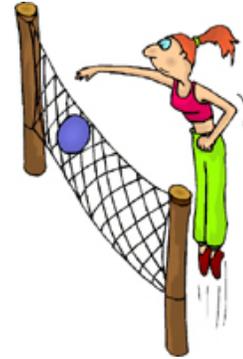


Spike it rich....

The Ergonomics of Volleyball



By Tamara Mitchell

Volleyball is played in over 200 countries around the world by people of all ages and skill levels.^{1,2} It is second only to soccer in popularity throughout the world.² Volleyball was invented in 1895 by William G. Morgan at the YMCA in Springfield, Massachusetts.^{1,2} 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 Beach volleyball evolved sometime in the 1920's and organized beach tournaments began as early as 1948.² Volleyball was first recognized as an Olympic sport in 1964 in Tokyo for both men and women.^{1,2} At the 1996 Olympic games in Atlanta, beach volleyball was added as a full medal sport.^{1,2} 65% of the players registered with USA Volleyball are less than 18 years of age.

There are several types of volleyball; indoor, outdoor sand, outdoor grass, water, and wallyball each with distinct set of rules and number of players per side.^{1,3,4,5} 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. The only position that does not rotate and that has specific responsibilities is the libero in indoor volleyball, a position added in 1999 with no attack responsibilities.⁶ This position is responsible for saving the ball and keeping it in play, passing to other players, and it requires quickness and excellent ball-handling skills.⁶

We will focus in this article on the repetitive motion (overuse) injuries which can be caused or exacerbated by the sport of volleyball. Some of the biggest websites covering volleyball coaching, rules, education, and training do not even mention the most common injuries and prevention strategies, although concussion, a relatively rare traumatic injury in volleyball, is discussed at some length on the TeamUSA Volleyball website.^{7, 8,9,10} 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.¹¹ 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.¹²

Traumatic injuries

Ankle injuries are by far the most common traumatic injury in indoor volleyball, while knee injuries are the most common traumatic injury in beach/sand volleyball.¹³ Although the reported incidence rate of sprained ankles is only 1/1000 hours of play and practice combined, it averages 4 ½ weeks of lost time from play or practice, so this type of injury is quite serious. Up to 80% of sprained ankles involve a previously sprained ankle and it happens most often within a year of the prior sprain.¹³ Use of a wobble or balance board during warmup has been shown to effectively reduce ankle sprains in both male and female players.¹³

Finger injuries are also quite common in volleyball.^{14,15} Many traumatic injuries occur at the net during play and are a result of players crossing the centerline in indoor games, though there is no centerline in outdoor games. Rule changes to make any contact with the centerline a fault resulted in a large number of violations, interrupted play, and the changes were abandoned.¹³ It appears from injury data that allowing players to cross centerline as long as it doesn't interfere with the opponents, is moderately effective in keeping injury rates down. Intervention programs aimed at technical training, balance board training, and injury awareness training have also proven quite successful in reducing injury rates.¹³

Overuse injuries

Overuse injuries are caused by repeated stress to a body part that eventually leads to wear, strain, inflammation, and fatigue such as tendinitis, cartilage damage, etc. 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, strength, explosive power and speed, agility, and endurance.¹⁶ Conditioning in addition to the usual drills performed for skill, is necessary to ensure that overuse injuries are kept to a minimum.¹⁶ The training program needs to be tailored to the functional needs of the body to play the game. Volleyball is not a sport that requires aerobic endurance over the long haul. It requires high energy movements over a short duration.¹⁷ It is important to train the energy systems and quick-twitch muscles used in volleyball such as running short sprints, practicing speed agility drills, and weight training that emphasizes circuit training emulating the anaerobic nature of the sport.¹⁷ The average play in volleyball only lasts 6 seconds with 14 seconds of inactivity, but that doesn't account for timeouts, player substitutions, and the many breaks in the game.¹⁷ For this reason, traditional cardiovascular training is not required because the endurance required for the game, although it does require cardiovascular fitness, is of a different nature than that used for aerobic sports like running, swimming, or bicycling.¹⁷ Training at slow speeds does not improve the performance of the energy systems and the muscle fibers required for the explosive actions in volleyball.¹⁷ At the same time, excess muscle mass or fat is a detriment to being quick and agile.¹⁸

- *Power* - Explosive movements require training for a combination of both strength and speed of movement, or power.¹⁹
- *Speed* is required in forward, backward, and lateral movement from one point to another point.¹⁹
- *Agility* involves the training of body movements in a coordinated and efficient manner during starting, stopping, landing, and changing direction.¹⁹
- *Flexibility* training enables the player to utilize power, speed, and agility through a full range of motion.
- *Endurance* training needs to be specific to the bursts of high speed, power, and strength required repeatedly throughout the game. The athlete needs to be able to perform these short bursts at the end of the game just as well as at the beginning of the game without tiring.¹⁹

Conditioning

There are two important concepts with regard to training and conditioning for volleyball. First is Functional Movement and the second is Functional Training.

