Principles of Prevention and Treatment of Common Volleyball Injuries

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Injuries are, regrettably, an unavoidable hazard of sports participation. Although volleyball and beach volleyball are by most estimates relatively safe sports – particularly in comparison to other sports such as football (soccer) – epidemiologic research has revealed that volleyball athletes are at risk for certain types of injuries. Serious injuries which interfere with the athlete's ability to participate have obvious immediate consequences (time lost from training and competition) and may have long term implications as well (chronic disability and functional limitation). Coaches and trainers should therefore have an understanding of the most common volleyball-related injuries in order to appreciate the potential impact injuries may have on the both on the athlete and the team.

One of the first considerations in discussing the injuries for which volleyball athletes are at risk is to define what constitutes an injury. One accepted definition used in research is that an injury is any condition for which an athlete seeks medical attention. Injuries so defined may in turn be further subdivided into conditions that result in "time lost" from either competition or training and those that do not limit playing time. The length of time loss (typically reported in days or weeks) therefore provides a measure of injury severity that can be used to compare different types of injury. For example, in their 2004 study chronicling the injuries that occurred during one volleyball season in the Dutch professional league, Verhagen et al determined that shoulder injuries resulted in an average time lost from training or competition of 6.5 weeks – by far the longest mean absence from participation compared to other injury sites documented in their study.

Injuries are also commonly categorized by and compared based upon the body part affected (e.g. shoulder, knee, ankle, lower back). One additional useful classification criterion is whether the athlete was injured as the result of acute tissue overload or whether the injury resulted from chronic overuse. Acute injuries, such as ligament

sprains and muscle strains, occur when the limits of tissue distensibility and integrity are suddenly overwhelmed. The athlete is usually able to recall an exact mechanism of injury to correspond to the sudden onset of pain and functional limitation. In contrast, overuse injuries (e.g. tendinopathies) often occur insidiously. As a result the injured athlete often cannot recall a specific traumatic incident or a definite mechanism of injury. A hybrid of these two injury mechanisms occurs when tissue that has been weakened from overuse suddenly fails in response to an acute load. The athlete will identify the moment of "injury", but may not appreciate the impact of the chronic tissue overload that predisposed him (or her) to ultimately develop outright tissue failure.

Numerous studies reporting on injury patterns in volleyball have been published. Unfortunately, differences in the definition of injury and in calculation of incidence rates make it difficult (if not impossible) to directly compare these studies. Nevertheless, it is generally accepted that the most commonly occurring injuries are acute ankle sprains, followed by overuse conditions of the knee (patellar tendinopathy) and shoulder (multidirectional instability, impingement) and the lower back (nonspecific mechanical low back pain).

Acute Injuries – Ankle Sprains

Ankle sprains are clearly the most common volleyball-related injury, accounting for just over half of the acute injuries recorded prospectively by Bahr et al and Verhagen et al. Ankle sprains occur most frequently at the net when one player lands on another player's foot, inverting the ankle and stretching (or tearing) the ligaments on the lateral (outer) aspect of the ankle. Athletes who have suffered an ankle sprain in the past are more likely to suffer a subsequent injury. If the injured player has difficulty accepting weight onto the involved ankle, or if bearing weight results in severe pain, she or he should not continue playing and should seek prompt medical attention.

The goal of initial treatment for ankle sprains (and for acute injuries in general) is to limit internal bleeding and swelling, and to provide an environment conducive to

tissue healing. The acronym PRICE is easy to recall and nicely summarizes the early steps in caring for an acute ankle sprain. PRICE stands for:

Protection - Protect the ankle from further immediate injury. Depending on the severity of the sprain, a period of immobilization and restricted weight bearing may be necessary. As the athlete's condition improves, he or she may resume progressively more advanced activity patterns. However, use of an external support (brace, or taping) is generally recommended for the first six months following injury.

Rest - As mentioned, a period of restricted activity promotes early tissue healing. Weight-bearing may resume as symptoms subside, and activity may progress accordingly.

Ice - Application of ice (or other cryotherapy modality) provides analgesia and helps to minimize swelling. Although there is no consensus on treatment parameters, cold treatment is often applied for 20 minutes at a time (followed by 20 minutes without ice). Three such on/off cycles of cryotherapy may be administered in succession several times per day over the first 24 – 48 hours following the injury.

Compression - Temporary compression immediately following the injury limits swelling in the injured ankle, which in turn facilitates restoration of normal range of motion.

Elevation - Elevating the injured ankle also helps to minimize swelling immediately following the injury.

