

Spike it rich....

The Ergonomics of Volleyball

By Tamara Mitchell

Edited by Sally Longyear



People of all ages and skill levels play volleyball in over 200 countries around the world. William G. Morgan at the YMCA in Springfield, Massachusetts, invented volleyball in 1895. The goal was to create a game that would be less stressful than basketball on the bodies of young athletes, yet enjoyable and competitive enough to keep young people fit.¹ While most of us envision volleyball as a fun game played occasionally at beach parties or the park, it is a sport with varsity school teams and traveling professional teams. Volleyball was first recognized as an Olympic sport in 1964 in Tokyo for both men and women. At the 1996 Olympic games in Atlanta, beach volleyball was added as a full medal sport.¹ 65% of the players registered with USA Volleyball are less than 18 years of age.

There are three types of volleyball. Outdoor sand volleyball is played with two players per side. Indoor volleyball is played with six players per side. Park or grass volleyball is a new discipline of outdoor volleyball and is played with four players per side. Sand volleyball requires a higher level of overall fitness than indoor volleyball, since two players must cover the same sized court with fewer players.¹ In volleyball, players rotate position, so unlike other sports where players play one position throughout a game, volleyball does have the advantage that different motions are required in playing the different positions: serving, setting, spiking, etc.

We will focus in this article on the repetitive motion (overuse) injuries which can be caused or exacerbated by the sport of volleyball. As with most sports, acute injuries caused by sudden trauma do occur, but they are much less prevalent than overuse injuries. Between 50-80% of all injuries in volleyball are overuse injuries.² In fact, most injuries are not serious enough to result in more than a few days of lost play. Blocking, followed by spiking, accounts for the highest rate of injury. Defense maneuvers (e.g., serving, passing and setting) account for a smaller number of injuries.² A recent study of professional beach volleyball players found that the three most common overuse conditions were low back pain, knee pain, and shoulder problems.³ The same study found that the most common acute injuries were knee, ankle and finger injuries.

Although wrist and forearm injuries are rarely reported as a result of playing volleyball, anyone currently suffering symptoms of Repetitive Strain Injury (RSI) in the wrist or forearm is not advised to play this sport. Volleyball requires hitting a ball with the hands and arms with force, which will cause further injury to damaged tissues.⁴

Traumatic injuries

Ankle, knee, and hand injuries account for most of the acute or traumatic injuries during volleyball play. Overuse injuries of the knee are far more common. Most finger sprains and closed fractures can be managed by splinting or taping and they rarely result in time missed from play or practice.

Ankle injuries account for 15-60% of acute injuries.^{2,5,6} The centerline is a line immediately beneath the net that separates the court into two halves. The rules regarding stepping on or over the centerline have a large impact on the safety of the game, since the most common ankle injury occurs when a blocking player's foot lands on the opponent spiker's foot that has crossed the centerline.² This accounts for 50% of all sprains.⁵ Recent research has been conducted to determine if injuries could be reduced by changing the centerline rules. Disallowing players to cross the centerline at all resulted in termination of too many rallies due to violation of the rule, which disrupted the

game. In fact, these violations often occurred in cases where there was very low injury risk (i.e., no player from the opposing side was in the vicinity).⁵ Another rule was proposed in 1998 allowing players to step completely over the line as long as there was no interference with the opposing team. This was discarded as too risky and was discarded. What is currently being suggested by researchers, based on rules followed by the United States women's collegiate Volleyball (NAGWS) requires front-row attackers to be more cognizant of the centerline, penalizes violations, yet doesn't interfere with the flow of the game for players or spectators. Specifically, the proposed rule allows hands and feet to completely cross the centerline as long as (1) there is no safety hazard; (2) there is no contact with the opponent; and (3) the distance of the encroachment is not significant. A safety hazard exists any time an opponent or teammate is jumping nearby.⁵

Overuse injuries

Prevention of overuse injuries is far better than treating injuries after they occur. The best way to prevent overuse injuries is to train properly before playing by developing flexibility, then build up strength and cardiovascular fitness.⁷ Gradually increase play time incrementally. Do not expect to play for hours without injury if you have not trained for it.⁷ On the other hand, do not overtrain, which can also contribute to overuse problems. There should be no pain with exercise. Any muscle soreness following exercise should be gone within one or two days. If pain persists or if there is specific tenderness or swelling, there may be a strain, tendinitis, or a sprain. Follow the guidelines for P.R.I.C.E. for any injuries you are aware of (described in our previous article on Injury).⁷

A 15 minute warm-up period prior to playing and 10 minute cool-down period after playing is recommended. Warm-up may consist of fast walking or light jogging around the court, jumping rope, or jumping jacks. Skill-specific drills should follow warm-up. Typically warm-up consists of hitting the ball back and forth by setting it or passing is between two players (called pepper). This is often followed by spiking practice where one player sets the ball and another spikes. Serving practice then immediately precedes the game.¹ There are a lot more drills which will facilitate greater flexibility. These are described further in Attachment 1.

