Managing Overuse Injuries: A Systematic Approach

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In Brief: Cumulative, repetitive microtrauma can cause tissue damage that leads to overuse injuries, which constitute a large share of sports-related disorders. The authors explain their five-step approach to treating overuse injuries: establishing a pathoanatomic diagnosis, controlling inflammation, promoting healing, increasing fitness, and controlling tissue abuse. The case of a 28-year-old male runner with heel pain demonstrates their management of overuse injuries.

Despite the benefits of exercise, many Americans are inactive or exercise at levels too low to derive cardiovascular benefit. The recent surgeon general's report on physical activity and health (1) and the National Institute of Health's Consensus Conference on Exercise and Cardiovascular Health (2) both encourage physicians to prescribe exercise for patients. All too often, however, individuals begin exercising enthusiastically, only to suffer from overuse injuries that force them to stop and seek medical attention. Physicians who understand the causes of overuse injuries and apply a sound strategy for diagnosis, management, and rehabilitation can effectively help such patients. Understanding "prehabilitation" is also important for physicians who want to prevent overuse injuries that might otherwise sabotage their patients' exercise programs.

Epidemiologic Patterns

Overuse injuries may be the most common class of sports injuries encountered by primary care physicians. A literature review reveals that 30% to 50% of all sports injuries result from overuse (3). Baquie and Bruckner (4) recently reported that overuse injuries at their center during a 1-year period were twice as frequent as acute injuries, with the most common presentation being anterior knee pain. Some studies (5,6) of running injuries have demonstrated that the majority of presenting problems are related to overuse, with patellofemoral disorders being the most common. One study (7) that evaluated the role of age in injuries showed that patellofemoral dysfunction and stress fractures were more prevalent in young athletes, while metatarsal pain syndromes and plantar fasciitis were more prevalent among older athletes. A recent review (8) concerning injuries to female athletes found that injuries once thought to occur more frequently in women, such as patellofemoral pain and stress fractures, are more sport specific than gender specific.

Our experience at the DeWitt Army Community Hospital Primary Care Sports Medicine Clinic is similar to that of comparable centers. All patients are seen initially by primary care physicians and only referred to our sports medicine staff if needed. Injuries seen by our sports medicine staff are related more often to overuse (52%) than trauma (48%). The most commonly seen overuse injuries include rotator cuff tendinitis (11.7%) and patellofemoral tracking disorders (10.6%) (9).

Injury Mechanisms
Overuse injuries result from repetitive microtrauma that leads to inflammation and/or local tissue damage in the form of cellular and extracellular degeneration. This tissue damage can culminate in tendinitis or tendinosis, stress fracture, synovitis, entrapment neuropathies, ligament strains, or myositis.

These injuries are most likely to occur when an athlete changes the mode, intensity, or duration of training—a phenomenon that Leadbetter describes as the "principle of transition (10)." In his profile of such an injury (figure 1: not shown), an abusive training period involves a cycle of repetitive overload on tissues trying to adapt to the new or increased demands. A mismatch between overload and recovery leads to tissue breakdown at the cellular level. In theory, subclinical damage can accumulate for a long time before the person becomes symptomatic.

Repetitive overload can cause other problems besides overuse injuries; collectively, these problems are called the overtraining syndrome (11). When individuals rapidly increase their workouts without adequate recovery time, they may overtrain and experience poor performance, fatigue, disturbed sleep patterns, myalgias, weight loss, and neuroendocrine and immune dysfunction. If athletes do not recognize the symptoms of this syndrome, they risk chronic overuse injuries as well as failed performance, illness, and premature retirement.

Both intrinsic and extrinsic risk factors contribute to overuse injuries (table 1). Intrinsic factors are natural biomechanical abnormalities. High arches, for example, have been shown to predispose military recruits to a greater risk of musculoskeletal overuse injury than low arches or "flat feet (12)." A recent study of male infantry trainees identified genu valgum, excessive Q angle, and genu recurvatum as risk factors for overuse injuries associated with vigorous training (13). Extrinsic (avoidable) factors that commonly contribute to overload include poor technique, improper equipment, and changes in the duration or frequency of activity. Training errors are the most common cause of overuse injuries in recreational runners. Vulnerability to extrinsic overload varies with intrinsic characteristics (14).