PRICE treatment should be initiated as quickly as possible following the injury (Figure 1). Acute injuries should also be promptly evaluated by a trained medical professional in order to carefully assess the extent and severity of injury, arrange for diagnostic testing as needed in order to arrive at an accurate understanding of the nature and extent of the injury, and formulate a definitive treatment plan. The athlete should be monitored carefully, and examined periodically to confirm that healing is progressing as expected. In addition to range of motion and strengthening exercises, the comprehensive treatment of ankle sprains should include instruction in a program

of neuromuscular (proprioceptive) re-education. This involves having the athlete balance on the involved limb, limiting corrective motion to the involved joint to the extent possible (Figure 2). As the athlete improves, these balancing exercises should be made progressively more challenging (both in terms of duration, and in terms of adding unstable surfaces or other challenges to the maintenance of balance). Return to play decisions following an ankle sprain (or indeed any injury) should be guided by functional recovery rather than mere absence of pain. In their 2004 study, Verhagen et al documented that ankle injuries resulted in a mean of 4.5 weeks of time lost from training or competition.

Since ankle injuries are so common among volleyball players and result in considerable time loss, it makes sense to try to prevent them. Primary prevention entails practicing proper footwork at the net, integrating proprioceptive exercises into the athlete's regular conditioning program, and consistent use of external ankle braces. Only recently has there been any evidence for a significant prophylactic effect from the use of semi-rigid external ankle orthoses (Figure 3) among volleyball players. Despite some concern voiced by coaches and athletes alike, there is no evidence in the literature to suggest that the use of ankle orthoses increases the risk of knee injuries. Another means of reducing the risk of ankle sprains would be to modify the existing centerline rule, which allows for a portion of the foot to penetrate onto the opponent's court without a violation. While such rule changes have been discussed, it seems unlikely that any substantive modification of the centerline rule would be possible without significantly altering the dynamic aspects of the sport as it is currently played.

Overuse Injuries – Patellar Tendinopathy

Anterior knee pain represents the second most common diagnosis among volleyball athletes. The most common causes of anterior knee pain among volleyball players are patellofemoral syndrome, and patellar tendinopathy (also known as "jumper's knee"). Both of these diagnoses represent overuse conditions. Fortunately, volleyball players appear to be at relatively low risk for acute knee problems, such as injury to the anterior cruciate ligament. Nevertheless, overuse conditions such as

patellar tendinopathy can extract a very high cost in terms of loss of time, and may lead to chronic debilitating symptoms that adversely affect the athlete's quality of life.

Unlike acute injuries, which have a distinct mechanism and time of onset, overuse injuries are insidious in nature. Athletes with overuse injuries generally cannot recall a specific moment when their injury occurred, but report instead a history of activity related discomfort that has become progressively more severe over time. Many athletes attempt to "play through" or compensate for the initial symptoms of overuse pathology, and only after the pain becomes limiting or the performance deficit intolerable will the athlete take time off from training or competition. Consequently, treatment of overuse injuries is often challenging. The first priority is to alter or minimize the load on the injured area. This is generally accomplished through activity modification. Reducing the load on the injured area allows the affected tissues an opportunity to recover and begin healing. However, in order to adequately treat an overuse injury, it is important to examine the athlete's risk factors for injury.

Risk factors for injury (which can be defined as those qualities which increase the likelihood that an athlete will develop a certain type of injury), may be categorized as either "intrinsic" or "extrinsic" to the athlete, and as either "modifiable" or "unmodifiable". Risk factors for jumper's knee include the volume of jumping and jump training which the athlete must endure (*extrinsic, modifiable*), the biomechanics of the knee during the spike approach and upon landing from the jump (*intrinsic, modifiable*), and the composition of the surface on which the athlete trains and competes (*extrinsic, modifiable*). Ferretti and colleagues documented that hard, unforgiving surfaces increase one's risk of developing jumper's knee. Not surprisingly, therefore, jumper's knee is less common among beach volleyball players than it is among indoor volleyball athletes. The amount of knee valgus stress on the lead (usually non-dominant) knee during the spike approach jump is a risk factor for developing patellar tendinopathy, as is the degree of knee flexion achieved during landing from the spike jump. Interestingly, those athletes who had the greatest jumping ability were found to be at the greatest risk for developing patellar tendinopathy. There are undoubtedly other genetic susceptibility factors involved in the pathogenesis of jumper's knee, since not all athletes who undergo comparable jump training programs will develop symptomatic jumper's knee. Practical prevention

strategies for jumper's knee include strengthening and conditioning the muscles of thigh, hip, and buttocks so that they can effectively absorb the shock of landing from jump after jump. Analysis of technique is also important, as bending too deeply at the knees when landing from a jump, or excessively "toeing in" during the loading and take off phases of the jump can predispose the athlete to jumper[1]s knee. Perhaps the most effective preventive intervention is simply reducing the load on the knee extensor mechanism by limiting the volume of jumping required during training sessions.