Knee and leg.

Overuse injuries to the lower extremities account for a large number of injuries. The foot, shank, ankle, and knee experience repeated heavy loads during jumping and landing in volleyball. The body absorbs the weight of landing two ways. Bone deformation refers to the process by which applied forces are progressively attenuated as they are transmitted through the microstructures of the bone. Accumulation of microdamage to the bone may result in a stress fracture. An excessive number of microfractures are believed to produce localized stiffness and consequently are a precursor to osteoarthritis.⁸

The second means of absorbing the weight of landing is a lengthening of muscles and tendons as a shock absorber.⁸ Volleyball players performing blocking movements may experience asymmetrical loading during landing. Over a season, asymmetrical loading causing greater load on the lead leg will probably cause different injury patterns between the legs.⁸

“Jumper’s knee” (Patellar tendonitis), is the most frequent overuse injury in volleyball players. Up to 80% of overuse injuries are jumper’s knee.⁶ Studies have found that those athletes who could generate the greatest power and force had the highest impact forces upon landing, making them more susceptible to jumper’s knee. Other variables that have been found to correlate to development of jumper’s knee are turning the lower legs and feet outward when jumping, deep knee flexion angles at take-off and landing, playing more often than four times a week, and between 20-25 years of age.⁶

Recommendations for preventing knee and leg overuse injuries are:^{6,7,8,9}

- Since the highest jumpers are the most prone to jumper’s knee, limit jump training, especially if symptoms occur.
- Do not bend knees more than 90 degrees at take-off and landing.
- Do not turn the feet and lower legs outward when jumping.
- Play on courts with softer surfaces, such as sand, wood or synthetic “forgiving” surfaces; avoid concrete and linoleum courts.
- Prepare the lower body for asymmetrical loads through task-specific exercises, but allow for adequate recovery to avoid overuse injury from training and play. Overtraining can contribute to overuse problems.

- Watch out for signs of overuse injury. Only a delayed onset of *muscle* soreness is acceptable.

Shoulder.

Approximately 85% shoulder injuries occur as a result of overuse.¹⁰ Of all overuse injuries, 8-20% affect the shoulder, second to jumper's knee.¹ The rotator cuff is defined as the whole complex of muscles and tendons along with the ball and socket joint of the shoulders. Since volleyball involves a great deal of overhead activity and arm rotation with force, the rotator cuff is a prime candidate for overuse injury.

The shoulder has the widest range of motion of any joint in the body, but as a result, it is also the least stable joint. Rotator cuff muscles dynamically stabilize the shoulder joint and act in concert with the ball (humeral head of the upper arm) and the socket (glenoid fossa). The ligaments provide stability at the extremes of shoulder motion, whereas the shoulder girdle muscles work to coordinate motion of the upper arm (humerus) and the shoulder blade (scapula) throughout the shoulder's range of motion. To better understand the operation of the shoulder, associated problems, treatment of injury, and injury prevention stretches, please watch the dynamic presentation on the National Institutes of Health, Medline website.¹¹

Shoulder tendinitis is very common among volleyball players due to repetitive overhead arm movement. Shoulder pain, weakness, or both may be present. Diagnosis should be made to rule out other injuries, but if tendinitis is present, treatment includes rest, daily use of ice packs, and anti-inflammatory medications (aspirin or ibuprofen).⁶ A shoulder rehabilitation program should include exercises specific to the instability or tendinitis.⁶

Nerve compression called Suprascapular Neuropathy (SSN) is also very common in volleyball players. It is believed to result from the "floater" serve, a serve with no spin which is the most difficult to return. When performing this serve, the player must stop the overhand follow-through immediately after striking the ball resulting in a forceful exertion of muscles to decelerate the arm. The suprascapular nerve gets compressed. SSN is often painless because the suprascapular nerve is entirely a motor nerve. Since no pain is involved, medication is not required. Strengthening exercises are recommended after diagnosis rules out the possibility of ganglion cysts compressing the nerve.^{1,6}

Impingement injuries are inflammation of the rotator cuff tendons and the fluid inside the shoulder (bursa). A predisposition to impingements may be due to the structure of the size, shape and thickness of the outer edge of the scapula bone. The repetitive forward and overhead motions of the arms required in volleyball, along with fatigue are the primary causes for this condition. Prior to treatment, rotator cuff tears should be ruled out by a physician.¹²

