

Hoopin' it Up!

The Ergonomics of Basketball

By Tamara Mitchell



Basketball was invented in 1891 by James Naismith when a new indoor sport for winter was needed.^{1,2} Naismith nailed a peach basket to the wall of the gym and used a leather soccer ball.^{1,2} The ball was retrieved from the basket after each shot by climbing a step ladder or poking it out with a long dowel.^{1,2} Clearly the equipment and the game have evolved, but the essential elements of running, jumping, cutting, stopping, and shooting on a hard floor are the same as the original game.

Most of the injuries in basketball are traumatic injuries; that is, they occur suddenly or from a forceful blow. The most common traumatic injuries in basketball are ankle sprains, jammed fingers, knee injuries caused by the stop and go, and the lateral maneuvers required in the game, deep thigh bruising, facial cuts, and stress fractures.³ In many cases, traumatic injuries are unavoidable due to contact with other players and the complex, rapid movements required.

This article focuses on overuse injuries in basketball rather than traumatic injuries. Overuse injuries in basketball are caused by repeatedly stressing an area until it is damaged. Overuse injuries and some traumatic injuries can be minimized or avoided through a proper conditioning program and attention to preventive measures.

Overuse Injuries

The body has an amazing capacity to become stronger through use and exercise, building stronger muscles, bones, tendons and ligaments as they are put under increasing stress, then allowed to recover.⁴ This process is called remodeling and it involves the breakdown and subsequent buildup of tissue into stronger and more functional structures. If a sufficient rest period for healing is not allowed, breakdown will exceed buildup and the result over time is an overuse injury where the tissue becomes damaged.^{4,5}

In basketball, the most prevalent overuse injuries are patellar tendinitis, or "jumper's knee", Achilles tendinitis, and shoulder and rotator cuff problems.

Jumper's knee is characterized by pain in the tendon just below the kneecap. This injury is almost always a result of improper training or conditioning, excessive stress, or fatigue.¹ Over-training for jumping can lead to jumper's knee, so it's important to train for jumping in the pre-season phase of conditioning, but back way off during in-season conditioning.

Achilles tendinitis is common in basketball players and it is caused by injury and inflammation to the tendon that connects the muscles in the back of the calf to the heel.⁶ It is brought on by the repetitive eccentric loading of the tendon.¹ The forces during running and jumping are approximately eight times body weight.

Shoulder problems include impingement syndromes and rotator cuff or bicep tendon strains.¹ Repetitive shooting and rebounding drills can lead to this problem, so this is another case where over-training can lead to injury.

Shin splints are common in basketball from the impact forces of running and jumping. They may also occur from excessive pronation of the foot.

Hamstring strains often result from training errors. Insufficient warm-up may be a factor. In addition, excessive quadriceps training to increase vertical jump height and running speed can contribute to a quadriceps-hamstring strength imbalance.¹

Injury Prevention

Injury prevention involves preparing the athlete's body for this intensive sport throughout the season as well as attending to the physical, environmental, and psychological factors which can lead to injuries. Take at least one season off every year as well as reduce training and playing time when there is pain or discomfort to reduce the risk of serious injury and to prevent burn-out.³

Specific recommendations to prevent overuse injuries include:⁴

- Proper training and technique
- Performing adequate warmup
- Adopting a hard/easy workout schedule
- Cross-training with other activities to maintain fitness levels
- Incorporating strength training, improving flexibility where needed for full range of motion, and increasing core strength
- Replace shoes before they become worn.
- Avoid play on concrete courts. A more resilient wood floor is much easier on the body.



Photo courtesy: Basketball91.com

Warm-up, stretching, and cool-down. Important in all sports and physical activities, warming up for 5-10 minutes by jogging or stationary cycling to the point of perspiration can decrease injuries by increasing blood flow and oxygenation of the blood, increasing muscle temperature, nerve response and speed, and increasing relaxation and concentration.^{1,7}

The use of static stretching has not been found to reduce injuries in sports and it reduces performance in sports. Please read our article on the Great Stretching Debate⁸, for more information about this. Unfortunately, many websites still recommend slow static stretches including, surprisingly, the American Association of Orthopedic Surgeons, but dynamic functional stretching has been the recommendation based on many years of solid research.^{9,10} Dynamic functional stretching incorporates drills that cover the length of the basketball court prepare the body with a progression of sport-specific movements with increasing intensity.^{1,5}

- Forward/retro jogging
- Lateral shuffles and cariocas (stepping exercises)
- High-knee skips
- Bounding
- Butt-kick runs
- Angle cuts
- High-knee runs

Flexibility should be included throughout all phases of training. Functional stretches should focus on body parts of the individual that have been determined to lack full range of motion. Stretching areas that already have full range of motion is not useful and can actually promote joint laxity that can lead to injury.