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<th>Intrinsic</th>
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<td>Malalignment</td>
<td>Training errors</td>
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<td>Muscle imbalance</td>
<td>Equipment</td>
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<td>Inflexibility</td>
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<td>Muscle weakness</td>
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<td>Instability</td>
<td>Sports-acquired deficiencies</td>
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Sports-acquired deficiencies, categorized as an extrinsic risk factor, actually are the result of both biomechanical abnormalities and training errors. Sports activity can overload an athlete's musculoskeletal system in predictable ways. Repetition without proper conditioning can propagate muscle imbalance and flexibility deficits. Throwing is a classic example, as demonstrated in both baseball pitchers and water polo players (15). Chronic overuse from throwing creates an imbalance between the internal and external rotator muscles of the shoulder. The external rotators, continually required to eccentrically decelerate the arm, are subject to overuse fatigue, which produces strength and flexibility deficits. These maladaptive changes are believed to play a role in rotator cuff tendinosis.

Kibler et al (16) have developed a model for describing the cycle of musculoskeletal overload and injury production (figure 2: not shown). The model includes five interrelated categories—the tissue injury complex, the clinical symptom complex, functional biomechanical deficits, the functional adaptation complex, and the tissue overload complex. A thorough evaluation of the
primary injury and the secondary sites of injury or dysfunction, including all five categories (see "A Runner With Heel Pain: Putting It All Together," below), allows the physician to develop an effective rehabilitation program.

**Five Steps to Management:**

The diagnosis and management of overuse injuries require a multidisciplinary approach. The sports medicine physician's responsibilities are to establish a correct pathoanatomic diagnosis and direct rehabilitation, which enlists the expertise of the directing physician, physical therapists, orthotists, athletic trainers, and coaches. At the Nirschl Clinic and DeWitt Army Hospital Primary Care Sports Medicine Clinic, we use a five-step management pyramid (figure 3: not shown) designed to return the athlete to sports participation. (17)

1. **Make a Pathoanatomic Diagnosis**

Accurate diagnosis of most overuse injuries requires no more than a good history, physical examination, and selected radiographs. A thorough history is the key to successful diagnosis because it allows for correct injury identification that can be confirmed through physical examination and radiographs. Vague diagnoses, such as "runner's knee" and "shin splints," do not clearly define the anatomic dysfunction, while diagnoses such as patellar tendinitis and medial tibial stress syndrome more precisely define the disorder by pointing to its origins.

The physician should begin by asking the athlete questions that identify the "transition" that may have contributed to the overuse. When did the injury first occur? Did you recently purchase new shoes or a new racket? Have you changed training locations or your training regimen?

Questions should also focus on the quality of the athlete's pain. Does the pain occur only with sports activity or also with activities of daily living? Pain phase scales, such as Puffer and Zachazewski's (18), can often be helpful in classifying the injury, determining prognosis, and gauging rehabilitative progress. Type 1 pain occurs after activity only; type 2 occurs during activity, but does not impair or restrict performance; type 3 occurs during activity and is severe enough to interfere with performance; and type 4 is classified as chronic and unremitting. Nirschl's seven-phase pain scale (table 2) is somewhat more useful because it separates the activities of daily living from sports performance.

