Chapter XIX

THEORY OF PHYSICAL PREPARATION FOR VOLLEYBALL

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Introduction - Principles

Volleyball is a sport that not only requires a number of individual skills and technical abilities of each player, but it also requires that the players have a high degree of development in a number of physical and/or physiological parameters in order to be successful. This chapter deals with the development of the various physical/physiological fitness components that are of most importance for volleyball. Each of the factors dealt with here can be influenced by training.

No matter which component or series of components one deals with in a training program, a number of principles, concepts and relationships must be understood and properly applied if the training is to result in the desired outcomes.

By far the most important principle in training is the Stress Adaptation (S-A) Principle. Simply stated, the principle says that if the human body is subjected to a stress the body will somehow adapt to that stress by changing. It does not matter which fitness component is considered, the principle still applies. But what do the terms “stress” and “adaptation” mean? Both are very broad terms that can be used to describe a single type of stressor (e.g. lack of O₂) and its effect on a single part of the body, or they can encompass a complex series of stressors as they affect the entire body. In general, a stress is any stimulus (condition, circumstance) to which the body is subjected; if that stimulus is strong enough and is repeated frequently it should result in changes in the body. These changes that are brought about by the stress are called adaptations. It is important to recognize that the stress or stimulus can be one of disuse as well as it could be physical activity, and that the response or adaptation could be either positive or negative relative to the desired outcome. The success or failure of the training program depends upon the coach’s ability to select and administer the stress that will result in the most productive adaptation.

To help understand how the S-A Principle applies to physical preparation for volleyball, we can consider training to be the stress, and the effects of the training to be the adaptation.
Obviously then we as coaches must make the right choices in developing the various aspects of the training program if we expect the end results to be volleyball players who are properly prepared for the demands of the competition. Each aspect of a training program is a specific application of the general S-A Principle, therefore it is imperative that the coach properly apply the principle in designing and administering the players’ training.

If a proper application is to be made, another important principle must be understood - the principle of specificity of training. The fact that training outcomes are highly specific to the process of training is one of the most widely ignored or overlooked principles in volleyball training programs throughout the world. Literally hundreds of examples can be found of players practicing techniques that will hinder proper skill development, or using weighted shoes in the mistaken belief that the shoes will help develop great jumping ability. Combining the two principles, it can be stated that specific adaptations will result from the specific characteristics of the stress that was applied. In other words, if you strength train the left biceps muscle, that muscle (and only that muscle) will adapt by becoming stronger, but it will not improve its aerobic endurance capacity or any other characteristic that is not directly affected by the stress of the strength training.

The following questions are designed to help the coach properly apply the S-A Principle into any specific training regimen. First one must ask about the adaptations:

1. What specific changes in the players are desired at the end of the training period? Answering this will help to target the stress applied.
2. To what extent will these adaptations determine the players’ success? Obviously we do not want to spend 90% of our training time developing some factor that will contribute only 1% to the success rate of the team.
3. What demands will the toughest competition to be encountered by the players place upon the body systems being trained? Answers to this question will not only help to further refine the answers to Question 1, but they will also help to define the specifics of the stress to be applied.

With the desired adaptations clearly defined, one then must examine the stress:

1. What kind of stress should be applied? If the desired outcome is aerobic endurance, then the stress must not be one that develops muscular strength. The nature of the stress must be very similar to the nature of the competitive demands for which the training is being done.
2. How much stress should be applied?
3. How often?
4. For how long should it be applied? Questions 2, 3 and 4 refer to the training load - its intensity, duration and frequency. They are the toughest questions to answer, and the
ability to answer them is a major determinant in separating the good coach from the average coach.

5. Where specifically should it be applied? If you desire anaerobic endurance in the arms, do not waste a lot of time stressing the aerobic capacity of the arms or any other muscle group.

Every movement initiated by muscular action requires two factors: (1) the application of contractile force, and (2) time to exert that force. The two factors, when combined in a maximum effort, are inversely related. The closer one comes to exerting maximum force, the less time that force can be exerted (or the fewer are the number of repetitions that can be performed). This inverse relationship is important to understand when applying the S-A Principle to strength training or endurance training, since the two kinds of training require opposite kinds of stress for optimal training results (adaptation). Strength development requires training at high percentages of one’s maximum contractile force (and therefore relatively short periods of time), but training for optimal endurance development necessarily focuses on long periods of time (or many repetitions of an action) with a relatively low percentage of maximal contractile force.

The following graph (Maximum Exercise Continuum) illustrates the inverse relationship between force and time (or repetition) in exercises that are done to their maximum. And it shows the approximate place on the continuum where strength developing (S), aerobic endurance-developing (AE) and volleyball-related anaerobic endurance-developing (V) exercises would fall. Thus it can be seen that training using exercises that would fall to the extreme left side of the continuum will optimally develop strength but will not develop aerobic endurance, while exercises that would be placed to the right portion of the continuum are endurance-developing in nature. Exercises that would fall toward the middle of the continuum will help to develop both muscular strength and cardio-respiratory endurance, but will not develop either to their respective maximum.
Strength Training

Three different terms will be dealt with in this section: (1) strength, (2) power and (3) muscular endurance (or strength endurance). Although all three are highly related, and training for one will have an impact on all three, they are different enough from each other to be considered separately.

