Overuse Injuries in Young Athletes: An Overview

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Of children between 5 and 17 years of age, it is estimated that more than 30 million are involved in organized athletic programs (Landry, 1992; NATA Research and Education Foundation, 2001). The extent of participation is highlighted by the fact that large numbers of children are involved with not only traditional school-based and agency-sponsored programs (Little League) but also club programs, summer camps, and personal training programs. These factors have created an environment in which many youngsters train and compete on a year-round basis, often in a single sport. Given these circumstances, it is not surprising that overuse injuries have become commonplace in children. A recent study found that 50% of injuries in children presenting to a sports-medicine clinic were classified as overuse injuries (Watkins & Peabody, 1996). These injuries might not be self-limited; that is, they might not resolve without intervention (DiFiori, Puffer, Mandelbaum, & Mar, 1996). In addition, recovery from overuse injuries among children might take longer than recovery from acute injuries (Baxter-Jones, Mafulli, & Helms, 1993).

Development of Overuse Injuries
Overuse injuries occur as a result of repetitive loading on a specific anatomic structure. An injury occurs when tissues (e.g., bone, tendon, nerve) undergo regular mechanical loading without sufficient recovery. The relative balance between loading and recovery is the key factor. Long-duration loading at a modest-intensity level with little recovery time can produce injury, or injury might develop with high-intensity, short-duration loading despite a more extensive recovery period. Simply put, when the amount of loading exceeds the remodeling capability of the tissue under stress, clinical injury can occur. The tendon model of overuse is perhaps the best studied. Histopathologic analysis of tendon from patients with chronic tendinopathies demonstrates a loss of collagen continuity, an increase in ground substance and vascularity, and an increase in fibroblasts and myofibroblasts. Inflammatory cells are absent (Khan, Cook, Taunton, & Bonar, 2000). Thus, overuse injuries typically involve degenerative tissue rather than acute tissue inflammation. Such injuries are more accurately described as tendinosis than as tendinitis. This distinction is important in developing sound management strategies.

Risk Factors for Overuse Injuries

Growth-Related Risk Factors
In the skeletally immature athlete, growth cartilage is present at the articular surface, the physis, and the apophyses. Growth cartilage
appears to be more susceptible to injury, based on basic-science studies and clinical observations of injury patterns (Alexander, 1976; Bailey, Wedge, McCulloch, Martin, & Bernhardson, 1989; Blimkie et al., 1993; Bright, Burstein, & Elmore, 1974; Flachsmann, Broom, Hardy, & Moltschaniwskyj, 2000).

The period of the adolescent growth spurt seems to be associated with increased risk for injury. During this time, rapid changes in the length, mass, and moment of inertia of the extremities result in increased stress on muscle–tendon junctions, bone–tendon junctions (apophyses), ligaments, and growth cartilage (Hawkins & Metheny, 2001). Strength increases allow for limb movements to continue to occur at the same level as before the growth spurt, but strength gains might occur more rapidly in some tissues than in others. Such asynchronous changes, combined with repetitive loading, represent risk factors for overuse injuries that are unique to adolescents.

Osteochondritis dissecans is a lesion that affects articular cartilage, usually at the ankle, knee, or elbow. Although it might be diagnosed in youngsters presenting with sports-related symptoms, the etiology is not well understood. Children can develop these lesions in the absence of repetitive loading. Although osteochondritis dissecans is a phenomenon of articular cartilage, it might or might not develop specifically as a result of overuse.

Apophyseal injuries occur as a consequence of traction at immature tendon–bone attachment sites. Injuries of the patellar tendon–tibial tubercle apophysis (Osgood-Schlatter disease) and the Achilles tendon–calcaneal apophysis (Sever’s disease) are typical examples. The weakness of the growth cartilage relative to the tendon is a contributing factor in these injuries. Decreased flexibility, creating increased traction at the apophyseal insertion of the tendon, has also been cited as a factor. It has been proposed that during the adolescent growth spurt flexibility decreases as the long bones grow more rapidly than their muscle–tendon attachments (Micheli, 1983). The relationship between decreased flexibility and growth, however, has recently been questioned (Feldman, Shrier, Rossignol, & Abenhim, 1999).