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<th><strong>Table 2. Nirschl Pain Phase Scale of Athletic Overuse Injuries</strong></th>
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<td><strong>Phase 1.</strong> Stiffness or mild soreness after activity. Pain is usually gone within 24 hours.</td>
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<td><strong>Phase 2.</strong> Stiffness or mild soreness before activity that is relieved by warm-up. Symptoms are not present during activity, but return afterward, lasting up to 48 hours.</td>
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<td><strong>Phase 3.</strong> Stiffness or mild soreness before specific sport or occupational activity. Pain is partially relieved by warm-up. It is minimally present during activity, but does not cause the athlete to alter activity.</td>
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<td><strong>Phase 4.</strong> Similar to phase 3 pain but more intense, causing the athlete to alter performance of the activity. Mild pain occurs with activities of daily living, but does not cause a major change in them.</td>
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<td><strong>Phase 5.</strong> Significant (moderate or greater) pain before, during, and after activity, causing alteration of activity. Pain occurs with activities of daily living, but does not cause a major</td>
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change in them.

**Phase 6.** Phase 5 pain that persists even with complete rest. Pain disrupts simple activities of daily living and prohibits doing household chores.

**Phase 7.** Phase 6 pain that also disrupts sleep consistently. Pain is aching in nature and intensifies with activity.

General health questions should identify recurrent minor illnesses, sleep patterns, nutritional habits, and overall mood states that may provide clues to an overtrained state. Female athletes should be questioned about a history of stress fractures, menstrual abnormalities, and eating habits, since these are manifestations of the "female athlete triad"; early identification of the triad—eating disorders, amenorrhea, and osteoporosis—allows for interventions that may prevent considerable morbidity. Determining an athlete's training intensity and goals may help the physician design a rehabilitation program that fits the patient's athletic objectives.

The physical examination seeks to identify the focal problem and uncover contributing intrinsic abnormalities. Using MacIntyre and Lloyd-Smith's (19) concept of "victims and culprits" can be helpful in a detailed examination (see "A Runner With Heel Pain: Putting It All Together," page 104.) The victim represents the presenting problem, while the culprit is the anatomic abnormality that created the victim. An example would be gastroc-soleus inflexibility (culprit) contributing to plantar fasciitis (victim).

Accordingly, the entire extremity and kinetic chain needs a thorough examination when evaluating a specific injury. A runner who presents with running-related anterior knee pain requires a detailed examination of the knee as well as an examination of the lower extremity, including the feet. Leg length discrepancies, sacral rotations, hamstring inflexibility, and subtle forefoot pronation are only a few of the many potential "culprits." The tennis player with elbow pain almost routinely demonstrates weakness in the rotator cuff. The baseball pitcher with shoulder pain needs an examination that includes the lower extremities as well as the trunk, since all are involved in the throwing motion. Failure to identify muscle imbalance patterns and structural malalignment often sabotages an otherwise well-planned rehabilitation program.

As described, the physical examination is primarily biomechanical. On occasion, dynamic assessment such as slow-motion video analysis may be required. Finally, the examination should include a look at equipment, such as running shoes and tennis rackets.

Radiographs aid diagnosis and can rule out related injuries such as fractures, intra-articular abnormalities, heterotopic calcification, and other pathologies such as tumors. A few overuse injuries, including those with combined pathoanatomic presentations (for example, rotator cuff tendinitis with combined labral pathology) or clinical evidence of major soft-tissue disruption, may require more advanced imaging techniques. Electromyographic studies and intracompartmental testing can be useful when clinically warranted.

**2. Control Inflammation**

Though inflammation is required for proper healing of injuries, an excessive or prolonged inflammatory response can become self-perpetuating and destructive. Therefore, controlling or suppressing inflammation is one of the primary goals of overuse injury treatment.

Control of inflammation has received considerable attention in the medical literature. The classic approach is RICE (rest, ice, compression, and elevation). At the Nirschl Clinic, prevention/protection, modalities, and medications are added to the acronym to create PRICEMM. Nearly all protocols for managing overuse injuries begin with the athlete abstaining from, or modifying, exposure to abusive activity. Rest, however, does not mean halting all
activity. Relative rest protects the injured area while avoiding the consequences of deconditioning and disuse atrophy. To prevent reinjury and ensure better compliance with rehabilitation programs, we emphasize what recuperating athletes can do to enhance healing and maintain fitness rather than what they cannot do. Athletes with lower-extremity injuries, for example, can frequently duplicate land workouts in a swimming pool.