Functional Movement.

Functional movement is a theory which guides the athlete into an appropriate sequence of training tailored to exact needs of the individual. The premise is that there is a hierarchy to training needs that should be considered which can circumvent a lot of injuries and people can continue to

play a sport for many more decades if they follow this path to training.²⁰ Specifically, mobility (range of motion) is the first priority. Improving mobility involves a lot of stretching and flexibility techniques that improve soft tissue health.²⁰ A full range of motion must be attained before training for stability.²⁰ Stability involves balance and symmetry training.²¹ If you don't have full range of motion and you are not moving in a controlled, balanced way, movement will be disrupted and will not be authentic, so these need to be corrected first.^{20, 21} After mobility and stability are corrected, movement can be added and finally you can start training for strength, power, and endurance. These basics tend to get ignored in today's training and conditioning programs which focus more specifically on sports-specific drills and skills.²⁰

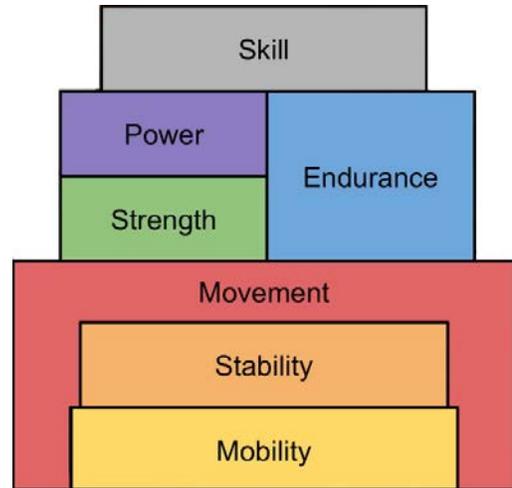


Illustration courtesy of Reference 21

An initial screening is done on the individual to identify functional limitations and asymmetries and the score is used to target problems and track progress and it is used to prescribe specific exercises to restore mechanically sound movement patterns.²²

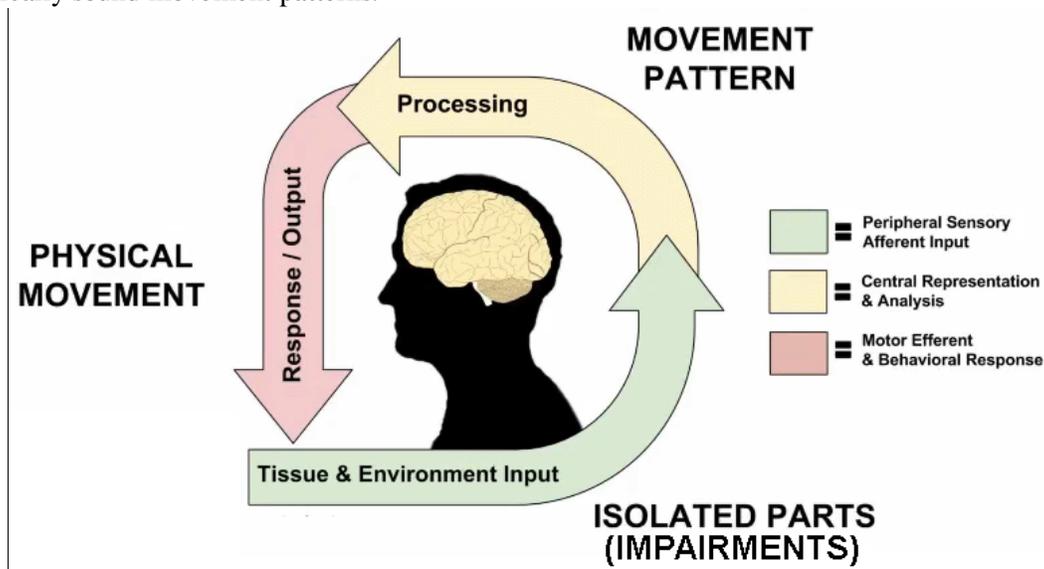


Illustration courtesy of Reference 21

By removing imbalances and problems in range of motion, the athlete may instantly see significant improvements in strength, power, endurance, and even skill because they are not wasting energy in inefficient movement, breaks in the kinetic chain of movement, and possibly damaging movement patterns that have become subconsciously engrained into the movements.²¹