SLAP (Superior Labrum Anterior-Posterior) lesions are tears in the upper biceps tendon and cartilage of the socket called the labrum.¹³ During the cocking phase of the volleyball spike, the arm is in extreme elevation and outward rotation, producing a twisting force at the biceps origin in the shoulder. Repetitive upward movement of the ball in the socket with detached labrum causes a high incidence of injury inside the joint itself. Unfortunately, SLAP lesions are often misdiagnosed and surgery is performed on the front of the shoulder. When reconstructive surgery has been performed properly on the rear of the socket joint, 84% of the patients returned successfully to previous levels of play.¹⁰ In most cases, surgery is not necessary. Treatment involves the use of anti-inflammatories, reduced activity, and physical therapy.¹⁴

Recommendations for avoiding shoulder injuries are:

- Strengthening the muscles and tendons of the shoulder will help to increase the stability of the shoulder and rotator cuff and reduce the potential for injuries. Please refer to the excellent websites of the American Academy of Family Physicians¹⁵, The Physician and Sportsmedicine⁶, the National Institutes of Health, Medline¹¹, and the Exercise Database¹⁶.
- Spike coordination drills with the shoulder joint held in different rotations.⁹

Low back.

Up to 14% of the overuse injuries in volleyball players are low back problems.^{1,6} The back takes a pounding every time the player lands. Volleyball players also arch and twist their backs to go up for spikes and then uncoil to violently hit the ball.

Recommendations for preventing back overuse injuries are:

1. Develop back muscles to help stabilize the spine.
2. Warm-up prior to play.
3. Decrease jumping activity.
4. Play on softer surfaces such as sand or wood.

Outdoor volleyball considerations⁷

Heat-related illness

Dehydration, heat cramps, heat exhaustion, and heat stroke are all dangers in outdoor volleyball. These things are far more dangerous than any of the injuries discussed in this article because they can lead to death. Weekend warriors will progress more quickly from dehydration to heat stroke than conditioned athletes. Initial signs of dehydration may include profuse sweating, weakness, fatigue, or a mild headache.⁷

Pre-load with non-alcoholic fluids (up to 64 ounces) prior to playing, and drink as often and as much as you comfortably can during play. Sports drinks replenish electrolytes and minerals better than water and you will probably drink more because it tastes better. Alcohol, heat and exercise do not mix because alcohol causes your body to excrete more fluids, impairs judgement, and masks your awareness of the signs of dehydration. Use an umbrella for shade and a fan and mist to cool your body in hot conditions.

Skin cancer

Outdoor volleyball increases your exposure to the sun and thereby increases your risk for skin cancers. Wear sunscreen and UV protection sunglasses to protect your eyes. Wear a hat, shirt, and use an umbrella to limit sun exposure.⁷

Cuts, Lacerations, and Blisters

Sand volleyball players are in danger of cuts and lacerations from sharp objects buried in the sand. Make sure you have a current tetanus shot and inspect all injuries immediately to determine the severity of the wound. Inspect the court and rake it prior to playing. Grass volleyball players may choose to wear shoes to avoid these injuries.⁷

Sand can get very hot, which leads to blisters. Invest in sand socks or use a pair of gym socks. If possible, wet the court's surface periodically until the sand cools or don't play during the hottest part of the day. Avoid popping a blister until after play to avoid infection.⁷

Further Reading

There is a new book on the market about volleyball for anyone who is serious about the sport. It covers biomechanics of volleyball skills, conditioning, nutrition, injuries and their prevention and treatment, gender issues, vision training, and volleyball sports psychology.¹⁷

This article and all of our articles are intended for your information and education. We are not experts in the diagnosis and treatment of specific medical or mental problems. When dealing with a severe problem, please consult with a healthcare or mental health professional and research the alternatives available for your particular diagnosis prior to embarking on a treatment plan. You are ultimately responsible for your own health and treatment!