The physis (or growth plate) can also be injured through overuse. Such injuries have been described in the proximal humerus, the proximal tibia, and the distal radius (Boyd & Batt, 1997; Cahill, 1977; Carson & Gasser, 1998; DiFiori, Puffer, Mandelbaum, & Dorey, 1997; Gross, Flynn, & Sonzogni, 1994; Roy, Caine, & Singer, 1985). This appears to occur when repetitive loading produces metaphyseal ischemia, which results in the inhibition of mineralization in the zone of provisional calcification. Chondrocyte life is then extended, and continued division of chondrocytes in the zone of proliferation causes growth-plate widening (Jaramillo, Laor, & Zaleske, 1993). Such injuries can produce partial or complete growth arrest (Albanese et al., 1989).

Intrinsic Risk Factors

Intrinsic risk factors include the following.

• History of prior injury. Youngsters presenting with an overuse injury might have a history of similar injuries. This can signal a failure to uncover the underlying cause of the injury (e.g., training errors, poor technique) or inadequate rehabilitation of the previous injury.

• Inadequate conditioning or preparation. Children who are initiating training programs without having had an opportunity to develop general strength, endurance, and proprioceptive skills might be at increased risk. Preparation focusing on age-appropriate activities can help address this.

• Anatomic malalignment and joint laxity. Alignment abnormalities including pes planus, pes cavus, patellofemoral malalignment, and others have often been cited as risk factors for overuse injury. Excessive ligamentous laxity might also predispose to overuse injury (Hoppmann & Patrone, 1989; Larsson, Baum, Mudholker, & Kollina, 1993). These factors are difficult to assess because the magnitude of their effect is not readily appreciated in the relatively static clinical setting. The true cause-and-effect relationship of malalignment and joint laxity to overuse injury is not clear (Ilahi & Kohl, 1998).

• Menstrual dysfunction. Menstrual dysfunction, which can be associated with low bone-mineral density, can increase the risk of stress fractures in some young athletes.

• Psychological factors. A child’s maturity level and motivation can affect his or her ability to develop general conditioning and training habits that can help reduce the chances of injury.
Extrinsic Risk Factors

Extrinsic risk factors include the following.

• Inappropriate training progression or inadequate recovery. Rapid increases in training frequency, duration, or intensity can lead to overuse injury. A failure to incorporate scheduled rest periods in the training program can also be a factor. Because children vary in physical and emotional maturity levels even within age groupings, it is important to recognize individual differences and adjust training appropriately. When it comes to training youngsters, one size does not fit all.

• Equipment problems. Equipment that is not well maintained or properly fitted can lead to injury. Overworn or inappropriate footwear can contribute to injury, as well. In addition, those new to a sport might not be familiar with the type of equipment needed or how to choose which is best for their child. For those established in an activity, changes in equipment (new shoes, new tennis racket) can trigger an overuse injury.

• Poor technique. As children progress in their sports, they attempt new skills. Improper technique such as poor serving mechanics in tennis can lead to injury—either when the new skill is introduced or later when training intensity increases.

• Psychological factors. Many of the external factors cited are affected to a significant extent by adults in a supervisory role. Coaches, parents, and even peers who are unaware of or ignore those issues can create an environment in which overuse injuries are more likely to occur.

Diagnostic Tests

In many cases a diagnosis can be made and treatment initiated without diagnostic imaging. In some situations, however, imaging tests are important in

<table>
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<tr>
<th>Injury Severity</th>
<th>Symptom Characteristics</th>
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<tr>
<td>Grade 1</td>
<td>Symptoms occur at the end of the activity, or only at initiation, then diminish.</td>
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<tr>
<td>Grade 2</td>
<td>Symptoms develop during activity, late onset, and diminish after activity is completed.</td>
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<tr>
<td>Grade 3</td>
<td>Symptoms develop during activity, early onset, and persist during remainder of activity, diminishing after activity has ended.</td>
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<tr>
<td>Grade 4</td>
<td>Symptoms develop during activity and limit training frequency, intensity, or duration.</td>
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<tr>
<td>Grade 5</td>
<td>Symptoms prevent training.</td>
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Note. Adapted from DiFiori and Hosey, 1998.