All training prior to training sport-specific skills is considered to be exactly the same.²⁰ These skills are considered NOT sports specific. In other words, it doesn't matter what sport you are training for, mobility, stability, strength, and power are all trained exactly the same.²⁰ After all of these four levels are achieved, then the athlete goes on to train for sports-specific skills.²⁰

We agree with almost of the concepts behind this theory and we support this type of training. However, the idea that the training phases of strength and power are exactly the same for all types of sport or activity does not seem appropriate. The problem lies in the fact that training strength and power is quite

different for the slow-twitch muscles and for endurance sports like running, than it is for training fast-twitch muscles that require explosive strength and speed. Certain training regimens are definitely not recommended for volleyball athletes because it is an overhead sport that can lead to overuse injuries and overtraining, especially of the knees and shoulders.

Functional Training.

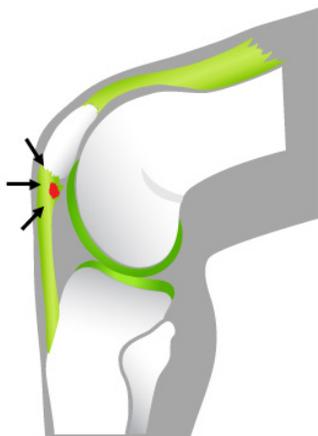
Training and conditioning should focus on training movements, interaction between muscle groups moving all three planes of motion, and all the links in the body’s kinetic chain, not individual muscles.^{23,25,24} This is called “functional training” and it involves integrated multi-joint exercises that develop joint flexibility throughout their entire range of motion, progressive overload of tendons and ligaments to increase their strength, core strengthening for stabilization and transfer of power to the arms and legs.²³ Functional training does not mean that you isolate an individual muscle or muscle group and you are supported or guided by a machine.¹⁸ Your body is required to do the stabilization!

There are two YouTube channels we feel provide exceptional tutorials on functional training for explosive power, speed, agility, flexibility, and endurance for reducing injury while playing volleyball and improving your game.

- KaiWheeler (eliminate the cardio workouts): <http://kaiwheeler.com/work-category/exercise-tutorial>
- The Renkens Center (Josh Renkens): <http://therenkenscenter.com/videos.php>

Although conditioning is necessary, overtraining can lead to overuse injuries as well.²⁵ It’s just as necessary to give the body time to rest and recover as it is to work on strengthening it. And mental fatigue or burnout happens, too.²⁵ Even elite volleyball athletes train all year, but the composition of the workout changes so that peak performance is targeted during the competition season, but the rest of the year is geared toward maintenance.²⁵

Knee and leg injuries and injury prevention.



**Patellar Tendinopathy
“Jumper’s knee”**

Illustration courtesy of <http://www.joggen-online.de/>

Patellar tendinopathy, or jumper’s knee, is the second most common injury suffered by volleyball players after ankle sprains, which is not an overuse injury.²⁶ Jumper’s knee has been reported to affect up to 50% of the male indoor volleyball players.¹³ Beach volleyball players have about a five times lower injury rate than indoor volleyball players because the playing surface is softer and more forgiving.^{2,13}

Jumper’s knee is felt as a pain just below the kneecap and is often felt more during the jump than at landing.²⁷ Rest, ice, and NSAIDs (nonsteroidal anti-inflammatories) are the general treatment until pain is gone.^{27,28} Misalignment of the kneecap and other issues with kneecap tracking predispose a player to this injury, as well as a wide pelvis, so female athletes are more susceptible.²⁸ Players who have the highest and most powerful jumps are at increased risk.²⁸

