Basic Athletic Training
Course Pack C

CHAPTER

22

Lumbar Spinal Conditions

STUDENT OUTCOMES

1. Locate and explain the functional significance of the bony and soft-tissue structures of the lumbar spine.
2. Describe the motion capabilities of the lumbar spine.
3. Identify the factors that contribute to mechanical loading on the spine.
4. Describe specific strategies in activities of daily living to reduce spinal stress in the lumbar region.
5. Identify anatomical variations that can predispose individuals to lumbar spine injuries.
6. Explain the measures used to prevent injuries to the lumbar spinal region.

7. Describe a thorough assessment of the lumbar spine.
8. Describe the common injuries and conditions of the lumbar spine and low back area in physically active individuals.
9. Identify rehabilitative exercises for the lumbar region.

INTRODUCTION

Low back pain is a widespread problem that affects both the athletic and nonathletic populations. In the adult population, low back pain is the leading cause of job-related disability and time loss.[1] Over 80% of adults will report having had episodes of low back pain at some point in their life. Low back pain affects both men and women. Most low back pain is short-term, lasting from a few days to about 12 weeks. Chronic or long-term low back pain refers to pain lasting longer than 12 weeks.[1] About 10% to 15% of youth sport athletes will report having episodes of low back pain.[2] Although the main causes of low back pain in athletes are musculotendinous strains and ligamentous sprains, chronic or recurring pain often is a symptom of lumbar disk degeneration or stress injuries to the bony articulations of the lumbar spine.[3] Pain emanating from the lumbar disks most commonly affects the low back, buttocks, and hips and may result from progressive damage to the annular fibers, particularly the pain fibers that reside in the outer third of the annulus.[4] Low back problems are especially common in equestrian sports, weight lifting, ice hockey, gymnastics, diving, football, wrestling, and aerobics.

This chapter begins with a review of the anatomical structures in the lumbar spine, followed by a discussion of the kinematics and kinetics of the region. Identification of anatomical variations that may predispose individuals to lumbar spinal conditions leads to strategies used to prevent injury. Assessment techniques used in assessing lumbar spine pathologies are presented, followed by information regarding common injuries sustained within the lumbar spine during participation in sports and physical activities. This chapter concludes with examples of general rehabilitation exercises and a

summary of topics covered.

ANATOMY OF THE LUMBAR SPINE

As mentioned in Chapter 21, the lumbar and sacral regions of the spine are anatomically and functionally unique. Normal lumbar curvature is concave and sacral curvature is convex from the posterior perspective.

Lower Spinal Column

The lower spinal column, which forms a convex curve anteriorly, includes five lumbar, five fused sacral, and four small, fused coccygeal vertebrae (**Fig. 22.1**). The sacrum articulates with the ilium to form the sacroiliac (SI) joint.