Modalities and medications are fundamental to controlling inflammation and are frequently incorporated in the treatment of overuse injuries. Their role, however, has yet to be clearly defined (20,21). We use both approaches to assist in pain control so the patient can make a quick transition from relative rest to rehabilitative exercise.

Though corticosteroids are potent anti-inflammatories commonly prescribed in managing athletic injuries, their employment in treating overuse injuries is controversial, and their role is not clearly defined by objective data. They can be used to treat patients who have significant (Nirschl pain phase 5 or greater) or refractory pain. We administer them with caution, however, because corticosteroids in oral and injectable forms are thought to decrease collagen and ground substance production, weaken the tensile strength of tendons, and ultimately result in poorer healing. When injecting corticosteroids near a weight-bearing tendon, we restrict sports participation for 2 to 3 weeks. Injecting into weight-bearing tendons is contraindicated. While we do not use corticosteroid injections more than three times a year for an athlete, there is no rigorous research to support or contraindicate more or less frequent use.

3. Promote Healing
All too often, after efforts to control inflammation relieve a patient's pain, he or she prematurely returns to participation and is reinjured. In fact, Ekstrand and Gillquist (22) demonstrated that failure to rehabilitate an athlete after an initial injury can cause recurrent injury. Athletes and healthcare professionals may fail to appreciate that rest and anti-inflammatory medications do not heal. Clinicians can ensure a successful return to activity only when inflammation control overlaps aggressive efforts to promote healing.

Healing involves the proliferation of vascular elements and fibroblasts that create collagen deposition and maturation in injured tissue. This proliferation is best accomplished with a combination of site-specific rehabilitative exercise and cardiovascular conditioning (23), the goal of which is to restore injured tissue to normal or near-normal function. Early exercise enhances tissue oxygenation and nutrition, minimizes unnecessary atrophy, and aligns collagen fibers to meet eventual sports-induced stresses. Progress through rehabilitative programs is best accomplished under the direction of a physical therapist or a certified athletic trainer, since each patient's regimen is based on the particular injury and an athlete's specific needs.

Successful rehabilitative exercise programs incorporate full-motion strengthening that balances antagonistic forces necessary for an athlete to meet the demands of his or her sport. For example, the athlete with patellofemoral syndrome requires attention directed to both quadriceps and hamstring strength and flexibility.

Good general body conditioning is also important in promoting healing because it:

- Increases regional perfusion through central and peripheral aerobics,
- Provides neurologic stimulus to injured tissue through neurophysiologic synergy and overflow,
- Minimizes weakness of adjacent uninjured tissue (decreases or eliminates destructive domino effect),
- Minimizes negative psychological effects, and
- Minimizes unwanted fat and helps control weight.
A good conditioning program incorporates strength training of uninjured tissues with appropriate forms of aerobic exercise. Exercises commonly used for such conditioning include stationary bicycling, stair climbing, upper body ergometry, and water workouts.

Rehabilitative exercise generally restores an athlete's previous level of function. However, a few patients may fail to respond to rehabilitation and may require surgery. Patients who fail to improve with conservative therapy, however, should seek a second opinion to be sure that all possible "culprits" have been identified and treated before surgery is considered. If surgery is necessary, it can provide a better physiologic environment for a renewed rehabilitative effort through resection of pathologic soft tissue and correction of underlying risk factors such as pathologic instability. We consider surgery for a patient when his or her:

- Rehabilitative program has failed (after 3 to 6 months),
- Quality of life is unacceptable, and
- Weakness, atrophy, and dysfunction persist.

4. Increase Fitness
Once healing and rehabilitative exercise have restored damaged tissues to normal strength, a patient's tissues need further strengthening to achieve the supernormal endurance and power required for the demands of sports. This is where fitness exercises enter the management pyramid. These exercises involve sport-specific rehabilitative exercises and further general body conditioning.