Prevention of jumper’s knee should focus on exercises to strengthen the vastus medialis muscle which can help stabilize the kneecap.²⁸ Coaching of proper jump techniques, reducing knee injury and strengthening the muscles supporting the knees is important. Jumping technique needs to ensure that the knees are not bent too deeply and that toeing-in during loading and takeoff is avoided.²⁵ Watch this video to see a demonstration of correct jumping practice: <https://youtu.be/dZtflqMmQFM> Use of plyometric exercises along with kinetic bands engages the entire body, improves speed, strengthens the leg, hip, and core muscles, and the



Vastus Medialis
Illustration courtesy of iStock.com

multidirectional control needed for volleyball.²⁹ Excellent information and videos about jump training and plyometrics is available in Reference 30 including requirements for players to meet prior to attempting to perform plyometric training.³⁰ The biggest dilemma is that, in order to improve jumping ability quite a lot of jump training is needed, however greater amounts of jumping and jump training actually increase the likelihood of Jumper's Knee developing.^{30,25} Strengthening and conditioning the muscles of the hips, thighs, and buttocks, jumping as much as possible on soft surfaces rather than hard surfaces, and making sure that jumping technique is perfect can go a long way to reducing the odds of injury.²⁵ Of course, genetic predisposition and anomalies in an individual player's physiology appear to account for some of the overuse injuries when other things are equal.²⁵

As we know, conditioning must involve quick, explosive movements that involve the complex array of muscles similar to the jumps required in play, rather than slow, isolated movements in traditional weight training scenarios. We suggest that doing plyometric exercises in an environment with a soft or cushioned surface is probably the safest way to condition the body parts necessary to prevent jumping overuse injuries:

Kai Wheeler's Plyometric Routine: <https://youtu.be/X6vwOXW4Cpk>

Livestrong's Explosive Plyometric Workout: <https://youtu.be/Oak29N93yX4> (We do caution that some of these exercises are not advised for people with wrist pain or issues.)

Shoulder injuries and injury prevention.

Shoulder pain is the third most common injury in volleyball players accounting for 8-20% of all injuries since it is largely an overhead sport involving the highly mobile, yet relatively unstable shoulder joint.^{13,26} The severity of these injuries is the worst of all types of injury resulting in an average of 6 ½ weeks of lost time from play, practice, or training.¹³ Injuries tend to involve tendiopathy or small tears in the rotator cuff due to overuse.²⁷

Since so much time is spent with the arms above the shoulders during play, strength training for volleyball should not involve lots of overhead lifts or training such as the military press.³¹ Poor posture and strength in the front of the chest needs to be counteracted with improved strength and flexibility in the thoracic region (upper back)³¹, the back of the shoulder capsule, scapula, and shoulder girdle (posterior capsule).²⁵ Avoid heavy shrugs, upright rows, flies and pec dec for the chest, and front and lateral deltoid raises.³¹

- Increase thoracic mobility using a large diameter foam roller (Josh Renkins): <https://youtu.be/SxQkVD0UQNg>.
- Posterior capsule stretches (Beacon Orthopedics): <https://youtu.be/MqdTBwu1pZo>
- Shoulder girdle stability/strengthening exercises (Elaine Huba): <https://youtu.be/WxKLTorHK1g>
- Rotator strengthening exercises (Elaine Huba): <https://youtu.be/JrFxlvcw2Ys>
- To strengthen the muscles of the upper back, follow the exercises on this video: <https://youtu.be/ICxDDAWi2Q>.

General core stabilization exercises to strengthen the core is also advisable to correct posture and to enable energy transfer throughout the kinetic chain of the body.²⁵

Low back injuries and injury prevention.

Up to 14% of the overuse injuries in volleyball players are low back problems.¹ The back as well as the hips, knees, and shoulders take a pounding every time the player lands.³² Volleyball players also arch and twist their backs to go up for spikes and then uncoil to violently hit the ball. Serving often involves hyper-extending the spine to generate a more powerful follow-through.³² Lower back pain can result from various sources, but in most cases, it resolves by itself in a few days.²⁵ If lower back pain continues, a sports medicine practitioner or chiropractor should be consulted to determine the source of the issue and to rule out serious injury.²⁵ Following that, an exercise program can be tailored to strengthen the back with the assistance of a physical therapist or with a trainer.²⁵

