The Biomechanics of Overuse Injuries in Endurance Athletes

Discussions on common types of overuse injuries in endurance athletes including treatment guidelines and prevention. Injuries include swimmer's shoulder, achilles tendonitis and more.

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The primary goals of an endurance athlete are: 1) to arrive at the starting line healthy and injury-free, 2) to have optimized training in order to be in the best shape to meet the demands of the race, 3) to finish the race with a great personal performance without injury or illness, and 4) to recover from the effects of the race.

Completing an endurance event such as a triathlon requires an athlete to have adequately prepared both physically and mentally for the challenge. Common errors in training for an endurance event are over-training, under-training, or a poorly planned training program. These errors can lead to injuries and problems during training as well as during the race.

Overuse Injuries in Endurance Athletes

Injuries in endurance athletes are a common occurrence.(3,9,11,12,14,29,30) Consistently pushing the body to its limits, both physically and mentally, will inevitably result in injuries. These injuries can drastically alter training and will probably affect racing performance. It is imperative that an endurance athlete quickly recognize these injuries and treat them in order to achieve optimal performance. For athletes and their treating practitioners, the keys to preventing and treating injuries are to recognize training errors that can lead to an injury, recognize the early signs of an injury, and address injuries as soon as possible.

Knowing and understanding errors in training that put an athlete at a higher risk for injuries is an important component of designing a training program. There are several common periods of training in which an athlete is more vulnerable to injury: when adding training volume; when increasing training intensity; when adding new movement patterns such as swim stroke, running form or bike position; and when returning from an injury or an absence from training.

Biomechanical problems, both extrinsic and intrinsic, may contribute to developing overuse injuries (see table 1). (9,29,30,32,33)

Table 1

Extrinsic biomechanical factors include:

1) New or different equipment such as a different bike, pedals, aerobars or wetsuit
2) New or different shoe type, style or wear
3) Different bike cleats or positioning of cleats
4) Changing bike position
5) Changes in road surface such as cement or canted roads

Intrinsic biomechanical factors include:

1) Muscle imbalances
2) Leg length discrepancy
3) Lower extremity alignment
4) Poor flexibility
5) Changes in technique or form such as swim stroke or running form
6) A sudden change in training volume, intensity, frequency or activity- "Too much, Too hard, Too soon"
7) Previous or untreated injury

Overuse injuries make up the majority of injuries in endurance athletes and they are preventable.(9,12,30) Acute injuries are difficult to prevent but are less frequent.(28,30,32) The best way to prevent and reduce the risk of overuse injuries is by correcting any of the above factors when

recognized.

Common Types of Overuse Injuries in Endurance Athletes
Endurance training produces repetitive stress to muscles, tendons and tissues around joints and bones. The continuous stress produces repetitive microtrauma. Overuse injuries result from the body's inability to keep up with repair of the damage created from repetitive microtrauma to tendons and muscles. The body's tissue eventually breaks down resulting in pain, inflammation, and weakness. If an athlete ignores the pain and inflammation and continues to train, it will lead to macrotrauma and disruption of the tendon or muscle.

The types of overuse injuries encountered in endurance sports relate to the type of repetitive motion the body encounters. In triathletes, injuries to the shoulder result from the motions involved with swimming while lower extremity injuries result from motions involved with running and cycling. Most overuse injuries (9,11,30) are treated successfully by adhering to practical guidelines (see Table 2). The following paragraphs will describe the most common overuse injuries seen in both male and female triathletes.