A patient can begin such exercises once he or she achieves pain-free range of motion, and strength and endurance tests indicate a return to a preinjury state. Sport-specific activities work the athlete's target tissues, providing neurophysiologic stimulus and redeveloping proprioceptive skills. Sport-specific agility, speed, and skill drills, such as plyometrics, interactive eccentric and concentric muscle loading, anaerobic sprints, and interval training, coordinate interaction of the athlete's antagonistic and supporting muscles.

5. Control Abuse
The final step in overuse injury management is to control force loads to the rehabilitated tissue. Controlling tissue overload means modifying intrinsic and extrinsic risk factors identified in the patient's history and physical examination. Effective control of tissue overload includes:

- Improving the athlete's sport technique,
- Bracing or taping the injured part,
- Controlling the intensity and duration of the activity, and
- Appropriately modifying equipment.

Improving the athlete's sport technique is critical since abnormal and improper biomechanics quickly promote reinjury.

Bracing and taping can control abuse during rehabilitation and when the athlete first resumes sports activity. Counterforce bracing helps control an athlete's muscle balance. Groppel and Nirschl (24), for example, have shown that elbow counterforce braces decrease elbow angular acceleration and electromyogram muscle activity and thus are of value in treating tennis elbow. We have successfully used counterforce bracing to treat patients with tennis elbow, plantar fasciitis, and patellar tendinitis.

Training errors—excessive frequency, intensity, and duration—are the principal risk factors for overuse injuries. The clinician must emphasize that more is not always better and explain that overtraining precipitates injury and causes fatigue and decreased performance. Athletes should be encouraged to follow basic training principles of progression and periodization,
which imply gradual increases in workload and training cycles that emphasize programmed rest.

Modifying equipment requires paying attention to shoes, sport-specific equipment, and playing or training surfaces. Subtle abnormalities in an athlete’s foot biomechanics can contribute to numerous lower-extremity overuse injuries. Physicians need to attempt to correct these abnormalities through rehabilitation, use of proper footwear, and if necessary, custom orthoses. Wide-bodied rackets or rackets with improper grip size often predispose tennis players to overuse injuries of the upper extremity. Lower-extremity injuries, such as plantar fasciitis and stress fractures, often result from poor or hard playing surfaces. An ideal playing surface provides adequate traction, cushion, and evenness so athletes can avoid the excessive forces from repetitive pounding, twisting, and turning.

**Back in Action**

Traditionally, athletes have been allowed to return to limited activity when they demonstrate full range of motion and when the injured extremity shows 80% to 90% of the strength of the uninjured extremity (objectively measured with functional lower extremity testing). These two criteria, however, are only minimums. Before an athlete returns to activity, the physician, coach, and trainer should consider two other questions:

- Does the athlete demonstrate sport-specific function?
- Is the athlete psychologically ready?

When all involved are satisfied with the answers to these questions, the athlete can safely return to full activity.

**'Prehabilitation' and the Preparticipation Exam**

Because overuse injuries can be so perplexing and frustrating to athletes, coaches, trainers, and healthcare professionals, many authors have written about preventing these injuries through identifying and modifying risk factors. Kibler, a major proponent of "prehabilitation (25)," and others (26) believe that physicians can use the preparticipation examination to identify an individual's weaknesses and flexibility deficits, so that preventive exercise may begin before injury occurs. We currently follow this concept of prehabilitation at the Nirschl Clinic with elite tennis players and at the DeWitt Army Community Hospital Primary Care Sports Medicine Center with active-duty soldiers. We hope that data from well-controlled studies will soon support what we have observed anecdotally.

The five-step overuse injury pyramid outlines a process of evaluation and management that we have found helpful in treating individuals with overuse injuries. Along with prehabilitation, the pyramid provides a functional approach to these injuries that offers patients the best chance for recovering from injury and maintaining an active life.