Even with an appreciation of some of the modifiable risk factors for anterior knee pain, effective treatment of jumper's knee often remains elusive, further underscoring the importance of prevention. Some athletes benefit from the use of an infra-patellar strap, which is thought to redistribute the traction force on the patellar tendon during activation of the quadriceps, thereby reducing the risk (or minimizing the symptoms) of tendinopathy. Eccentric quadriceps training (Figure 4, shown without the incline board that can be used to make the exercise more demanding) may be of some benefit as a pre-season conditioning exercise, but this type of exercise has not been shown to be effective in treating symptomatic patellar tendinopathy during the competitive season. Advances in our understanding of the underlying cellular and tissue pathophysiology have led to new methods to treat this condition, which at its worst can be potentially career-threatening. Among these treatments is sclerosis of neovessels under ultrasound guidance, which has been shown to be of some clinical benefit. Other less proven methods of treatment include injections with platelet rich plasma. Although thought to deliver concentrated growth factors and cellular mediators involved in tissue healing direct to the site of tissue injury, there is little scientific proof of the effectiveness this technique. Severe cases of patellar tendinopathy may require surgical intervention.

Overuse Injuries – Shoulder Problems

The shoulder is the third most commonly injured body part overall. Injuries to the shoulder most often occur as the result of chronic overuse. Acute shoulder trauma (such as an anterior shoulder dislocation) does occur, but it often occurs in the context of underlying overuse-related pathology. Spiking is perhaps the most

dramatic skill in volleyball. It has been estimated that an elite volleyball player, practicing and competing 16 to 20 hours per week, may perform as many as 40,000 spikes in one season. The volume of overhead loading inherent in that much activity places enormous demands on the glenohumeral joint specifically and the shoulder girdle in general.

The shoulder is an extremely mobile joint that permits the volleyball athlete to swing high for a spike or reach out for a block. Athletic shoulder function is dependent upon the precise action of the rotator cuff and the muscles that stabilize the scapula (shoulder blade). These muscles must be well conditioned and work in a coordinated manner to ensure pain-free shoulder function. Unfortunately, through repetition and the sheer volume of training, the muscles and tendons of the shoulder girdle may become overloaded and fatigued. This is turn may result in "wear and tear" damage to the shoulder, which over time may culminate in a time-loss injury. Regrettably, treatment of overuse conditions of the shoulder girdle (such as rotator cuff tendinopathy) is often incompletely successful. Accepted principles of non-operative treatment include load reduction (limiting the number of spikes or serves performed) and correction of any underlying imbalances of strength or flexibility through appropriate training programs (Figure 5). Some conditions, such as shoulder instability due to injury to the glenoid labrum, may require surgery if conservative management does not restore the athlete to an acceptable level of function.

As with jumper's knee, comprehensive treatment of volleyball-related shoulder problems requires that specific risk factors for injury be identified and addressed. Our understanding of the risk factors for volleyball-related shoulder problems is unfortunately quite limited. Kugler et al (1996) described the adaptive changes in scapular positioning they observed in elite volleyball players, but there has been little volleyball-specific follow-up to this insightful paper. In their recent study, Reeser et al found that spiking volume (*extrinsic, modifiable*) and scapular dyskinesis (*intrinsic, modifiable*) were associated with an increased incidence of shoulder problems. Shoulder pain was also associated with core instability (*intrinsic, modifiable*), reflecting the importance of the kinetic chain in generating power for the spiking motion. Wang and Cochrane, along with other researchers, have documented the ratio of eccentric shoulder external rotational strength to concentric shoulder internal

rotational strength among volleyball players. Their work, collectively, suggests that a reduced ratio represents a risk factor for injury. Wang and Cochrane (2001) also documented that those with a longer training history had a higher incidence of shoulder problems. Lastly, there have been numerous reports in the literature describing the suprascapular mononeuropathy that is common in volleyball players, but the risk factors for the onset of this condition remain a matter of debate. Similarly, treatment for this condition is somewhat controversial, since it frequently is essentially painless and causes little or no performance deficit.

Prevention of shoulder pathology among volleyball athletes has been poorly studied. It is not known whether intervening in any of the aforementioned areas, such as instituting a program of flexibility training to address the deficit of glenohumeral internal rotation commonly observed in the dominant shoulder, will minimize or eliminate the volleyball athlete's risk of developing shoulder pain. Nevertheless, it is probably advisable to incorporate posterior capsular stretching into the shoulder girdle strengthening and scapular stabilization program followed by elite volleyball athletes. Most conditioning programs also include a program of core stabilization exercise designed to promote correct posture and facilitate the generation and efficient transfer of power throughout the kinetic chain.

