BACK INJURIES IN THE YOUNG ATHLETE

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Back injuries in the young athlete are a significant phenomenon, estimated to occur in 10% to 15% of participants. The prevalence, however, varies between sports and, in some cases, the specialty position played. In gymnastics, the incidence of back injuries is thought to be 11%, whereas in football linemen, it has been recorded as high as 50%.

Back injuries include single-episode macrotrauma ("acute") and repetitive microtrauma ("overuse") injuries. Efforts have been successful in minimizing catastrophic acute spinal injuries in contact sports, such as football, hockey, and rugby, through rule changes and equipment modification. Noakes et al recently reported a 46% reduction in the number of spinal cord injuries with the avoidance of the high tackle in schoolboy rugby, in South Africa. On the other hand, the less dramatic, overuse injuries appear to be increasing as more young athletes are required to perform repetitive skills as part of their training programs. What is of concern is that these overuse back injuries, once present, are difficult to overcome, and recur in 26% of males and 33% of females.

This article reviews current concepts in the management of acute back injuries and then addresses overuse back injuries.

ACUTE INJURIES

Fractures

Acute fractures of the thoracic and lumbar spine occur in collision sports, such as rugby, football, and ice hockey. Thoracic and lumbar compression fractures occur with axial loading in a flexed or vertical posture. They are less frequently associated with catastrophic spinal cord injuries than with cervical spine injuries. Nonetheless, attention to initial, proper spinal immobilization is critical with the fallen athlete to prevent further injury during transportation. The Interassociation Task Force for Appropriate Care of the Spine recently drew up guidelines for pre-admission management of these injuries. The athlete with a suspected spinal injury is assessed first for breathing, circulation, and neurologic status. If there is concern for life support, the athlete is
placed in a supine position while maintaining spinal immobilization by splinting the head to the trunk. Emergency medical services are implemented. The facemask is the critical element and should be removed with readily available tools before transport. The helmet and chinstrap are removed only if the helmet does not allow immobilization or if the design prevents airway establishment. Leaving the helmet and shoulder pads on during transportation to the hospital is preferable because they align the trunk and upper spine in unison. If removal is required for airway management, the spinal alignment must be maintained while removing both. First removing the cheek pads facilitates helmet removal. These steps all should be well rehearsed before an event. An initial neurologic assessment by the emergency medical team leader is important for prognosis and consideration of returning later to contact sports.

While maintaining immobilization in the emergency room, lateral cervical, thoracic, and lumbar radiographs are obtained. Although unusual, compression fractures of the thoracic and lumbar spine do occur in athletic competition. These are secondary to compression and axial loading in a neutral or a flexed position. Thoracolumbar compression fractures of less than 25%, without neurologic symptoms, are not associated with posterior instability. Posterior instability, however, becomes a concern as the compression approaches 50%. Several classification systems have been described to assess stability radiographically. One functional description is Denis's three-column theory. The anterior column consists of the anterior longitudinal ligament and the first half of the vertebral body. The posterior vertebral body to the pedicles comprises the middle column, and the bony arch with its ligamentous attachments is the posterior column. Two-column involvement implies instability. Usually, an intact middle column indicates stability. If instability is suspected, it is assessed best with computed tomography (CT) with sagittal and coronal reconstruction. MR imaging is helpful to assess associated ligamentous and disc involvement when neurologic symptoms are present.

Stable thoracic fractures are immobilized in a thoracolumbosacral spinal orthosis (TLSO) or Jewett brace for 6 to 12 weeks. Stable lumbar fractures require only 4 to 6 weeks in a similar brace. Athletes with stable lumbar fractures that heal well usually return to full competition when they demonstrate full range of motion, strength, and are symptom free. Thoracic fractures pose more of a concern for potential cord involvement. An athlete with a minimal compression fracture without any neurologic involvement may be considered for return to competition when well healed. The athlete, parents, and coaches, however, should be aware of the risks. Unstable thoracic fractures that require instrumentation are a contraindication to returning to contact sports. Unstable lumbar fractures requiring instrumentation usually are a contraindication to contact sports. A single-level fusion may be considered, with the understanding that forces are transferred to the adjacent disc level and predispose to degeneration.