Some recommendations for preventing back pain and overuse injuries are:^{32,33}

- 1) Core strength and stability, hip mobility, and balance training.
 - a) Front and side plank: <https://youtu.be/VjliCOjTkK0>
 - b) Yoga pushup: <https://youtu.be/DGYwtffEIR4>
 - c) Hip flexor mobilization: <https://youtu.be/10o5LDr-INs>
 - d) Kettlebell swings (advanced): <https://youtu.be/XthoN13IQtE>
- 2) Force transmission training.
 - a) Medicine ball side throws: <https://youtu.be/10H-L2lg68>
 - b) Medicine ball slams: <https://youtu.be/cWghPf9dso0>
- 3) Cross-training and playing a variety of other sports can strengthen other body parts and reduce the chances of overuse injuries from focusing on one sport, especially for young players.
- 4) Warm-up prior to play.
- 5) Play on softer surfaces such as sand or wood when possible.
- 6) Take time off. Don't play volleyball year round.

Warming Up

Warm up exercises for volleyball are dynamic stretches that actively prepare the muscles and nervous system.³⁴ Static stretches do not teach the body to move safely, effectively, and powerfully because they relax and turn off your muscles, which is not what you want to do prior to a game.³⁴ Dynamic warm up exercises can help balance out tightness and flexibility issues that develop because of repetitive movements in the game.³⁴ Dynamic stretches should be done prior to games and prior to plyometric exercises.³⁴ Reference 34 has some excellent illustrated dynamic warmups including Forward Hand Walks, Forward Lunge Walks, Straight-leg Deadlift Walk, Walking Quad Stretch, and Lateral Lunge.³⁴

Cooling Down

Cooling down after playing is important for recovery and injury prevention.^{35,36} Cooling down is often ignored, but it is important because it helps the heart rate, breathing, and body temperature gradually return to normal, it helps remove hormones and waste products produced during play from the blood such as adrenaline, endorphins, and lactic acid, it reduces injury and soreness, and it accelerates muscle recovery from the workout they had during play.³⁶ Cool down starts with just gentle exercise so that you don't stop moving suddenly causing your heart rate and temperature to drop suddenly.³⁶ This can simply be a few ball tosses with partners or walking around for 3-5 minutes.³⁶

Cool down may or may not involve stretching depending upon whether the individual has limited range of motion.³⁵ If there are no flexibility or range-of-motion issues, static stretching may be counterproductive because it can actually lead to laxity in the joints and lack of stability for athletes that are already flexible enough.³⁵ If static stretching is needed, a good time to do it is after a workout because the muscles are warm and they are less likely to be injured, and the effect of slowing quickness of muscle contraction will not affect game performance.^{35,36} Reference 35 has some illustrated static stretches that are appropriate during cool down, but if you have gone through the process of evaluating your range of motion as recommended, you will know exactly the body parts that are tight or unbalanced and those areas are what you should focus on after playing.

The last phase of cool down is refueling. Drink plenty of water and eat something within the first hour after you finish playing to rehydrate and replenish the nutrients your body used.³⁶

Proper technique

Avoid overuse injuries by using full body power, trunk rotation, arm positioning, proper jumping, landing, and footwork. The following links can help understand good technique, but a good coach will work with individual players to help them develop good form and good habits to avoid injury.

- Reduction of shoulder injuries through proper technique: <https://youtu.be/WFfhAkrNAo4>
- Tips for developing volleyball technique: <http://www.strength-and-power-for-volleyball.com/volleyball-techniques.html>
- Drills for developing good technique, habits, skills, and strategy: <http://www.strength-and-power-for-volleyball.com/volleyball-drills.html>

Functional movement analysis will help the player identify errors in movement, flawed coordination, lack of flexibility, etc. that directly affect technique and performance.²⁵²⁴ Learn to identify the difference between muscle soreness and pain that indicates damage.²⁵²⁴ Use of ice and anti-inflammatories that is often the protocol for pain can mask pain that should be a signal that there is a problem or injury.²⁵²⁴ In addition, if there is pain and an athlete continues to play through it, compensating movement patterns develop which are not correct or balanced and the result is strain to other body parts that have to assume the function of the injured body part. This generally leads to injury and complications to additional body parts that were not involved in the original injury.^{SMSmarter} Heed pain when it arises, take corrective action, and give the body time to heal.

Further Reading

For more in-depth reading on this topic, please read Reference 37. It covers biomechanics of volleyball skills, conditioning, nutrition, injuries and their prevention and treatment, gender issues, vision training, and volleyball sports psychology.³⁷

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