Ballistic stretching, which involves bouncing at the end range of motion, may cause muscle or tissue damage and is not recommended.¹

Cooling down after playing is important for recovery and injury prevention.^{11,12} 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.¹² Cool down starts with just gentle exercise so that you don't stop moving suddenly causing your heart rate and temperature to drop suddenly.¹² This can simply be a few ball tosses with partners or walking around for 3-5 minutes.¹²

Cool down may or may not involve stretching depending upon whether the individual has limited range of motion.¹¹ 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.^{11,12} Reference 11 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.¹²

Conditioning. Basketball requires high-intensity anaerobic bouts with rest periods during brief time-outs, between periods, or if the player is substituted out of the game. Players must have an excellent aerobic base to meet the demands of the game. In addition, flexibility, power and jump training, speed and agility drills, and strength training all need to be developed.¹³ There is neither time nor energy enough to incorporate all these types of training into a conditioning program, so it's important to identify the areas where the individual player needs improvement and to focus on those things, as well as to train and condition differently for each season: off-season (2-3 months), pre-season (3-4 months), and in-season (6 months). Testing to determine the areas where improvement is needed can be designed with the guidelines in Reference 14.

The discussion of conditioning covered in our article on volleyball applies perfectly to basketball as well since they both involve training for an explosive sport that involve lots of overhead motion, agility to handle sudden movements in all directions, twisting of the body, jumping, sudden stopping and changes in direction, with short bursts of high intensity energy. Please read our article on Volleyball for a more complete discussion of conditioning for this type of sport.¹⁵ The theory of functional movement training is quite important in its phased approach to training that is customized for each individual based on testing in the various dimensions.

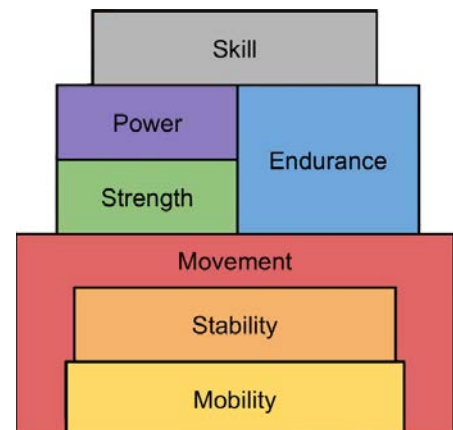


Illustration courtesy of Reference 17

Conditioning throughout the year needs to be *periodized*, that is it needs to be broken down into phases throughout the year that fit together as a sequence, one phase leading to the next and relative to the season of play.¹⁶ Sports Fitness Advisor defines the conditioning in each phase and we outline these basics below. For much more detailed information on the training phases please refer to Reference 13.

Over-training is highly probable if the training program does not take into account the stresses of each season. Over training either aerobically or anaerobically can lead to anomalies of the resting heart rate and blood pressure, decreased performance and recovery, sleep disturbances, prolonged illnesses, and mood changes or irritability, among other symptoms. Training errors can also contribute to overuse injuries.¹

Strength training for basketball is very different from strength training for many other sports or for general body building.¹⁶ Basketball involves explosive power, so strength training needs to have three specific goals:¹⁶

- Acceleration and speed on the court
- Range of shots and passes
- Explosive power, especially for jumps
- Risk reduction for joint and tendon injuries

Off-season conditioning consists of aerobic, strength, and flexibility conditioning.¹³ Aerobic conditioning should not involve any basketball or running. It should be of fairly low intensity, 2-3 days per week, and it is good to focus on a completely different sport such as swimming or cycling that does not use the same muscles and tissues that are used during basketball.¹³ Strength training can be started after a few weeks of rest if the basketball season has been strenuous and it should focus on core stability with light loads and high repetition.¹³ Basketball places asymmetrical and uneven loads on the body, so building a good baseline of balanced strength, correcting any imbalances between extensor and flexor muscles, asymmetries in strength between the two sides of the body, strengthening the joints, ligaments, and tendons prior to the more intense strength training of following phases, and strengthening stabilizer muscles are the goals in this phase.¹⁶ Flexibility training should be done to ensure full range of motion through dynamic stretching.¹³

Pre-season conditioning should actually be divided into two phases: early and mid-to-late pre-season.¹³ Early pre-season conditioning should last about 4 weeks and should include a gradual ramping up of the intensity of aerobic training. After 2-3 weeks, begin interval training and switch to jogging rather than swimming or cycling.¹³ Flexibility training continues throughout this phase. Strength training should be changed toward the end of early pre-season to a maximal strength program with much heavier weights, few reps at near maxim, and only 3 sessions per week allowing days off between strength training sessions.¹³

In mid-to-late pre-season conditioning, phase out aerobic conditioning and focus more on anaerobic endurance drills with sessions lasting 30 minutes, 2-3 days per week.¹³ Flexibility training continues throughout this phase with 3 sessions per week. Strength and power conditioning should be continued up to about 4 weeks prior to the season, switching primarily to plyometric training for the last 4 weeks.¹³ Ballistic exercises with medicine balls and jump squats were found to be the most effective means to power train for jumping in basketball showing an 18% improvement in jump height as compared to traditional weight training (5% increase) or plyometrics (10% increase).¹⁸ These last few weeks of pre-season conditioning should also focus on speed and agility drills that are basketball-specific including passing and shooting.¹³ The agility drills should be intense, but should not leave the player fatigued and there should be days off between drills for recovery.¹³