Table 2 Guidelines for Overuse injury treatment

1. The principle of P.R.I.C.E.
   P = Protection – protect the injured extremity
   R= Rest – relative rest: cross training or deep-water running
   I= Ice – apply ice for 20-30 minutes every 2-3 hrs for first 3 days
   C= Compression – apply an elastic wrap to reduce swelling
   E= Elevation – raise extremity above the level of the heart

2. R.E.S.T. = Resume Exercise below Soreness Threshold
   Reduce Volume: 25 – 30%
   Reduce Intensity: 10 – 20%
   Reduce Frequency: 25 – 50%

3. Correct Biomechanical Problems
   Obtain a formal gait analysis
   Adjust your bike to the proper position
   Have your swim stroke evaluated and corrected
   Use orthotics if recommended
   Use correct running and cycling shoes
   Strengthen muscle imbalances
   Adhere to a regular stretching program

4. Have your Training Program Analyzed by an Expert
   Training progression should only be 5-10% per week
   Include rest days and easy days in your schedule
   Cross train
   Develop an aerobic base in your training
   Periodization
   Balance between each discipline

Swimmer's Shoulder
The most common overuse injury (33) developed in swimming is rotator cuff tendonitis, better known as "swimmer's shoulder." Repetitive stress around the shoulder causes inflammation and microtrauma to the muscles and tendons surrounding the shoulder ball and socket joint called the rotator cuff. Rotator cuff tendonitis is usually caused by pool workouts that are either too much, too hard or too frequent (that is, too many total yards per session, too many high intensity yards, or too many session per week); shoulder muscle imbalances; and poor stroke form.

Symptoms usually consist of pain localized to the shoulder cuff, stiffness and difficulty raising the arm above 90 degrees, weakness, pain at night; and poor aero position on the bike. The aero position is when a cyclist rides with a flat back, head lowered and forearms positioned parallel to the bicycle

frame (on clip-on bars, for example) to reduce aerodynamic drag.

For most cases of swimmer's shoulder, treatment consists of rest, ice, and compression to reduce inflammation and pain; adjusting training by decreasing overhead activities such as swimming and lifting weights; and decreasing the volume of swimming to allow adequate healing.

In some cases this requires the practitioner to recommend a complete cessation of swimming for a period of time, and avoiding the aero position on the bike as much as possible. The athlete should sit upright with hands on the top bar.
In severe cases or if symptoms persist for longer than two weeks in general, it is recommended to see a sports medicine specialist for further evaluation and treatment. Often, treatment requires physical therapy to strengthen the weakened muscles and reduce pain and inflammation.

Sacroiliac Joint Dysfunction
Sacroiliac joint, or SI joint dysfunction is a very common cause of low back pain in triathletes.(2,22) It was noted to be one of the three most common injuries to athletes at the Ironman Triathlon in Hawaii.(22) As the SI joint is a major joint in the body that connects the back to the hip with supporting ligaments holding it together, a structural or muscle imbalance can lead to irritation, termed SI joint dysfunction.(9,28,29,30)

Contributing factors include leg length discrepancy, tight hamstrings, gait dysfunction, and poor bike positioning.(32) Symptoms usually result from problems with running or cycling.(9,29,30,32)

SI joint dysfunctions cause pain in the lower back above the hip. The pain is usually a dull ache but sometimes can be sharp during exercise. The pain may radiate to the hip or back. An athlete may sometimes describe a catch in their lower back.

The best way to treat SI joint dysfunction is to:
1. Identify and correct the contributing factors.
2. Include a program of back and leg strengthening and stretching.
3. Correct any muscle imbalances, leg length discrepancies, or ankle overpronation.
4. Make sure the bike fits properly. A common cause is having the seat too high or stretching too far forward on the aerobars.

Iliotibial (IT) Band Friction Syndrome
The iliotibial band, or IT band, is a structure located on the outer side of the leg from the hip to the knee. IT band friction syndrome is a condition common to both cyclists and runners, and is caused by IT band tendons rubbing against bony prominences of the hip and knee. The rubbing causes irritation, pain, and inflammation. Most commonly it causes a dull to sharp pain on the outside of the knee. It may cause a snapping sensation or bursitis in the outer hip area. Initially, pain is usually aggravated by cycling or running up or down hills. As it progresses, the pain will occur during all training activities. It significantly interferes with hill workouts and sprints. After long cycling or running sessions, an athlete may feel pain in the groin area as the tight IT band causes increased strain on the adductor muscle.

IT band syndrome is caused by:
1. Biomechanical imbalance or overuse.
2. Repetitive running on canted roads.
3. A leg length discrepancy.
4. Cycling with fixed bike cleats.
5. Low back and hamstring tightness.
6. IT band tightness and overuse.