**Acute Disc Herniation**

Acute herniation of the nucleus pulposus has a 2% incidence in adults. It occurs less frequently in the young athlete and is less clear on clinical presentation, often lacking sciatica. The adolescent may present with back spasm, neurogenic scoliosis, hamstring tightness, and buttock pain. Examination usually reveals decreased lumbar motion, a positive straight-leg raise test, and possibly a decrease in reflexes or strength. Lumbar radiographs are obtained to rule out associated pathologic conditions. An MR imaging study often is performed for refractory or progressive changes.

The pathogenesis of disc pain is explained only partially by the mechanical pressure of the disc protrusion. Symptoms of acute disc herniation may occur with minimal disc changes visualized by MR imaging criteria. Secreted cytokines, such as phospholipase A2 and nitric oxide, that stimulate inflammation at the dorsal root ganglion have been identified. The nucleus pulposus itself may be a direct neurotoxin to the dorsal root ganglion, thus, minimal overt disc injury may produce profound symptoms.
Disc herniation with the anulus attaching an avulsed fibrocartilage ring apophysis is unique to the adolescent. This has been postulated to occur in flexion as a posterior rim avulsion fracture, and has been shown to occur with compression loads fracturing the endplate and ring apophysis posteriorly with an anular attachment. Using MR imaging analysis, Itaka et al [31 demonstrated the disk fragment posing a risk for nonunion and canal compromise. Two thirds of the endplate fragments had interposed disc. Evaluation by MR imaging often is diagnostic; however, CT scanning and careful review of plain radiographs also may be required. [62

Disc herniations often are managed successfully with a multidisciplinary approach, including a temporary lordotic brace that allows early resumption of daily activities. Physical therapy is initiated with an extension-biased stabilization program when the patient is able. Therapy includes a peripelvic flexibility and isometric strengthening program, which is advanced to co-activation techniques using balance ball exercises. The pain management service assists with medication, such as the tricyclic antidepressants, neuroleptic agents, biofeedback techniques, and epidural corticosteroids. Surgical management is required only for cauda equina syndromes, a progressive neurologic deficit, and refractory pain. The presence of a hinged fibrocartilage often necessitates a surgical excision. [43 Athletes with disc herniation may return to competition when they have attained a full range of motion, strength, and sport-specific attention to technique.

**Contusions, Strains, and Subluxations**

Contusions and sprains are often self-limited and are those most often referred for second stage medical treatment. Adolescent growth spurt, however, may predispose to an acute apophyseal avulsion at the attachment of the lumbodorsal fascia to the apophysis of the iliac crest or spinous process. This may cause prolonged pain that necessitates further medical evaluation, such as a bone scan, when looking for other causes. Typically, apophyseal injuries will demonstrate increased uptake and are treated with rest, anti-inflammatory measures, and flexibility, and gradual strengthening therapies. Another refractory pain syndrome is the costovertebral subluxation, dislocation, or even fracture. [61 Reduction of a subluxed rib can be dramatic. Most often, massage, mobilization, NSAIDS, and sometimes a corticosteroid injection are successful in treating these conditions.

**OVERUSE INJURIES**

Adolescent and adult injury patterns differ. Forty-seven percent of young athletes presenting at Boston Children's Hospital had a final diagnosis of spondylolysis, whereas most adults presenting at an affiliated adult back center proved to have discogenic pain. [49 The uniqueness of injuries to the young spine reflects certain growth-related risk factors.

**Risk Factors**

**Growth Cartilage**

The adolescent spine has areas of growth cartilage and immature ossification centers that are susceptible to compression, distraction, and torsion injury. During growth, these areas often are the weakest link of force transfer. [67 The anterior column consists of the vertebral body and intervertebral disc. The vertebral body ends superiorly and inferiorly with the epiphyseal growth plate and overlying cartilagenous end plate and its contiguous ring apophysis. The apophysis is attached to the outer anulus fibrosus. [4 The end plate nourishes the avascular disc through hydrostatic motion. Injury to the end plate compromises the disc nutrition and the vertebral barrier
to a disc intrusion, such as the Schmorl's node. Injury to the apophyseal ring produces avulsions with hinged fibrocartilage (Fig. 1) .

**Figure 1.** Injury to the apophyseal ring produces avulsions with hinged fibrocartilage.

The posterior column is the neural arch, including the facet joints, the spinous process, and the pars interarticularis. A single ossification center is on each side of the neural arch at the pedicles. Ossification progresses posteriorly and may be congenitally incomplete on the superior portion of the pars interarticularis of the lower lumbar vertebrae, especially at L5. This superior arch is subject to stress from the abutting inferior articular facet of L4, described by Lane in 1886. Consequently, spondylolytic stress fractures may be more frequent in the presence of this incomplete ossification. In cadaver studies, Merbs demonstrated the incomplete lysis of the superior aspect of the L5 pars. The posterior arch also contains the growth cartilage of the facet joint and spinous process apophysis and is subject to traction of the dorsolumbar fascia and lordotic impingement.