In-season conditioning is used to supplement playing the game. Two sessions per week of strength, agility, speed, and power drills is sufficient. Continue flexibility training 3 sessions per week.¹³

Shoes and foot support. The importance of proper shoes cannot be emphasized enough. Considerable research has been done with regard to shoes and the advantages of ankle support. High-topped basketball shoes offer ankle support and are specifically designed to withstand the multidirectional forces and shock absorption encountered during play.^{1,7,19} Basketball players should wear shoes that fit well. Various lacing techniques can alleviate problems with pressure points that may arise. Watch this video to learn if changing the lacing of the shoe can help persistent problems with fit: <https://youtu.be/qSzbnfAL3Mw>.



Shoes need to be replaced frequently. When shoe materials break down, stress to the foot, leg, and related soft tissue and bone structures increases. Over time these stresses result in fatigue injury. It is recommended that shoes be replaced monthly during the season in practice and during games.¹⁹ Shoes are expensive, but so are injuries! The average high school basketball player will use only one new pair of basketball shoes per season.¹⁹

When you buy shoes, go to a store where you can try various models on and when possible shop at a store that caters to athletes.²⁰ Do some research before you shop to find out which current makes and models of shoes others are finding work best for the position you play.²⁰ Shop at the end of the day when your feet are more swollen to prevent buying shoes that are too small.²⁰ Try shoes on both feet, inspect them carefully for defects, try to determine when the shoes were manufactured.²⁰ Materials break down even if they are just sitting on the store shelf.

Court Surface. The surface of the court should be clean, dry, and free of debris.¹ Indoor wood courts are the best surfaces because they offer shock absorption and can reduce stress on the body.¹ Outdoor asphalt courts are more dangerous. Concrete courts are the hardest of all and can result in lower extremity injuries such as stress fractures and shin splints.¹

Temperature and hydration. The higher the temperature, the more important fluid replacement becomes.¹ With dehydration, athletes become fatigued, which in turn increases the chances for injury.¹ Stay away from so-called sports drinks which are full of artificial colors, sugar or high fructose corn syrup, genetically modified organisms, artificial sweeteners, and artificial flavorings.^{21,22, 23} Nothing beats water, but if you want a bit more flavor, you can drink unsweetened tea or tea sweetened with stevia, water with a couple of drops of organic essential oil such as lemon, peppermint, orange, or spearmint, or you can add a few slices of strawberries, oranges, or cucumbers to the water bottle.²² If you're playing really hard or on an especially hot day, you can add 1/3 teaspoon of *unrefined* sea salt to 3 cups of water (never use refined salt or sea salt) to increase electrolytes and a balance of trace minerals.²²

Psychological factors. Often overlooked is the vulnerability to injury caused by stresses experienced by the players. Interestingly, studies looking at stresses in players' lives in relation to the incidence of injuries have found mixed results.¹ Some studies found a positive relationship, while other studies found no such relationship.¹ What is important is how the person perceives the life event, or stressor, and what coping skills that person has to deal with the experience. Coping skills can include self-confidence, relaxation at appropriate times, striving for best effort rather than perfection, managing anger, and recovering emotionally from a mistake during play. It is advised that professionals involved with the care, training, or coaching of athletes address these factors by identifying at-risk individuals and facilitate coping skills development. Psychological skill training (PST) serves not only to prevent injury, it also improves overall skill performance, concentration, and attention.¹

Children have been found to experience more overuse injuries if winning is emphasized more than learning and fun.¹ In addition, parental pressure to win can lead to fictitious injuries. Some children find injury their only escape from pressures imposed on them by parents and coaches.¹ So, be very careful about the attitudes and pressures you place on child athletes!

After-Injury return to play

The criteria for returning to playing are:¹

- Time for tissue healing has been observed (based on the type of injury)
- There is pain free full range of motion of the joint.
- There is no persistent swelling.
- Muscle strength and endurance of the injured limb is at least 90% of the uninjured limb.
- Flexibility is equal bilaterally (injured side/uninjured side equal).
- Joint stability is maintained by muscle control and/or a brace or tape.
- There is good proprioception.
- Cardiovascular fitness is equal to or better than the requirements of competition.
- Skills have been regained.
- There is no biomechanical dysfunction.
- The athlete is ready psychologically.

Athletes are vulnerable to psychological reactions to injury. These reactions can include loss of their identity as a skilled athlete, fear and anxiety regarding future recovery, feelings of separation and loneliness from teammates, lack of confidence in athletic and other skills, and performance decrements related to not properly pacing their return to playing status.¹ Professionals involved in the rehabilitation effort need to respond to the injured athlete by building rapport, advising them of what to expect in the recovery process, preparing them for possible setbacks, and teaching coping skills. The wrong attitude can encourage an athlete to play while hurt, leading to greater injuries.¹

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 your 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 health and treatment!

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