SPONDYLOLISTHESIS
IN
GYMNASTS

by

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for

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The number of gymnasts has grown tremendously in the past decade. In 1986, more than 130,000 female gymnasts were registered in the United States, 48,000 in the competitive class. This large number of participants as well as the changes in performance standards probably account for the steady increase in the rate of injury observed in this sport.(1)

Gymnastics is a creative art form with specific aesthetic demands. Performances must look effortless. A gymnast may not overtly grimace even though he or she is leaping much higher than a hurdler. Although her smile may be a bit phony, the athlete must look the part of the sweet sugar plum fairy even if her foot hurts. Limping into the wings or off the balance beam is not greeted with the same applause the injured quarterback hears when he struggles to the bench. Gymnasts demand grace, strength, and great flexibility, which is often a function of anatomic structure as well as heredity. Gymnastics requires a keen sense of timing, balance, and coordination. More and more children begin these activities at a very young age despite the rigorous training required. Gymnasts practice year round. There is no "off" season. Low weight is desirable in female gymnasts. Shoes worn in by the gymnast have no cushioning, no shock absorbent material or design, and no room for orthotics. Just as concrete is a disaster for the runner, so it is for the gymnast. All of these factors weigh heavily upon the gymnast's body.

Gymnastic injury rates, which have been reported to be twice those of other noncontact sports, approach the rates noted in football and wrestling. Additionally, the injury rate in gymnastics appears to be proportional to the skill and competitive level of the athlete. Injury rates show a steady rise as the level of competition accelerates from high school and club level to the collegiate and elete level.(2) Currently gymnastics trials for women are composed of four events. These events are: balance beam, uneven parallel bars, vault exercises and floor exercises. Men compete in six events: parallel bars, horizontal bars, rings, pommel horse, long horse vault, and floor exercise.

The young gymnast who is engaged in strenuous training and competition on a year-round basis places demands on the low back unparalleled in sports.(3) Strains and sprains involving the lumbar area occur in gymnasts as in other athletes. In addition to the usual soft tissue injuries, symptomatic bony defects in the pars interarticularis may develop in the gymnast who is in strenuous training and competition. Those bony lesions that produce symptoms are most often the result of repeated trauma and stress rather than one traumatic episode. Diagnosis is made more difficult because the initial radiographs are quite often normal. If, however, the developing defect is recognized early, treatment can be quite effective and may prevent disability.(4)

Spondylolisthesis is the slipping of all or part of one vertebra forward on another. The term was coined by Kilian in 1854 and is derived from the Greek *spondylo*, meaning vertebra, and *olisthesis*, meaning to slip or slide down a slippery path. Early researchers did not recognize the fundamental lesion to be the pars instead assuming that the fundamental lesion was caused by a slow subluxation of the lumbosacral facets. Naugebauer, in 1881, made an extensive study of anatomic specimens throughout Europe and was the first to recognize that the slip can occur by elongation of the pars without its coming apart.(6)

Lytic spondylolisthesis occurs only in humans, who alone have a truly upright stance. Defects have not been reported in other primates. Rosenberg reviewed radiographs of 125 patients in an institution, none of whom had ever assumed the standing position, and did not demonstrate a single pars defect.(7) Humans alone have the bipedal gait and only true lumbar lordosis which both contribute to the occurrence of spondylolisthesis.

There is no evidence that the defect is present at birth. The most common age of radiographic manifestation of pars interarticularis defects is between five and seven years. The incidence increases slightly until adulthood but does not increase significantly thereafter in whites. (8)

A definite familial tendency exists in the development of pars interarticularis defects. In the 36 families Wiltse studied in 1952, no defects were found in members under the age of five years, yet the incidence was forty percent in members over the age of ten.**(9)**

Baker has found the incidence of the defect in adult white Americans to be 5.8 percent. Roche and Rowe, from a study of 4200 adult skeletons, found a smaller incidence of 4.2 percent. They found in their studies that the incidence in the white male was 6.4 percent; in the black male, 2.8 percent; in the white female, 2.3 percent; and in the black female, 1.1 percent. Stewart found that Eskimos to have by far the highest incidence, as high as 50 percent in isolated communities north of the Yukon.(10)

One study of radiographs of 100 female competitive gymnasts demonstrated an incidence of spondylolysis of 11 percent. When this is compared to the general nonathletic white female population whose incidence is 2.3 percent as mentioned earlier, a strong correlation between activity level and risk of spondylolisthesis can be made. In another study of one hundred young female gymnasts engaged in competitive level gymnastic showed an 11 percent incidence of pars interarticularis defects. This is four times that expected in a general Caucasian female population, and is about two times higher than expected in a general population of young males.

