The stress placed by gymnastics on the musculoskeletal system is well known, and disorders about the upper extremity-especially of the shoulder-and of the lower extremity-particularly the knee-certainly occur with great frequency. Another area of special concern in the young gymnast, however, is injury to the back and spine in the course of training and competing in this sport. The demands placed on the back, the lower back in particular, for both dramatic range of motion and a high level of strength in performing maneuvers and in absorbing shock of dismounts may well exceed that of any sport.

In association with such demands, the incidence of disorders of the spine in gymnasts appears to be high. This potential for back injury appears to result not only from single episodes of macrotrauma but also from the repeated microtrauma of hyperflexion, hyperextension, or twisting while performing gymnastic maneuvers. Jackson et al. first noted an apparent increased incidence of spondylolysis in young female gymnasts when compared with a control population. They hypothesized that this was due to the repeated hyperextension of the spine occurring in gymnastics. Snook reported two cases of spondylolysis among 66 major injuries in competitive female gymnasts. More recently, a report by Dzilba and Cervin suggested that high level competitive gymnasts appear to have a disturbingly high incidence of problems including not only spondylolysis but also frank vertebral apophyseal compression fractures and mechanical back pain. They reviewed the case histories of five elite gymnasts with back pain and noted evidence of radiographic degenerative changes on all of their radiographs. Although the increased incidence of spondylolysis in gymnasts has received most attention, we have found that back pain in the gymnast may be due to a variety of causes, ranging from simple hyperlordotic back pain through vertebral body fractures and disorders of the intervertebral discs.

**Figure 1.** A and B: A young gymnast is shown in a zero degree of lordosis, anterior-opening Boston brace for spondylolysis.

**Figure 2.** The hyperextension test, done with each leg, can be diagnostic of spondylolysis if pain is elicited with the maneuver.

**SPONDYLOLYSIS**

Spondylolysis is certainly of greatest concern as a cause of low back pain in the gymnast. These athletes will usually present with complaints of low back pain, although this is sometimes associated with radiating pain into one or both buttocks. This pain is often first noted when the gymnast does a back flip or back walk-over and is often insidious in onset. Occasionally, the gymnast will indciate a single episode of hyperextension, or a fall, as initiating the pain. Although initially only elicited with gymnastic maneuvers, the pain often becomes progressively more severe with activities of daily living, to the point where it may interfere with simply sitting in school or sleeping. It is, however, usually relieved by supine positioning.

**Examination**

Examination often re-
will often elicit pain. In the case of the "ther while hyperextending the back the child stand on one leg, then the on the ipsilateral leg may prove to be partiicularly against resistance, may ect a fracture of the pars elements. Careful uestioning will usually reveal whether the athlete feels that he or she has lost flexibiliy, since flexibility of the back and hamstrings is a carefully monitored quality in the gymnast. Plain radiographs of the lumbar spine, including anteroposterior, lateral, and both oblique views are obtained to assess the integrity of the posterior elements. Both oblique views must be obtained, since only a single pars interarticularis may be fractured. Although a Grade I spondylolisthesis may be evident on the lateral radiograph, particularly if a standing view is obtained, it is extremly rare to encounter a higher grade slip in these patients. If the plain radiographs are interpreted as being normal but a high index of suspicion for spondylolysis persists, based on the history and clinical findings, a technetium-99m radionuclear bone scan with low back pain, suggestive plain radiographs, and "normal" bone scans who have gone on to demonstrate further symptoms and, in one case, to progress to a first degree slip.

Figure 1. A and B. A young gymnast is shown in a zero degree of lordosis, of the lumbar spine should be obtained (Fig 4). We have had several pa- tients with initially "normal" plain radiographs who, on subsequent evaluation, showed clearcut evidence of pars defects on additional radiographs. If this study shows increased uptake of radionuclide, we treat the child for a presumptive diagnosis of spondylolysis. Unfortunately, not even a normal plain radiograph and a negative bone scan will absolutely rule out spondylolysis as a cause of low back pain. In addition, the presence of an active bone scan should not be used as an absolute criterion for whether to institute treat- ment in a child with spondylolysis. We have had a number of cases of children anterior-opening Boston brace for spondylolysis.

