and jerk and the snatch, the lift must be completed quickly if it is to be successful. Furthermore, decreases in power as the weight approaches 1RM are much smaller in resistance training. As a result, as the weight lifted increases from about 95% to maximum, the speed of movement decreases only slightly (5).

Because speed of movement must be maintained in weightlifting, mechanical power outputs in the movements tend to be very high. Research has shown that the power outputs from the second pull in either the snatch or the clean is 4–5 times higher than the power output from either squats or deadlifts and 11–15 times greater than that of the bench press (5).

As a result, the weightlifting-style movements are ideal for developing speed, power, coordination and kinesthetic awareness (2). Resistance training movements strengthen muscles at a similar velocity and in the same sequence that they are recruited when performing a variety of athletic movements.

Due to the high forces developed when jumping and landing, knees and ankles are also vulnerable to injury. A comprehensive program combining resistance training, plyometric training, and flexibility training is the best approach to protecting these joints. This is especially important for female athletes due to the higher frequency of knee injuries in this group (9).

Upper Body Training

Besides the obvious need for leg and hip strength/power, one of the most important factors for success in volleyball is upper body strength, both for performance reasons (one of the most important factors in spiking velocity is shoulder extension strength at high speeds, and, as already mentioned, the arms contribute 10% to takeoff velocity during the vertical jump) and injury prevention. The shoulder joint musculature and rotator cuff muscles are of major concern due to their role in stabilizing the shoulder and the high forces produced while spiking and blocking (4). Indeed, the most common injury to the hitting shoulder is a rotator cuff tear. Rotator cuff exercises should be performed in 2 sets of 12 repetitions, using slow and controlled movements. Elastic bands or light dumbbells may be used when performing the rotator cuff exercises (4).

Conclusion

Volleyball is a high-speed, explosive, powerful sport. To best improve physical performance requires the application of specificity and overload. An important area of emphasis is lateral movement. Most strength training movements occur in a sagittal plane (cleans, squats, and forward lunges), but most athletic events, including volleyball, are a mixture of straight-ahead and lateral movements. Dumbbells should make up a significant portion of the training program, because extremely high capacities for balance and body control are required to perform dumbbell exercises. Training the trunk is also of importance.

Although abdominal training is an important aspect of trunk training, a strong low back is also significant. Improving vertical jump performance is a critical portion of the volleyball training program. Whereas jumping ability is related to power production, it is important to remember that the best gains in power will occur when there are increases in both strength and speed. Besides the obvious need for leg and hip strength/power, one of the most important factors for success in volleyball is upper body strength, both for performance and injury prevention. ♦

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