**Biomechanics**

Another growth-related risk factor involves the biomechanical factors of kinematics and kinetics. Kinematics relates to body motion, whereas kinetics relates force to mass and its motion. The kinematics of lumbar flexion and extension involve a constantly changing, instantaneous axis of rotation or pivot point. The pivot point of lumbar motion centers near the nucleus pulposus, in normal lordosis, and moves to the facets in extension. This transfers compression forces from the disc to the facets and tensile forces to the disc and its anular attachments. Subsequently, injury patterns may be seen simultaneously anteriorly and posteriorly. This is demonstrated clinically in spondylolysis, an injury of repetitive extension, in which 68% of patients show concomitant anterior disc and end plate involvement. Repetitive torsional and flexion forces are most stressful to the posterolateral disc.

Kinetic forces include intrinsic (musculotendinous inflexibility) and extrinsic (collision and ground reactive forces). Spinal motion depends on coordinated trunk muscle activation and pelvic flexibility. Intrinsic biomechanical defects include:

- Iliopsoas inflexibility
- Femoral anteversion
- Thoracolumbar fascia tightness
- Abdominal weakness
- Genu recurvatum
- Thoracic kyphosis

Increased lordosis compresses the posterior elements, whereas excess lumbar flexion compresses the discs. Iliopsoas inflexibility increases lumbar lordosis and shear forces to the disc. Other factor that increase lumbar lordosis include tight thoracolumbar fascia, genu recurvatum, thoracic kyphosis, and weakened abdominal musculature. Femoral anteversion limits the hip turnout and is often compensated for the immature dancer, for example, by increasing lumbar lordosis, which releases the ilioinguinal ligament, allowing increased turnout.
Trunk muscle weakness is a risk to spinal stability. Specific muscles include the multifidi, lower abdominal, and internal oblique. Co-activated performance of these muscles creates a hydrostatic shock absorber with the intra-abdominal contents. This has been demonstrated during the pull phase in sculling, with exhalation and biofeedback training of coactivation, which enhances this hydrostatic cushion.

Identifying intrinsic deficits and understanding their interaction with sport-specific forces can help to anticipate potential individual injuries and allows for prehabilitation and rehabilitation. Indeed, certain sports show predilection for overuse spinal injury.

Degenerative disc changes are predominantly an adult phenomena; however, the condition also has been well documented in the preadolescent gymnast. Goldstein et al showed an 11% incidence in the pre-elite, 43% incidence in the elite, and 63% incidence in the Olympic gymnast. He also demonstrated that when the volume of training exceeded 15 hours, the risk of injury increased from 13% to 57%. Sports involving flexion, axial loading, and rotation, such as weight lifting, collision sports, and bowling, most commonly are involved with nucleus pulposus herniation. Spinal changes of lumbar Scheuermann's kyphosis with apophyseal ring avulsions and Schmorl's nodes have been associated with flexion and axial loading, as seen in gymnasts, football players, and divers with a flattened lordotic back. Hyperextension in dancing, figure skating, and interior football lineman has been associated with spondylolysis.

Nutrition

Nutrition also is a risk factor. The young female athlete may not be meeting her caloric requirements, which results in diminished estrogen production and menstruation, and inadequate maintenance of her calcium stores. Adolescent and early adult deficiencies may result in irreversible osteopenia and stress fractures such as spondylolysis.

Evaluation

Overuse back injuries may present with the gradual onset of pain, initially related to activities. Pain may be intermittent at first and then become more constant. A mild acute injury, however, may precipitate symptoms in a previously asymptomatic overuse injury. The timing and direction of evaluation in the young athlete with back pain requires an understanding of age-related differences. The adolescent athlete should be studied formally after 3 weeks of persistent back pain, in the absence of warning signs such as fever, weight loss, nocturnal pain, and immunocompromise. Conversely, back pain is quite uncommon in the prepubescent population, occurring at 1% incidence of 7-year-old and 6% incidence of 10-year-old children. In these age groups, formal studies are initiated early. In the adult, radiographs are obtained at 6 weeks, in the absence of warning signs.