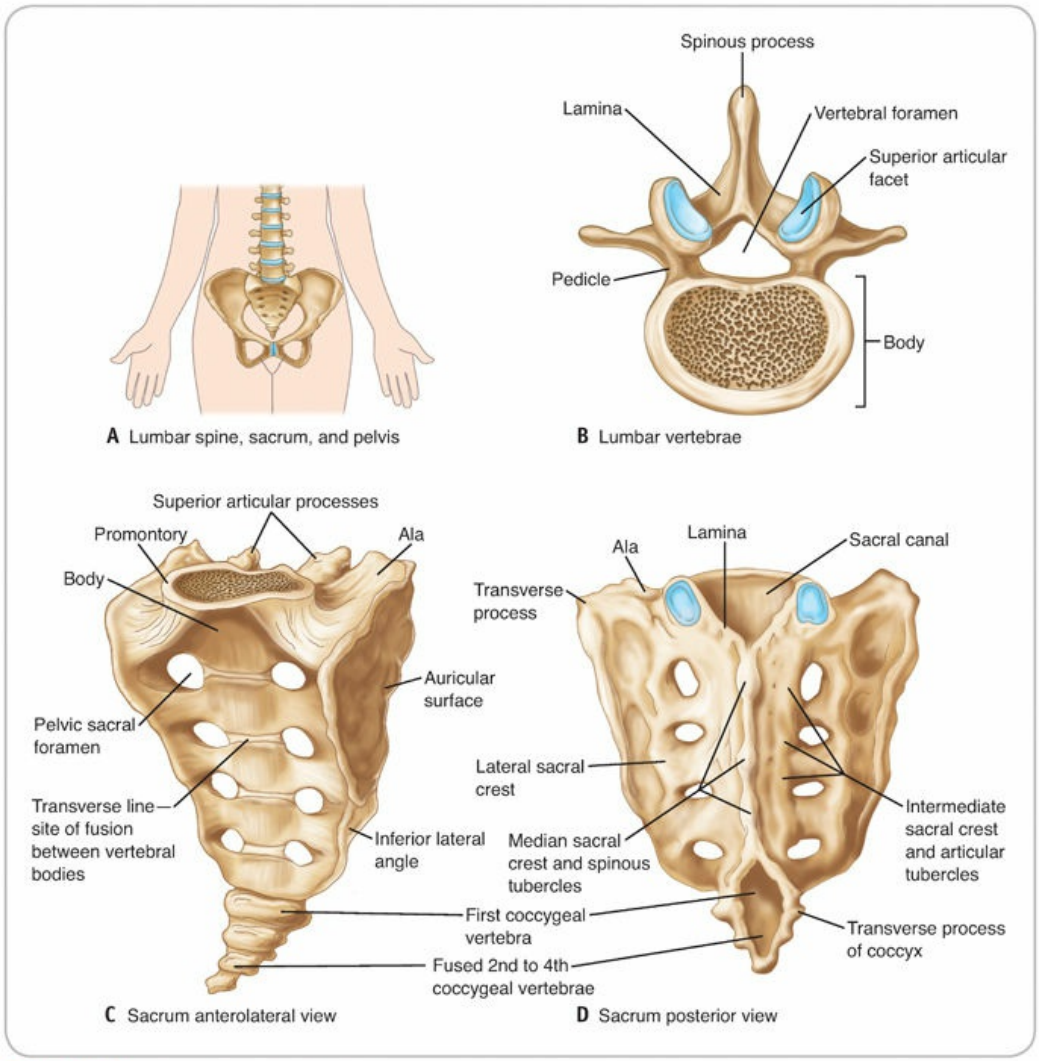


Figure 22.1. Bones of the lumbar region. A, Lumbar spine, sacrum, and pelvis. **B,** Superior view of lumbar vertebra. **C,** Anterolateral view of sacrum and coccyx. **D,** Posterior view of sacrum and coccyx.

Supporting the weight of the head, trunk, and upper extremities, the lumbar vertebral bodies have larger articulating surface areas and greater depth than those of any other spinal region. In addition, the orientation of the facet joints varies in comparison to the cervical and thoracic spines (see **Fig. 21.4**). Information concerning the general structures of the spinal vertebrae and intervertebral disks is presented in Chapter 21.

Ligaments of the Lumbar Spine and Trunk

General information regarding the spinal ligaments is presented in Chapter 21. Specific to the lumbar spine, several ligaments, including the iliolumbar

ligaments, posterior SI ligaments, sacrospinous ligament, and the sacrotuberous ligament, are responsible for maintaining its articulation with the sacrum (Fig. 22.2).