Low Back Pain

Volleyball players, along with the rest of the general population, frequently complain of lower back pain. More often than not, the pain will resolve spontaneously within several weeks, and as such probably does not indicate serious pathology. However, mechanical back pain is much less common among young athletes, and those individuals 20 years of age or younger who have persistent back pain that limits them from participating in activities (such as volleyball) should be evaluated by a sports medicine physician. There are many different causes for back pain, and as a result the exact cause of an individual's lower back pain often cannot be precisely identified. That said, if a young athlete's low back pain is made worse by lumbar extension (bending backwards), then a stress fracture of the lumbar spine ("spondylolysis") should be ruled out. If the athlete has suffered an acute strain of the muscles of the low back, then the pain will typically be self-limiting and should

improve rapidly over a few days. Pain related to an intervertebral disc injury or spinal nerve impingement may be disabling, and should be treated aggressively. Anti-inflammatory medicines such as ibuprofen can help to control symptoms in the short term. Volleyball training (especially jumping and strength training) should be curtailed until the athlete is feeling better. Because of the different types of injury that may give rise to low back pain, it is difficult to give general recommendations for exercises that would be therapeutic in all situations. For this reason, an appropriate exercise prescription should be developed in consultation with a trainer, physical therapist, or sports medicine physician. Prevention of lower back problems includes minimizing torsional stress on the spine, particularly while loaded, as well as minimizing extremes of or repetitive flexion and/or extension - particularly in the young athlete. Proper weight-training technique is an important aspect of a comprehensive injury prevention program, as is an integrated program of core stabilization.

Principles of Injury Prevention

Over the last 20 years, the ability of sports medicine professionals to diagnose and treat athletic injuries has improved dramatically. Athletes are now capable of returning from serious injuries faster than ever before due to aggressive treatment and rehabilitation programs. The greatest remaining challenge in the field of sports medicine is to design and implement programs that will reliably prevent injuries from occurring in the first place. Although injuries cannot be entirely avoided, our present understanding of the basic risk factors associated with the most common volleyball-related injuries can help coaches and athletes prepare themselves and their teams for a successful season with minimal risk of injury. Several general strategies that can be adopted in an effort to reduce an athlete¹s risk of volleyball-related injury are presented below. Although certainly not exhaustive, the principles briefly outlined form the foundation of a sound volleyball injury prevention program.

1. Follow a sport-specific program of strength training and conditioning.

Volleyball is primarily an anaerobic sport. Nevertheless, volleyball athletes should maintain good cardiovascular fitness as it will enhance their ability to recover

between points and after matches. Elite volleyball players also train to become strong and powerful, not only for the performance advantage offered but because well-conditioned muscles are better able to endure the demands of sport participation, and are less likely to become injured. In addition, fitness allows the athlete to maintain optimal form and technique throughout a match, thereby minimizing the risk of fatigue-related injuries. Warm-up prior to and proper cool-down following a competition readies the athlete for the demands of the event and facilitates subsequent recovery.

2. Avoid overtraining.

Adequate rest is almost as important to an athlete's development and performance as proper training. Athletes who train too hard may not give their bodies sufficient time to recover, resulting in an increased risk of overuse injuries. Each athlete has a unique tolerance for training and individual needs for rest and recovery, making it difficult for a coach to take a "cook book" approach to training for all members of the team. Athletes who persistently train without sufficient rest are at risk for developing a syndrome of mental and physical fatigue commonly referred to as "burnout". Elite athletes train for volleyball throughout the year, but vary the intensity and composition of their workouts so that they achieve and maintain peak fitness during the competition season. There is evidence that this practice, known as periodization, further reduces an athlete's risk of injury.

3. Pay attention to and practice proper technique.

As we have seen, most ankle sprains occur when an athlete lands on a teammate's or opponent's foot while making a play at the net. Practicing good blocking footwork and controlled spike jump approaches and landings can minimize the likelihood of contact-related injuries about the centerline. It is also important to attend to technique, since subtle alterations in performance and technique often provide the earliest clues that an athlete is developing (and attempting to compensate for) overuse related dysfunction.