A history of sports involvement can help narrow the differential diagnosis. The physical examination with lumbar flexion and extension is helpful in locating an anterior versus posterior problem. Physical findings such as extension pain with a central disc protrusion, or flexion pain with a spondylolysis under distractive forces, may overlap and be confused. Having the patient stand on one leg and extend enhances the specificity for a posterior problem. The history and exam help place the athlete into an anterior (flexion-based) or posterior element (extension-based) injury (Table 1).

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<th>TABLE 1 -- CLASSIFYING EXAMINATION FINDINGS</th>
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<td>Flexion-Based Injuries</td>
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<thead>
<tr>
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<td>Disc degeneration</td>
<td>Spondylolytic process</td>
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<td></td>
<td>1. Stress reaction</td>
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<td>Atypical Scheuermann's kyphosis</td>
<td>2. Fracture (spondylolysis)</td>
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<td>3. Spondylolisthesis</td>
<td>1. Apophyseal avulsion</td>
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<td>Internal disc derangement</td>
<td>2. Spinous process impingement</td>
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<td>Transitional vertebrae</td>
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EXTENSION INJURIES

**Spondylolysis and Spondylolisthesis**

Spondylolysis is a stress fracture of the pars interarticularis, associated with sports that involve repetitive flexion and extension. There is also a strong familial association, and spondylolysis has been identified in approximately 50% of Alaskan natives. Spondylolysis may be asymptomatic. Sarasta reported 13% of patients presenting with long-term pain. Athletes, however, present from a different cause, with repetitive stress destabilizing the pars.

The radiographic evaluation of the athlete with hyperextension pain is initiated with an anteroposterior and a lateral radiograph (Fig. 2). Oblique views are not helpful and add ionizing radiation. Congeni et al reviewed patients who underwent positive bone scans and negative oblique series and demonstrated an 85% incidence of fractures on CT imaging. Saifuddin et al explained this by showing that only 32% of pars fractures fall within the necessary 15° of the oblique beam. A bone scan with SPECT imaging is performed next. The SPECT improves the detection of spondylolytic lesions over the planar bone scan. SPECT imaging localizes the lesion. If a focal area of uptake is seen, a limited CT is performed at the isolated level, with 3 mm cuts, to classify the fracture. Fractures are classified as early, progressive, and terminal. In athletes without rigid bracing, Morita showed that none of the terminal and 73% of the early lesions healed. Other investigators, however, have reported sclerotic lesions healing with rigid bracing. Current studies seek to clarify a difference with rigid bracing, using similar CT classifications.

Figure 2. Imaging protocol for symptomatic lumbar hyperextension. AP = anteroposterior; SPECT = single photon emission computed tomography; PT = physical therapy.

All symptomatic fractures are treated using an antilordotic lumbosacral orthosis with physical therapy as described in the following protocol.

**Brace Protocol**

*Visit One:* Spondylolysis diagnosis finalized. Boston overlap brace fitted at 0° of extension. Physical therapy initiates peripelvic flexibility and antilordotic strengthening.
Activity restricted to physical therapy, stationary bike, and swimming, except butterfly and breast stroke.

Visit Two (4 to 6 weeks later): Clinical assessment determines no pain with activities and none on lumbar hyperextension. Spinal stabilization strengthening begun with extensions to neutral.

OR

Persistent pain at this visit initiates a search for a co-morbid diagnosis.

Visit Three (4 months after visit one): Limited CT repeated.

If healed, wean from brace.

If nonunited and symptomatic, consider electrical stimulation with brace.

The athlete with persistent symptoms at 4 to 6 months and a persistent nonunion may be offered external electric stimulation. If the patient remains symptomatic and has a persistent nonunion at 9 to 12 months, surgical posterolateral in situ fusion at L5 is performed. L4 is addressed with direct fixation. Return to sports is allowed after there is demonstrated union, and the athlete is pain free and manifests a full range of motion.

Injuries that reveal diffuse uptake on bone scan represent stress responses, and a CT is not performed. They are treated with physical therapy and modified bracing until pain free. In a young athlete, a symptomatic, minimal grade I spondylolisthesis with 1- to 2-mm slippage is treated as a symptomatic spondylolysis. The goal is to achieve a bony or fibrous, stable union.