Muscular strength is the ability to exert contractile force. A muscle’s ability to exert force is determined by the strength of the individual fibers of that muscle and by the number of fibers that can be recruited during any single contraction. Thus it is determined by a combination of the protein infrastructure (i.e., the contractile elements) of the fibers and by the neuromuscular coordination of each effort to exert force. Both of these elements can be improved through proper training.

Power is the rate at which force is applied; in other words,

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\text{Power} = \frac{\text{Force}}{\text{Time}}
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It is sometimes called explosive strength, and it involves not only strength, but speed. Therefore power can be improved through training that specifically is targeted to improve speed or strength or both.

Muscular endurance (or strength endurance) is the ability of a muscle to either sustain or repeat a contraction over a period of time when that contraction involves a high percentage of that muscle’s maximum force.

The question now arises, “How do we properly apply the S-A Principle to these three aspects of strength training?” It can seem to be a pretty confusing topic when one considers all of the various systems and programs of strength training that have been advocated over the years. There is the Overload Principle; the Progressive Resistance Exercises (PRE); the terms: isometric, concentric, eccentric, isokinetic, and plyometric; circuit training; etc. All of them have a legitimate relationship to strength training, but they are all subordinate in importance to the central S-A Principle. To capsule the application of the S-A Principle to strength training in general terms: one must cause the muscles to exert at least 75% of their maximal contractile force every other day over a period of six weeks or more, working each exercise for between 1 and 3 sets of between 1 and 12 repetitions. In that one statement we have answered all of the questions concerning the stress that we asked previously. But one must keep in mind that the figures given (6 weeks, 1 to 3 sets, 1 to 12 reps) are only guidelines, they are not “magic” numbers that must be strictly adhered to; they only ensure that the exercises are strength-developing in nature and are not going to become cardio-respiratory endurance developers. To apply the basic principle to a more specifically defined set of desired outcomes, one needs only to modify the way in which it is applied. For example, the decision could be made to work the muscles eccentrically at slow speeds for 3 sets of 15 reps if the specific desired outcome is the development of slow, sustained muscular endurance for doing “negative” work.
Obviously such a decision would be wrong for volleyball players. Volleyball players need explosive strength (power) and muscular endurance much more than they need “pure” strength (increased maximal contractile force).

If players are relatively weak and need to increase their maximal contractile force as a base or foundation from which to build more power and/or muscular endurance, the strengthening exercises should emphasize heavier weights (or resistance) with fewer repetitions. However, even in these kinds of exercises the players should be encouraged to contract against the resistance explosively; they should not be taught to purposely work slowly unless there is a real chance of injury from fast work (e.g. if the weight machine is poorly designed). The form of contraction used and the type of resistance used is not critical to the basic outcome of increased strength as long as the basic principle is followed. Those factors only become important as one more specifically defines the desired outcomes; then the form of resistance, type of contraction and technique used in the exercise become much more important due to the specificity of training outcomes.

To incorporate the principle of specificity of training into a strength training program, all one needs to do is choose exercises that imitate the movement patterns that one wishes to strengthen and then add the proper amount of resistance to that movement so that near-maximum force must be used to perform the movement. If the movement is one that is complex and involves more than one muscle group or several different joints, it would probably be best to break the movement down into component parts and train each component separately. That way one can ensure that proper resistance is being applied to all of the muscles involved.

To help develop power one needs to perform the exercises at the maximum rate of speed that the resistance will allow, probably using slightly less resistance than would be used for pure strength development. Also one should “speed train” the same exercises, performing the exercises at maximum speed with low or no added resistance. Some sprinters and jumpers have successfully developed greater leg speed (and thereby greater power) by sprinting downhill; this causes the speed training to be faster than normal with below normal resistance. If a volleyball player can gain strength through explosive resistance training (moderate to heavy) and then gain speed in the same exercise through speed training, the end result should be increased power (greater force in less time).

A lot of the jump training that is prevalent in volleyball programs throughout the world results not only in increased power and thereby increased vertical jumping ability, but it also (and perhaps more importantly) results in increased anaerobic jumping endurance. The degree to which one can increase the maximum vertical jump is significantly limited by the hereditarily-determined percentage of fast-vs-slow twitch fibers present in the jumping muscles of that person. If the player does not have a relatively high percentage of fast twitch fibers, that person will remain a relatively low jumper even though a good jump training program (including jumping technique work) can help somewhat. What is perhaps more important for that player is the ability to jump repetitively at a high percentage of his/her maximum vertical jump throughout the volleyball match.