With continuous shear and compression, as is found in gymnasts, particularly in hypertension, the inferior lumbar facet is subject to alternating loads of force. Cortical fatigue stress can produce fracture of the pars interarticularis experimentally. The same amount of force resulting in spondylolysis in the laboratory is easily observed in gymnastic practice. Gymnasts routinely hyperextend and hyperflex the spine in performing “back walkover” and “front walkover” maneuvers and experience jarring dismounts, vaults, and flips.

Many factors may be important in predisposing the young athlete to develop pars interarticularis defects. The increased incidence of spina bifida occulta at the L5 and S1 levels associated with L5 pars defects has been well established in the literature. Spina bifida occulta was present in 9 of 11 gymnasts with pars interarticularis defects in one study. There is an ongoing debate by researchers about whether the presence of a defect in the closure in the posterior wall of the spinal canal is associated with or merely pre-dispose the pars of L5 to develop fractures. Strong hereditary pre-disposition of those who develop spondylolysis and spondylolisthesis is another factor that has been well documented. The role of repeated trauma must be a major factor in the development of pars defects in the athlete.

The pars interarticularis, when subject to unusual repetitive forces of hyperextension, tension, torque, and compression, has the potential for fatigue failure. Although the body has the capacity to heal, when the cellular mechanism of repair fails to keep pace with the microscopic damage caused by repetitive force, breakdown or failure of the osseous structures may occur.

The athlete who presents with posterior element pain will often report vague low back pain that may radiate to the buttocks and posterior thigh, and occasionally into the calf or ankle when the pain intensifies. The pain will be reported as being worse when standing, improved when sitting, and usually worse if the athlete lies supine with legs extended. On physical examination the pain is provoked by extension maneuvers and maneuvers that couple extension with rotation and axial loading. Moreover, the pain can be further intensified with ipsilateral single-leg standing while carrying out extension maneuvers. During the examination, the patient's posture is often found to be lordotic. Straight leg raising may cause back pain without radicular referral, but hamstring musculature is usually quite flexible in gymnasts, rendering this test useless. However, poor flexibility of the iliopsoas will often be observed, especially on the same side of involvement.(11) The aching in the low back is present with daily activities but becomes much more pronounced when the patient competes and performs maneuvers involving the extremes of lumbar motion and, in particular, hyperextension. The most common aggravating activities elicited in the history are related to walkover maneuvers, dismounts, vaults, and flips.

Local paraspinal tenderness with reproduction of pain may be noted by the experienced practitioner. Localized deep paraspinal muscle spasm can also be observed over the affected joint or neural arch. History and physical examination alone can not differentiate between the gymnast suffering from facet joint synovitis versus pars interarticularis stress fracture. However, spondylolisthesis will be accompanied by a prominence of the affected spinous process coupled with localized paraspinal guarding and hypermobility upon segmental palpation. These signs upon palpation allows spondylolisthesis to be identified on physical examination.(11)

Unless there is accompanying intervertebral canal stenosis or disc herniation, no neurologic deficit will be noted with posterior element injury subtypes. However, lower extremity referral zone pain is not uncommon due to dorsal ramus activation. Additionally, lower extremity paresthesias may occur as a result of excitation of sensor fibers of the exiting mixed spinal nerve that lay adjacent to the medial edge of the facet joint capsule. If the athlete is suspected of having a neural arch fracture, radiographs that include oblique projections are necessary.

Often athletes trying to excel in competition continue to train in spite of low back pain. Ignoring the "warning pain" increases the risk of developing pars defects. In one study group, 3 young female gymnasts sought medical attention for low back pain, and had negative roentgengraphic evaluations. They continued to train in spite of the chronic nature of their pain, and progressed to develop pars interarticularis defects.(4) It is also noted that several female gymnasts who referred for evaluation of low back pain had pars defects on the initial lumbar roentgengrams, continued to compete on a some what limited basis, and proceeded to bone healing.

Observing that some lesions heal while the athlete continues to compete or with varying degrees of restriction raises the question of whether surgery is necessary for early diagnosed spondylolisthesis. Early restriction of activities may allow healing to progress without developing roentgenographic evidence of fracture. Bone scan is the gold standard for early diagnosis of spondylolisthesis of the lumbar spine in the gymnast. Early spondylolisthesis with associated pars interarticularis defects will produce a negative plain film evaluation. The stress reaction in the pars results in increased bone turnover and is best documented by technetium pyrophosphate bone scanning. (6) If a pars defect does appear on initial radiographs, it is important to determine whether this represents an acute or chronic process, since the former have a greater healing potential. Acute defects appear fuzzy and are well delineated, whereas chronic changes usually demonstrate bone resorption and smooth, sclerotic borders. A bone scan may be helpful in distinguishing whether another level is involved, whether the lesion is old or acute, or whether the lesion is unilateral or bilateral. If the scan is negative, it can be assumed that the defect has less chance for bony healing. Symptoms may subside even without bony healing.