Spondylolisthesis is the forward slippage that occurs with one vertebral body over our inferior vertebral body. Wiltse et al classified this as dysplastic, isthmic, degenerative, traumatic, and pathologic. The isthmic type is the concern in the athlete. Myerding graded spondylolisthesis by percentage of slip. Each 25% increase in slippage of the L5 over the inferior sacral end plate increases the grade by one (i.e. 0-25% is grade I; 25-50% is grade II, and so forth). Athletes are at a low risk for progression of spondylolisthesis. Muschik followed athletes involved in 20 hours per week of vigorous athletic activity over an average of 4.8 years, and found that 33 of 62 athletes demonstrated a minimal 10.5% progression of the slippage. Seitsalo et al reviewed Finnish ballet dancers and found 25% with spondylolisthesis without any increase in pain scores compared with the dancers without spondylolisthesis. Nonetheless, slippage is associated with rapid growth and is symptomatic. The slip angle is the angle formed between the lower L5 end plate and the superior end plate of S1. When this angle exceeds 50°, this is a risk for progression. Treatment of a chronic slippage involves temporary antilordotic bracing and lumbar stabilization with coactivation techniques. In the young athlete, surgical stabilization is indicated with progression beyond 50%. Surgery also considered with neurologic symptoms, demonstration of slippage progression, persistent pain, or cosmetic deformity. Surgical intervention often involves a posterolateral fusion.

Lordotic Low Back Pain

A tight thoracolumbar fascia is a consequence of rapid growth. The resulting hyperlordosis with a flat midback and thoracic kyphosis is characteristic. Several pain syndromes may ensue. Traction apophysitis may occur at the iliac crest, spinous process, and even at the anterior vertebral ring apophysis. This also may cause an impingement of adjacent spinous processes forming a pseudarthrosis (Baastrup's syndrome) and often is a diagnosis of exclusion after evaluation with a bone scan. Increased activity may be seen in the area of the injured apophysis. Treatment
is directed at thoracolumbar and peripelvic stretching. Temporary antilordotic bracing may be of assistance.

**Transitional Vertebrae**

A *transitional vertebra* represents an incomplete segmentation of the lower lumbar and upper sacral vertebrae. A pseudarthrosis may form between a bony lumbar extension to the sacral ala or iliac wing, readily identified on plain radiographs. Athletes participating in rapid flexion and extension may cause severe inflammation of the pseudarthrosis (Bertolotti's syndrome), which may mimic a spondylolysis. Careful review of the bone scan may show an area of uptake at the pseudarthrosis. Alternatively, the disc above the pseudarthrosis may degenerate or protrude. An MR image may assist here. Kim and Sur demonstrated an association of spondylolisthesis progression with transitional vertebrae. An isthmic defect at L4 with an associated L5 sacralization was most at risk for progression.

Initially, the treatment requires quieting the inflammation at the pseudarthrosis or disc, which is achievable in a rigid lumbosacral orthosis. Physical therapy is used to stretch and stabilize the spine. Sport-specific training is necessary to avoid the injury pattern. Occasionally, a fluoroscopically assisted corticosteroid injection of the pseudarthrosis or disc is therapeutic and diagnostic.

**Facet Syndrome and Sacroiliitis**

Facet chondromalacia often is a diagnosis of exclusion because clinical tests are difficult to interpret. This may be refractory to stretching and stabilization programs. True facet arthrosis is more common in the older athlete, although even then, CT and bone scan imaging may be normal. Corticosteroid injections may be diagnostic and therapeutic. Treatment is initiated with peripelvic flexibility and antilordotic strengthening.

Sacroiliac dysfunction also may be obscure in its presentation. The sacroiliac (SI) joint is flat until after puberty; elevations and depression develop in late adolescence and early adulthood. The inferior portion is synovial, whereas only one quarter of the upper portion is synovial. Sacroiliac motion dissipates forces between the trunk and lower extremities. The typical motion is joint nutation with backward rotation of the ileum on the sacrum and counternutation with forward rotation of the ileum on the sacrum. Impaired function may occur with inequality of motion from side to side, similar to limb length discrepancy and unilateral hypomobility from trauma or from a failed back syndrome. The pain may be quite diffuse and even include sciatic symptoms. Other causes of SI pain include stress fractures in the athlete, hematogenously spread infections, and inflammation from metabolic and arthritic causes. Ankylosing spondylitis, psoriatic arthritis, and Reiter’s disease may all be involved. There is no specific radiographic test that identifies the inflammation in the joint. The bone scan is not sensitive for inflammatory pain. MR imaging provides information about stress fractures and infectious causes. The CT provides bony detail and some soft tissue information. Intra-articular blocks often are the gold standard for diagnosing the SI as a pain generator.