Treatment includes:
1. Rest and ice
2. Identify and correct any contributing biomechanical factors.
3. Correct Leg length discrepancies and ankle over-pronation with orthotics.
4. Have a professional evaluate your gait and bike position to make appropriate corrections.
5. A daily program of stretching to improve flexibility.

6. Massage therapy to stretch and loosen any adhesions or scar tissue. Scar tissue and adhesions develop with chronic IT band syndrome.
7. Improve any muscle imbalances with a strengthening program.

As the athlete recovers, appropriate training adjustments include decreasing the volume and intensity of training; avoiding hill workouts, running on canted roads and intense bike rides; using bicycle cleats where the leg is allowed to freely rotate between the shoe cleat and pedal; and deep-water pool running, which allows the maintenance of aerobic conditioning without aggravating the injury.

The best way for an athlete to prevent IT band friction syndrome is to include a regular program of stretching and strengthening into his or her training program. Avoid running on canted roads and replace worn out shoes often. Bicycle cleats with rotation will help while cycling.

Hamstring Muscle Injury

A hamstring muscle strain or tear is an injury that occurs while running or cycling. It usually occurs as a result of a sudden contraction during an intense session such as interval training, downhill running, or sprinting at the end of a race. The tear is usually a result of tight hamstrings secondary to over-training or a muscle imbalance. Muscle imbalances may exist between the hamstring muscle and the thigh and buttock muscles. Hamstring muscle tears usually occur at the muscle tendon junction near the hip or the knee and more rarely in the middle of the muscle.(9,17,29,30,31) The pain is usually sharp, localized, and sudden in onset. Muscle spasms may occur, as well. Once an injury occurs it typically is persistent and often difficult to get rid of completely.

The best treatment for mild hamstring tears is:

1. 1 – 2 days of rest
2. Ice and a compression wrap.
3. Gentle stretching and light massage
4. Gradual progression back into running and cycling
5. A diligent stretching program.

For more severe strains or if symptoms persist and you are unable to resume running, it is a good idea to see a sports medicine specialist.

The athlete should consider adjusting their training by

1. Decreasing the intensity of their running and cycling sessions.
2. Using shorter strides while running.
3. Avoiding running downhill and interval/speed workouts.
4. Deep-water running or swimming.

Again, it is important to emphasize to the athlete that the best way to prevent a hamstring injury is to include a daily stretching program into the training routine. Hamstring strengthening exercises will give better muscle balance.(17) An adequate warm-up period prior to interval or speed workouts also will help prevent muscle injuries.

Anterior Knee Pain

Anterior knee pain is a common complaint of many runners and cyclists.(9,28,29,30,32) Pain is usually surrounding or underneath the knee cap, but typically not localized to one specific area. The pain is usually associated with cycling or long runs. It worsens with sitting for long periods with the knee bent (called “theater sign”) or walking up and down stairs. Occasionally, there is swelling about the knee. It usually is gradual in onset but can begin after an acute injury to the knee. Symptoms resolve with rest and decreased activities.

The cause of anterior knee pain is multi-factorial. The basis of the pain stems from biomechanical factors that cause poor tracking of the patella (knee cap) in the femoral groove (thigh bone). Contributing factors include:

1. Tight hamstring muscles.
2. Muscle imbalances.
3. Weak quadriceps muscles.
4. Ankle over-pronation.

5. Poor bike position.
6. Arthritis.
7. Weak hip muscles (gluteus medius)

Initial management of anterior knee pain requires rest, ice, and anti-inflammatory medication. To prevent the problem from recurring, an athlete needs to identify and correct the factors contributing to anterior knee pain. This may require a careful evaluation by a sports medicine specialist to evaluate gait, biomechanics, and leg structure. Easy corrections include performing regular stretching, strengthening imbalanced muscles, using orthotics, increasing the height of the bike seat, and returning gradually to running and cycling when symptoms improve.