The bone scan is not necessary in all cases, since the diagnosis can usually be suspected from physical examination and radiographic studies. However, it is helpful in counseling the young athlete who is facing a considerable period of disability. Once the findings of the scan are positive, usually a minimum of three months and an average of six months are needed for the athlete to be able to return to pain-free competition. Some youngsters have been unable to return for considerably longer periods of time. The resolution of pain predates the resolution of activity demonstrated on the bone scan. The athlete can usually return to competition before the bone scan activity resumes normal levels.(4)

The goal of rehabilitation must be to return the athlete to the highest level of performance possible. Fortunately the majority of injuries can be successfully treated nonoperatively. A rehabilitation program can be divided into two phases: a pain control phase and a training phase. The pain control phase may include a variety of passive modalities, for example, flexion or extension exercises, specific chiropractic adjustments to the lumbar spine, and selected proprioceptive techniques. However, the key element of the rehabilitation program is the training phase, which emphasized back school, functional movement training, specific dynamic muscular lumbar stabilization techniques, and specific chiropractic adjustments.(2) Pain control treatment should be instituted as early and efficiently as possible. It is important not to get stuck in the pain control phase, but rather to advance as rapidly as possible to the training phase of treatment. The initial stage of pain control, back first-aid, treats the pain and teaches the patient to control the pain and muscle spasm. The treatment includes the application of ice, resting in a position of comfort, and basic instruction in body mechanics to facilitate pain-free movement while performing normal daily activities. The use of medicine should always be kept to a minimum. Athletes with posterior element pain will find pain relief in slight flexion. The athlete must be given exact instructions regarding their activity level. Open lines of communication are essential and instructions must be given to the coach as well.

Pain relieving modalities such as transcutaneous nerve stimulation (TENS) and pulsed alternating electrical muscle stimulation coupled with ice can be useful to reduce the acute pain.(3)

The use of chiropractic adjusting techniques can be extraordinarily useful to attain articular as well as soft tissue range of motion. Stiffened segments should be mobilized and tight soft tissues should be adequately stretched. Acupuncture is a useful adjunct in the treatment of a variety of painful lumbar disorders including spondylolisthesis. It has been reported that trigger points are found in predictable locations and that they correspond to well-established acupuncture points.(14) Endorphin release following acupuncture treatment has also been scientifically demonstrated.

After having successfully completed the pain control phase of the rehabilitation program, the athlete should begin the training phase. The key element in the training phase is to attain the adequate musculoligamentous control of lumbar spine forces to eliminate repetitive injury to the affected area. Analyzing their dismount techniques and floor routines is an important element of treatment and prevention.(8) The gymnast must be made aware of proper spinal positioning and muscle bracing to avoid injury.

Muscle fusion is essentially the use of the musculature to brace the spine and protect the motion segments against repetitive microtrauma and excessively high single occurrence loads. The concept of muscle fusion involves the co-contraction of the abdominal muscles to maintain a corseting effect to the lumbar spine, using the midline ligament and thoracolumbar fascia, coupled with proper pelvic positioning to accomplish the task. In order to apply the muscle fusion, adequate flexibility and spinal range of motion must be attained to prevent repetitive fatigue stress to the pars interarticularis. Therefore, adequate flexibility of the hamstrings, iliopsoas, gastrocnemius and soleus, hip rotators and the illiotibial band is important.(9)

Stabilization exercise is designed to develop isolated co-contraction muscle patterns in order to stabilize the lumbar spine in its neutral position and decrease the progression of and established spondylolisthesis. The use of proprioceptive devices such as rocker boards and wobble boards have been shown to hav a profoundly positive effect upon overall proprioception in athletes.

Numerous factors have been implicated in the cause of gymnastic related spondylolisthesis. Coaching techniques and the intensity of practice sessions probably play very important roles injury prevention, moreso than any other factors. The poor postural habits that young gymnasts learn in practice create the injuries of tomorrow. Proper coaching of dynamic lumbar stabilization techniques while stretching and while dismounting should have a dramatic effect on injury reduction.(1)

Gymnastic related spondylolisthesis are frequently encountered. With the rise in the number of participants in the sport, these injuries can be expected to increase. A definition of this condition has been presented along with rates of incidence in the general population as well as gymnasts. Common symptoms that a gymnastic patient with a spondylolisthesis might present with were also noted. Predisposing factors, standards of diagnosis, treatment, and prevention of these injuries have also been presented. Diagnosis must be timely and precise. Treatment must incorporate specific chiropractic adjustments as well as dynamic muscular stabilization exercises to prevent repetitive forces from initiating a traumatically induced spondylolisthesis.

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