The Physical Exam

Assess alignment, flexibility, joint laxity, and muscle tone. Compare extremities.
Carefully examine the injured area and attempt to determine the specific tissue injured.
Review the sport technique involved. Have the child demonstrate it for you.
Inspect the equipment used for fit, wear, and suitability for the sport and the child.
order to establish the diagnosis. Radiographs are helpful in the assessment of suspected stress reactions, osteochondritis dissecans, and growth-plate injuries. They can be used to assess joint alignment and to inspect for signs of inflammatory arthritis. Radiographs are especially important in cases that do not respond as expected with treatment. Such cases should raise suspicion for less common diagnoses such as tumors. When radiographs are unrevealing, bone scans and MRI can be used. The type of test used depends on the specific case. For example, bone scans are often used in evaluating suspected extremity stress reactions or spondylolysis. MRI is increasingly used to diagnose stress reactions. For youngsters with recurrent leg pain, compartment-pressure testing can be useful to diagnose exertional compartment syndromes. Other studies including CT scans, EMG and nerve-conduction studies, and duplex scans can be considered in selected cases.

**Treatment**

Overuse injuries can be successfully treated by implementing several general treatment principles. Reduction of tissue loading is foremost. It is essential to halt the overuse process by decreasing stress on the affected tissues. Complete rest from the activity might not be required. The history can help guide the extent to which training is reduced. For example, for a Grade 1 injury, training could be reduced by 25%, for a Grade 2 injury 50%, and so on. To offset the reduction in training, alternative activities should be added that do not stress the injured tissue. A typical example is cycling or swimming in lieu of running for an athlete with a stress reaction of the lower extremity.

Ice or other cold application is helpful to reduce pain and minimize inflammation. Nonsteroidal anti-inflammatory drugs are often used in the treatment of overuse injuries. Their effectiveness in this setting, however, has not been well established. Their primary benefit might be in enabling progress with a supervised rehabilitation program by minimizing pain. In most cases of overuse injuries in youngsters, however, relative rest and ice are sufficient in reducing pain.

As a method of restoring strength and flexibility, a comprehensive rehabilitation program is the cornerstone of treatment. Progressive strengthening exercises are important to strengthen damaged tissue and improve force dissipation. Flexibility exercises should be carefully implemented in order to avoid overstretches. Proprioceptive retraining is also an important component of the rehabilitation process. As strength and flexibility improve, sport-specific activities are reintroduced.

Finally, it essential to avoid reinjury. A plan should be developed to address the intrinsic and/or extrinsic factors that contributed to the injury.

**Prevention**

It is estimated that 50% of overuse injuries are preventable (American College of Sports Medicine, 1993). Suggestions to help reduce the likelihood of overuse injury include the following:

- Preparticipation exams. Screening by a physician can identify risk factors for injury and provide an opportunity to develop specific recommendations for addressing them.
- Proper adult supervision and coaching. Leagues and parents should take steps to ensure that the programs in which children are participating provide coaches with the resources to become educated about overuse injuries common in their sports and ways in which they can be reduced.
- Training programs that emphasize general fitness and avoid excessive training volumes. Although individual situations vary, the 10% rule—limiting increases in training frequency, intensity, and duration to no more than 10% per week—serves as a general guide (American College of Sports Medicine, 1993; Daulton, 1992). Periodization of training, which systematically varies training volume and incorporates scheduled rest periods, should also be considered.
- Delaying sport specialization. Allow children to experiment with different activities to develop skills and interest.
- Careful monitoring of training for children undergoing growth spurts. It might be appropriate to modify training during this time period because of the growth-related factors that can lead to injury.

**Summary**

Injuries that occur among children participating in sports are often the result of overuse. Several growth-specific issues, along with other intrinsic and extrinsic
factors, create special circumstances that can lead to overuse injuries in youngsters. Identifying these factors is important in developing a comprehensive rehabilitation program and avoiding reinjury. Prevention strategies such as gradual training progressions and educating parents and coaches should be employed in an effort to reduce injury occurrence and thereby maximize the enjoyment and benefits of youth participation in sports.

References