Achilles Tendonitis

The Achilles tendon is a cord-like structure located at the back of the ankle that connects the calf muscle to the heel. This tendon is prone to microtrauma and inflammation from the repetitive motion of running. The causes are:

1. Ankle over-pronation.
2. Tight calf muscles.
3. Excessive hill running.
4. Over-training.
5. Poorly cushioned shoes.
6. A change in running surface.
7. Excessive dorsi-flexion during cycling (the heel dropping below the pedal at the bottom of the pedal stroke).
8. Progressing too rapidly with the intensity and volume of training (greater than 10% per week). The muscle and tendon are unable to keep up with the increased repetitive stress and tissue breakdown occurs.

Achilles tendonitis causes pain and tightness localized to the ankle area. The pain is worsened with walking on the ball of the foot or on the toes. If the symptoms are ignored, pain and inflammation will continue, leading to further tissue damage, which may lead to a chronic tendonitis and the possibility of the tendon rupturing.(9,11,12,29,30)

To treat Achilles tendonitis:

1. Massage the area with ice.
2. Take anti-inflammatory medication.
3. Decrease the volume and intensity of training.
4. Avoid steep hills and hard surfaces.
5. Tape or wrap the ankle and use a heel lift (may bring about temporary relief).
6. Gradually increase volume and intensity.
7. Warm-up and stretch daily.
8. Include water running in training program.

It is important to give this time to heal. Typically this takes four to six weeks, but sometimes it may take up to six months or longer to completely heal. (17,30) Racing an endurance triathlon with this condition will end disastrously for the athlete. It could result in a partial or complete rupture of the tendon.

To prevent Achilles tendonitis:

1. Use a good pair of running shoes with a stable heel counter and good cushioning.
2. Warm-up and stretch regularly.
3. Consider orthotics.
4. Gradually increase training volume and intensity.
5. Avoid running on hills and hard surfaces, such as cement, in the beginning of training.
6. Check the foot position when cycling, as the athlete may need to adjust the position of cleats or seat height.

Plantar Fasciitis

The plantar fascia is a spring-like ligament that supports the arch of the foot. The ligament is stretched as it distributes the weight of the body on the foot during running. Over-training, foot

imbalances, running on hard surfaces or running in worn-out shoes can cause inflammation of the fascia, or plantar fasciitis.(9,11,15,17,29,30) Tight calf muscles are also a contributing factor.

Symptoms are gradual in onset but increase with continued running. Pain is localized to under the foot or the heel. This condition is also referred to as the “painful heel syndrome.” A typical complaint of plantar fasciitis is intense pain with the first step in the morning. Symptoms will gradually worsen and pain may occur with daily walking.

Plantar fasciitis is a serious running injury that can become severe enough to require several months to heal.

To treat plantar fasciitis:

1. Apply ice and take an anti-inflammatory medication.
2. Replace worn-out shoes with well-cushioned shoes.
3. Consider the use of orthotics and a heel cushion.
4. Stretch calf muscles daily.
5. Apply cross-friction massage to the plantar fascia.

If symptoms are persistent, athletes should consult a sports podiatrist to help evaluate the condition and prescribe the right treatment. Night splints are often used to keep the achilles tendon stretched while you sleep.

Training should be adjusted by reducing the distance of running. Light cycling and deep-water running are good alternatives. While the athlete should spend time on improving swimming, he or she should be warned to avoid wall push-offs that may aggravate the condition.

To reduce the chances of plantar fasciitis, the athlete should be urged to:

1. Stretch the calf muscles daily.
2. Wear well-cushioned shoes and replace them frequently.
3. Avoid running on hard surfaces.
4. Use orthotics if indicated.

To prevent over-use injuries, Athletes should be reminded of the guidelines in Table 3.

Table 3

1. Avoid over-training.
2. Listen to your body and REST when needed.
3. DO NOT try to make-up missed training sessions.
4. Address all injuries, even minor ones.
5. Allow your body time to recover and heal.
6. Include daily stretching into your program.
7. Include a strengthening program in your training.
8. Correct biomechanical problems.
9. Warm-up and cool-down adequately with each training session.
10. Monitor your training with a personal log.

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