High degrees of muscular endurance are not very important for the upper body of volleyball players. It is somewhat more important in the legs for maintaining low ready-position posture
when playing backline defense. Squat exercises using slightly higher reps (approximately 25) with slightly less resistance than used for pure strength development would be good for helping to develop the muscular endurance needed.

### Cardiovascular-Respiratory Endurance Training

There are basically two major types of cardio-respiratory endurance, aerobic and anaerobic. Aerobic endurance is the ability to persist at an activity that is relatively long lasting (several minutes to hours) that relies very heavily upon the $O_2$-ATP system to provide the continual supply of energy needed to perform. But an activity that is done at a rate faster than the $O_2$ system can provide ATP must rely on the anaerobic energy systems (PC or partial glycolysis) to provide the extra energy needed, thus the term anaerobic (without $O_2$) endurance. In either case the limiting factor in continuing the activity is the ability of the body to provide energy at the rate needed by the activity. Volleyball requires both types of endurance. During ball-in-play time volleyball is very much anaerobic with lots of explosive, quick bursts of energy. But between rallies, the movement patterns and recovery time are very much aerobic in nature.

When developing a training program for endurance development the coach should recognize that there are two main components of endurance development, general and specific. General refers to those facets of endurance capacity that are developed by any type of endurance exercise, in other words those changes in the cardiovascular and/or respiratory systems that will help to increase one's aerobic capacity (e.g. increased stroke volume of the heart) for all endurance activities. They include all of the changes that make those two systems operate at a higher efficiency during exercise. The specific components include the localized changes that occur in the trained muscles, such as increased glycogen storage and increased vascularization, as well as the specific energy system (PC, partial glycolysis, or $O_2$) that is being stressed and trained.

Unlike strength training, endurance training should be done every day, and it should emphasize time (or reps) while de-emphasizing the importance of force (or resistance to movement). Endurance training for the volleyball player should be done in the gym, not in the weight room.

Training for aerobic endurance entails long-lasting continuous movement at moderate to slow speeds such that one does not incur a large $O_2$ debt. It should be noted at this point that research evidence indicates that maximum aerobic endurance capacity and maximum muscular strength can not be developed simultaneously in any one person; the endurance training tends to decrease the effectiveness of the strength training.

Anaerobic training involves a different kind of stress. It requires many repetitions of short, all-out efforts that will significantly fatigue the muscles in a matter of seconds or certainly within a couple of minutes. From a purely physiological standpoint it is probably the most important element in a volleyball training program. If we coaches are going to expect our players to successfully perform explosive-type movement skills at the end of the fifth set, we must train them to do those skills with anaerobic endurance-developing drill work. Only when
the players' anaerobic energy systems are sufficiently stressed through high quality repetitions will they adapt to allow the players to work at very high intensity throughout an entire match.

**Flexibility Training**

Flexibility is defined as the range of movement in a joint or series of joints, and it involves the muscles, tendons, ligaments and connective tissue surrounding those joints. In any joint actions where skeletal structure permits movement beyond what the surrounding soft tissues (especially muscle) permit, the flexibility can usually be significantly increased with a proper stretching program. Both research and empirical evidences indicate that the best way to stretch muscles is to:

1. **Warm up first.**

   By first mildly exercising the muscles that are going to be stretched, one increases the internal temperature of those muscles. This temperature increase decreases the internal viscosity of the muscle thereby allowing for easier stretching with less possibility of injury from the stretching exercise itself.

2. **Use static stretching**

   Players should perform slow, sustained, static stretching exercises, not the ballistic (bouncing) type that has for so many years been used in various sports. The ballistic type of stretch causes a stretch-reflex-initiated contraction of the very muscle that is being stretched. A slow stretch produces less than half the tension increase in a stretched muscle compared with what a quick stretch produces.

   A good year-round flexibility program cannot only help to prevent a number of acute injury problems from developing, but it can also help to alleviate or prevent the chronic lower back pain to which so many volleyball players seem prone.

**Training other Fitness components**

Agility (the ability to change directions quickly), balance and neuromuscular coordination are abilities that are either combinations of the other components already referred to (as is agility) or they are so highly related to specific skills and techniques as to be more related to other manual chapters. In either case the training principle remains the same: specifically practice the component with exercises that are as close as possible to the desired-outcome skill, and do so often enough that the stress will stimulate a positive change.
Integrated Training

During the late 1970’s and early 1980’s, there was a trend in volleyball training programs as well as in a number of other competitive sports, to separate and compartmentalize the various aspects of a training program (e.g. ball-handling skills, endurance, psychological training, etc.). Each aspect was being trained as if it was somehow unrelated to the others. That was a mistake. A volleyball player is a complete human being, and the demands of the sport require that the player be prepared as well as possible in all aspects of the game together, not separately. So to the degree that it is possible, physical/physiological training should be integrated with skill training, tactics training, psychological training, etc. An example of such integration would be a very high intensity scrimmage-like drill that is maintained either for a set period of time (e.g. 3 minutes) or until a set goal has been attained (e.g. 3 points in a row scored without an error).
Bibliography

Books


Articles