Management
The management of symptomatic spondylolysis in the young gymnast re- mains controversial. Some physicians are content to manage the patient symptomatically with limitation of ac- tivity, including no further gymnastics. Occasionally, a soft elastic garment, or corset, and flexion exercises are added to the regimen. It is my opinion that this lesion should be treated as a fracture of the pars interarticularis - albeit a stress fracture, the result of repetitive microtrauma and every attempt should be made to reduce the fracture and protect the spine in order to maximize the potential for healing. For this purpose we have used a rigid polypropylene lumbosacral brace, which is con- structed with 0 degrees of lumbar flexion, in an attempt to flatten the low back and increase the chance for healing by opposing the fractured pars elements (Fig. 1). Once satisfacto- ry fitting of the brace is attained, the child wears the brace 23 hours per day, with one hour out of the brace for bath- ing and exer- cises, which in- clude abdominal strengthening, pelvic tilts, and antilordotic and lower extremity flexibility exer- cises. Brace treatment lasts for six months or until the bone scan, if initially positive, becomes negative.

Most children become asymptomatic within three weeks after brace treat- ment is initiated, and we allow activi- ties thereafter, including sports activi- ties so long as the child remains asymptomatic. For the gymnast, limit- ed bar work and tumbling are possible, but vaulting and most balance beam
work are not possible. The results of brace treatment are promising. Our most recent review of the results of bracing in symptomatic spondylolysis demonstrated that 32 per cent of patients attained bony healing with this program and that 68 per cent of the 75 patients became pain free and were able to resume pain free sports activity even if bony healing could not be demonstrated by plain radiographs. It is important to emphasize that athleticism incurred spondylolysis is a stable lesion. We have not encountered a significant slip in any of our patients, despite continued activity. We therefore believe that the child and parents may be counseled that this lesion does not result in spinal instability but, rather, in potentially activity limiting back pain in the young athlete or adult. As such, every effort should be made to heal the lesion. However, if a lesion does not heal but remains asymptomatic, we believe that the child may still safely participate in vigorous sports activities.

Although the presence of a positive bone scan at the site of fracture is indicative that the body is still trying to heal the lesion, and may reflect an enhanced potential for healing, the presence of a cold bone scan in a radiographic lesion should not be taken as a contraindication to brace treatment. We have attained bony healing in five patients with initially cold bone scans. Although we are pleased that 88 per cent of our spondylolysis patients treated with braces became asymptomatic and resumed full sports activities, we are still experimenting with new brace designs and different treatment regimens. We are attempting to increase the healing rate above 52 per cent, since frank bony healing of the lesion must hold a better long-term prognosis.

Vertebral body fracture
Another cause of back pain in the young gymnast is fracture of the vertebral end plates, particularly at their anterior margins. These fractures appear to be usually the result of repetitive microtrauma - most probably repeated flexion - which injures the anterior portions of the end plates and can result in frank vertebral wedging. In the gymnast, these fractures usually occur at the thoracolumbar junction and may involve three or more vertebral bodies, although one or two levels of involvement are more common. At times, these lesions may be labeled Scheurmann's disease, or "atypical Scheurmann's disease." Classic Scheurmann's disease, as characterized by Sorensen, occurs in the thoracic spine and involves at least three or more vertebral bodies with greater than 10 per cent wedging of each body. True Scheurmann's disease, of course, may also be the result, at least in part, of repeated flexion microtrauma of the dorsal spine in a child who has tight lumbar lordosis with forward flexion occurring in the dorsal spine rather than in the lumbar spine below. Once again, plain radiographs are usually sufficient to make the diagnosis of this microtraumatic fracture. A bone scan generally shows increased uptake at the lesions but is not necessary for diagnosis. Treatment is directed toward putting the spine at rest in order to facilitate normal bony healing if significant vertebral body deformation has already occurred, additional steps should be taken to unload the front of the spine and maximize the potential for bony reconstitution, in our opinion this is best accomplished with a semi rigid thermoplastic brace. If the lesion is at the thoracolumbar junction, a brace with 15 degrees of built-in lordosis is used to immobilize the back and unload the front of the spine. Best treatment is used, once again, for 23 hours per day and is continued until bony healing and vertebral body reconstitution are evident - usually four to six months.