4. Train (and maintain) core stability.

To function properly, joints (and in fact the body as a whole) must be mechanically stable. Stability is conferred through both passive and active mechanisms: the musculoskeletal anatomy provides the joint with an underlying passive structural stability which is augmented through dynamic (active) neuromuscular control. Such control can be learned, and indeed is an essential component of the athlete's ability to adapt to the demands of and excel in their chosen sport. When actively engaged in sports, athletes are rarely static - their position in space is constantly changing as they react to the competitive situation. In volleyball, although most of the activity is initiated by the legs, the culmination of a given movement often involves the upper limbs reaching overhead. Thus, even though the skill may be performed by the upper body, the energy to perform those skills is generated by the lower limbs and by the trunk. The smooth and efficient transfer of energy from lower limb to upper limb is dependent on an integrated response from the intervening segments of the "kinetic chain" - particularly the pelvis and the thoracolumbar spine.

Together the pelvis and the thoracolumbar spine form the foundation of what has become known as the athletic "core." Research has demonstrated that a stable, well-conditioned core plays a critical role in coordinating the body's movements and in minimizing the athlete's risk of both upper and lower limb injuries, as well as low back pain. The core may therefore be thought of as a functional integration of the associated anatomical structures of the pelvis and thoracolumbar spine, including the hip flexors, hip extensors, hip abductors and adductors, abdominals, paravertebral musclature, and the diaphragm. Developing and maintaining the athlete's dynamic core strength and stability will reduce his or her global risk of injury by facilitating proper coordination and energy transfer along the kinetic chain. Suggested exercises are presented in Figure 6.

5. Properly rehabilitate injuries.

Research has shown that a body part, once injured, is more likely to be injured again upon returning to play. To prevent acute injuries from becoming chronic recurrent injuries, it is imperative that the injured athlete receive careful evaluation from a

sports medicine provider, so that an accurate diagnosis can be made and a comprehensive treatment program started. Typically the athlete will be allowed to return to competition once they can perform sport-specific skills- such as jumping and spiking - without pain. However, a truly thorough program will rehabilitate the athlete "beyond the absence of symptoms". This philosophy requires that the athlete's trainer, therapist, or team physician identify and address any structural and/or functional factors that contributed to (or resulted from) the injury. For example, an athlete with a stress fracture of the lower back may develop inflexibility of the hamstrings and subconsciously alter his or her spiking form so as to minimize stress on the lower back. Unless these factors are identified and corrected during the rehabilitation process, the athlete may subsequently develop shoulder pain as a consequence of the altered mechanics.

6. Maintain proper nutrition and hydration.

Consuming a balanced diet with adequate caloric intake ensures that the athlete will have sufficient energy stores to allow full participation throughout the season. Dietary protein intake provides the building blocks to repair injured tissues, while fats and carbohydrates serve as fuel for the athlete's fire. Sufficient fluid intake (preferably water or - during competition - a sport's drink) prevents dehydration and minimizes the risk of developing heat illness. Coaches should be particularly attentive for recurrent injury among female athletes, as this may indicate the presence of the "female athlete triad" - a condition characterized by disordered eating (typically anorexia), which in turn leads to irregular or even absent menstrual cycles (amenorrhea), and eventually to loss of bone mass (osteoporosis).

7. Avoid early sport and position specialization.

Volleyball is a sport that can be enjoyed by the young and old alike. However, engaging young athletes in overly structured, competitive programs may increase their risk of injury. The American Academy of Pediatrics Committee on Sports Medicine and Fitness has discouraged "specialization in a single sport before adolescence", and it seems reasonable to conclude that the volume of training in developing athletes should be limited in order to reduce the risk of developing

overuse injuries. Unfortunately, no studies have been done to quantify what represents an appropriate training load for the young volleyball athlete. Athletes, coaches, and parents must therefore be particularly attentive to the early warning signs of overuse injury, including activity-related pain and deteriorating performance.

A Final Thought

It has been stated that great success comes from great collaboration. It seems reasonable to extrapolate on that theme and suggest that the modern international volleyball player may potentially benefit from the input of a myriad of professionals spanning the entire sports medicine spectrum, including biomechanists, nutritionists, physiologists, physiotherapists, and physicians. Of course, one must include the coach (trainer) in that list, since it is the coach who must decide how to best train the athlete and who ultimately implements the advice of the medical professionals regarding return to play following injury. In that regard, it should be acknowledged that on occasion the coach and the medical team may be at odds regarding their motivation. In the long run, however, it is the athlete's health and well being that should serve as the principle motivation behind all recommendations offered by the sports medicine team, in addition to serving as the deciding factor in all related decision-making.

For additional information on volleyball sports medicine and science, the interested reader is referred to "Volleyball" (part of the Blackwell Olympic Handbook of Sports Medicine and Science series) edited by Reeser and Bahr.

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