REFERENCES:

1. *Sports Injury: Prevention & Rehabilitation*, by Eric Shamus and Jennifer Shamus, ©2001 by McGraw-Hill Co., Inc., New York. "Chapter 4: Volleyball" by Drexler, D. M., Briner, Wm. W., and Reeser, J.C.
2. "Volleyball Injuries", by Thomas Souza, D.C., D.A.C.B.S.P.,
<http://www.chiroweb.com/archives/18/10/15.html>

3. "Injuries Among World-Class Professional Beach Volleyball Players", by Roald Bahr, M.D., PhD., & Jonathan C. Reeser, M.D., PhD., ©2003, The American Journal of Sports Medicine, 31:119-125.
<http://journal.ajsm.org/>
4. "Exercise for Computer Athletes (sic)", by Deborah Quilter, ©1996-2003, Deborah Quilter.
http://www.rsihelp.com/compcurr_980407.shtml
5. "The Effect of a Center Line Rule Change on the Incidence of Ankle Sprains and Rule Violations in Women's Collegiate Volleyball", by Jonathan Reeser, Julie Agel, Randy Dick, and Roald Bahr. ©2002, Oslo Sports Trauma Research Center, Norwegian University of Sport and Physical Education. <http://ostrc.no/>
6. "Volleyball Injuries: Managing Acute and Overuse Disorders", by Wm. W. Briner, M.D. and Holly J. Benjamin, M.D., ©1999, McGraw-Hill. The Physician and Sportsmedicine, 27(3), March 1999.
http://www.physsportsmed.com/issues/1999/03_99/briner.htm
7. "Beach Dangers", by Brenda Chan, P.T., ©July, 1997, Volleyball Magazine.
<http://www.volleyballmag.com/fitness/jul97.htm>
8. "Asymmetrical Loading of Lead and Lag Legs During Landing of Blocking Movements", by Jill McNitt-Gra, Ph.D., Barry Munkasy, M.S., Witaya Mathiyakon, M.S., P.T., Nancy Hillman Somera. National Collegiate Athletic Association (NCAA), Biomechanics Research Laboratory, and Women's Volleyball Coaching Staff, University of Southern California, Los Angeles, CA.
<http://www.avca.org/sportsmed/smpcarticles/smpcasymmetrical.htm>
9. "Spiking Injuries Out of Volleyball: A Review of Injury Countermeasures", by Erin Cassell, ©1994-2001, Monash University, Monash University Accident Research Centre – Report #181,
<http://www.general.monash.edu.au/muarc/rptsum/es181.htm>
10. "Shouldering the Load: Shoulder Injuries and the Volleyball Attacker", by Donovan A. Shaw, ©2002, USA Volleyball. http://www.usavolleyball.org/educat/articles/article_shaw.htm.
11. United States National Institutes of Health and the U.S. National Library of Medicine MEDLINE Plus Health Information Website. "Rotator Cuff Injuries".
<http://www.nlm.nih.gov/medlineplus/tutorials/rotatorcuffinjuries/op159101.html>
12. "Rotator Cuff Injury and Surgery", by Michael G. Ciccotti, M.D., ©2002, Rothman Institute, Philadelphia, PA.
<http://rothmaninstitute.com/sportsmed/rotator.htm>
13. "Animated Medical Graphics: SLAP Lesion of the Shoulder", ©1999 by Animated Medical Graphics,
<http://www.animatedmedical.com/SLAP/SLAP.html>
14. "Superior Labral Tear (SLAP Lesion)", ©www.emedx.com, Sports Medicine and Orthopedic Surgery.
http://www.emedx.com/emedx/diagnosis_information/shoulder_disorders/superior_labral_tear_outline.htm
15. "Rotator Cuff Exercises", ©2001-2003, American Academy of Family Physicians.
<http://familydoctor.org/handouts/265.html>
16. Exercise Database, (especially elastic band exercises).
<http://www.exercisedb.com/exercisedatabase/search.asp?muscle=Elastic%20Band>
17. *Volleyball (The Handbook of Sports Medicine and Science)*. By Jonathan Reeser and Roald Bahr. ©2003, Blackwell publishers.

Attachment 1 Pregame Drills¹

According to the FIVB 2000 rules, prior to a match, if the teams have previously had a playing court at their disposal, each team will have a 3-minute warm-up period at the net. If they did not have a court available to them, they may have 5 minutes each. If both captains agree to warm up at the net together, the teams may do so for 6-10 minutes. Following games, players need to cool down for a similar period in reverse function with decreasing intensity.

Self-passing drills.

Players pass the ball to a height of 1 ft. above the net and within a 5 ft. circle. three players incorporate lateral movement and ball control.

Setting drill.

Using a basketball court, a player is thrown a ball at the foul line and the player tries to pass it into the basket. If the player misses, set the rebound back into the basket.

Hands drill.

Three players begin on the end line, one at the right corner, one at the middle, and one at the left corner. An assistant tosses the volleyball to an area in front of a player. The player will move to the spot and then pass the ball to a predetermined area. Following the pass, the player will backpedal to tag the player standing at the end line. The players rotate in a clockwise manner after being tagged.