These children usually become asymptomatic in three or four weeks and, again, limited gymnastic training is allowed as long as they remain asymptomatic. As with spondylolysis, a high index of suspicion when the athlete first complains of back pain and early initiation of treatment will maximize results.

Discogenic back pain
The differential diagnosis of back pain in the young gymnast must include discogenic back pain. This disease in the prepubescent child is rare, but its incidence in the adolescent, particularly in the athletically active adolescent, appears to be increasing.

The presentation of this disease in the young athlete may be quite different than that usually encountered in the adult. Back pain, as such, may be a relatively minor complaint. More frequently the child, or his or her coach, may notice a loss of hamstring flexibility, sometimes unilateral, or the onset of a sciatic scoliosis.

Diagnosis may be difficult to make. Physical examination may reveal evidence of sciatic irritation, with positive straight leg raising or a positive Lasegue sign. Loss of reflexes or frank muscle weakness is unusual. Often, however, there will be a loss of the ability to forward flex the spine or reverse the lumbar spine on forward flexion, and this movement may elicit pain. As with all disc disease, conservative treatment aimed at resting the back in a neutral position and avoiding further pain or muscle spasm is the primary mode of treatment. In our experience, the adolescent with disc disease will usually respond rapidly to bed rest with decreased pain and muscle spasm, but this response may not last if activities are resumed too early. We will generally advise the family that their child will be out of vigorous sports activities for 6 to 12 months following a frank episode of discogenic
As with spondylolysis and vertebral apophyseal fractures in our initial series, only apex occur in the associated elements of the primary event and is usually not as- for spondylolysis or vertebral end plate injuries without pain. We present this treatment pro-

brace treatment useful in managing pain in this population. Tumors of the axial skeleton and infectious processes of the disc or lumbodorsal fascia. Children with spondylogenic back pain in association with sports activities will usually respond to a well supervised ex-
ercise program of abdominal strengthen ing, lumbodorsal and hamstring stretching, and antilordotic posturing of the lumbar spine. The pelvic tilt performed in both the supine and standing position is the foundation of this exercise program. Surprisingly, a survey of gymnasts in the Boston area by Dr. Michael Goldberg revealed that a number of these were relatively lacking in abdominal strength.

Tumor and infection

A final, extremely important consider-
ation must always be remembered in the young gymnast complaining of low back pain, even pain that is apparent-
ly associated with traumatic athletic ac-
tivities. Tumors of the axial skeleton and infectious processes of the disc or end plates must always be considered in the differential diagnosis of the young athlete with low back pain. The incidence of osteochondromatosis of the axial skeleton is low in any age group, of course, but the adolescent and young adult are particularly suscepti-
bile to this disease process. In addition, discitis, although more common in the somewhat younger child or young adolescent, can also be encountered in the older adolescent involved in sports activities. A recent case of ours outlines this point very clearly. This was the case of a 17-year-old elite tennis player who began complaining of back pain and radiation of pain into the buttocks. This pain was severe enough to warrant hospital admission and evaluation. A presumptive diagnosis of discogenic back pain with severe sciatica was then obtained. However, further evaluation showed elevation of the sedimentation rate and a positive bone scan at the L1-L2 level. Subsequent radiographs confirmed progressive narrowing of the L1-L2 level, and the diagnosis of disc space infection was made. The patient responded well to a program of rest, brace immobilization, and antibiotic treatment and did not require decom-

Summary

The complaint of low back pain in the adolescent must never be taken lightly. A high index of suspicion should be particularly entertained in a child participating in gymnastic training or com-

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