Sacroiliac stress fractures are treated with partial weightbearing for 4 to 6 weeks. Sacroiliac inflammation initially is addressed with a SI joint belt worn above the greater trochanters, along with ice and electrical stimulation. Gradual mobilization with heat and, finally, full closed-chain peripelvic strengthening are addressed, and limb length discrepancy is addressed. Intra-articular injections may be helpful in the progression of rehabilitation.
FLEXION INJURIES

Scheuermann's Kyphosis and Atypical Scheuermann's Kyphosis

Scheuermann first described the thoracic kyphosis with three consecutive anterior vertebral bodies wedged at least 5% each, along with associated vertebral end plate changes, Schmorl's nodes, and apophyseal ring fractures. He initially proposed this as an injury of traumatic origins. Repetitive flexion is associated. Sports such as water skiing have a high prevalence, when competitive skiing is started at the age of six. This is differentiated from a juvenile, postural round back, which is reversible with overhead arm extension. Treatment for these entities includes upper trunk and postural exercises; however, when the kyphotic curve in Scheuermann's reaches 60°, TLSO bracing is instituted. In contrast, juvenile round back syndrome may be considered for bracing when the curve reaches 70° to 80°.

Lumbar Scheuermann's is the atypical variety seen in sports of rapid flexion and extension, such as gymnastics and wrestling. This entity has similar manifestations with end plate fractures, Schmorl's nodes, and vertebral apophyseal avulsions. The changes, however, involve a lower segment at the thoracolumbar juncture. The presentation is with a flat back and a tight thoracolumbar fascia. These athletes are addressed with an aggressive therapy regime to stretch the thoracolumbar fascia and gradually improve spinal stabilization. A lordotic brace with 15° of lordosis is useful in returning the athlete to sports in 1 to 2 months. These braces may be adjusted with more or less lordosis to meet the individual's flexibility.

Disc Degeneration and Internal Disc Derangement

Disc desiccation and degeneration may be a typical part of aging. Progressive changes in a young athlete, however, are associated with microtraumatic overuse. Some investigators have also noted a strong association between adolescents with atypical Scheuermann's and disc degeneration in the lower lumber spine. This may represent a congenital weakness of the disc or injury to the vertebral end plate and nutritional deficits.

Another distinct disc abnormality is the internal disc derangement seen in the young adult. This represents a radial tear of the inner anulus. The nucleus pulposus presumably is irritating to the outer anulus. The tear is contained and pressure increases with any lumbar flexion, notably sitting. This is sometimes detected as a high intensity zone in the posterior anulus on T2-weighted MR images. The definitive diagnosis is by discography producing concordant symptoms at lower pressures.

Initial treatment for these disc problems is an extension-biased lumbar stabilization therapy program. Selective nerve root injections with a corticosteroid are sometimes helpful. Discography may be considered in the young adult with sitting intolerance and axial pain. Previously, a positive finding also required consideration for an anterior surgical fusion. Most recently, a less invasive internal disc electrothermy has been approved, and although it is showing initial promise, it is still controversial and untested in the adolescent population.

Atraumatic Causes of Back Pain

Consideration always should be given to atraumatic causes from the beginning. Atraumatic causes include infections with discitis and osteomyelitis. Tumors of the spine also occur in the younger age group. Warming symptoms include fevers, night pain, inordinate pain, age younger than 8, and any systemic symptoms. Inflammatory causes include reactive spondyloarthropathies, juvenile rheumatoid arthritis, and other collagen vascular diseases. Intra-abdominal causes also must be reviewed.
SUMMARY

The diagnosis of back pain in the young athlete should be specific and not attributed to nonspecific, mechanical causes. Risk factor identification and intervention are required. Treatment is then initiated in a specific pattern, addressing flexibility and muscular imbalances. Bracing is often used to allow healing of growth tissue. The lumbosacral orthosis may be molded in a lordotic posture to unload the disc or antilordotic posture to relieve the posterior column; however, customizing the lordosis to the individual biomechanics may be required. Spinal stabilization is initiated with therapy for strengthening isolated weaknesses and progressing to coactivation and proprioceptive techniques, such as the balance ball. Returning to competition is preceded with sport-specific training.

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