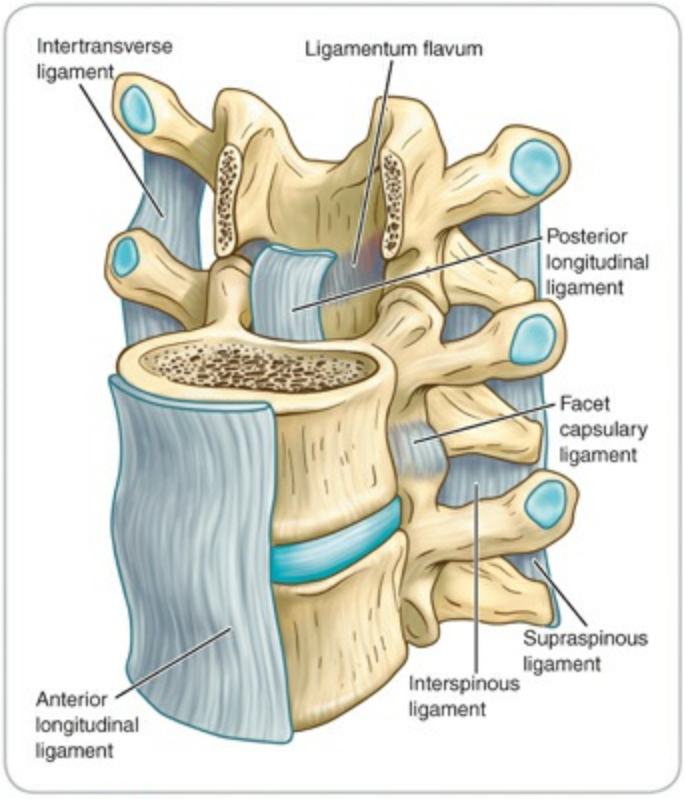


Figure 22.2. Ligaments of the lumbar spine.

Muscles of the Lumbar Spine and Trunk

The muscles of the trunk are paired, with one on the left side and one on the right side of the body (Fig. 22.3). These muscles produce lateral flexion and/or rotation of the trunk when acting unilaterally and trunk flexion or extension when acting bilaterally. Collectively, the primary movers for back extension are called the erector spinae muscles.

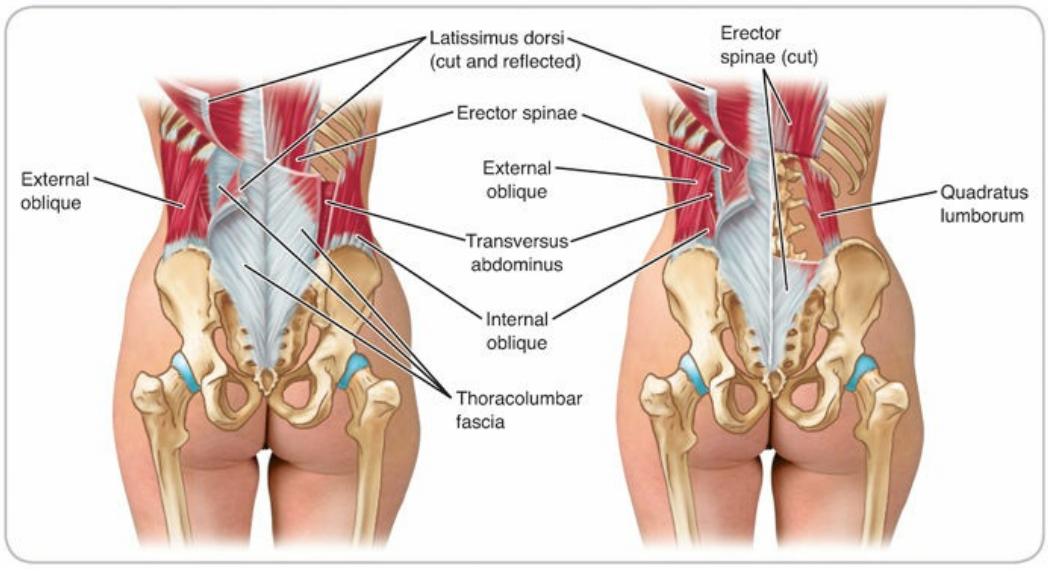


Figure 22.3. Muscles of the low back.

See **Muscles of the Lumbar Spine**, available on the companion Web site at thePoint, for the attachments, actions, and innervations of the major muscles of the lumbar region.

Spinal Cord and Spinal Nerves

The lumbar plexus and sacral plexus are prominent in the lower trunk. The distal end of the spinal cord, at approximately L1–L2, includes a bundle of spinal nerves that extends downward through the vertebral canal and is known collectively as the cauda equina, after its resemblance to a horse's tail.

The Lumbar Plexus

Supplying the anterior and medial muscles of the thigh region is the lumbar plexus, formed by the T12 through L5 nerve roots (Fig. 22.4). The posterior branches of the L2 through L4 nerve roots form the femoral nerve, innervating the quadriceps, whereas the anterior branches form the obturator nerve, innervating most of the adductor muscle group.

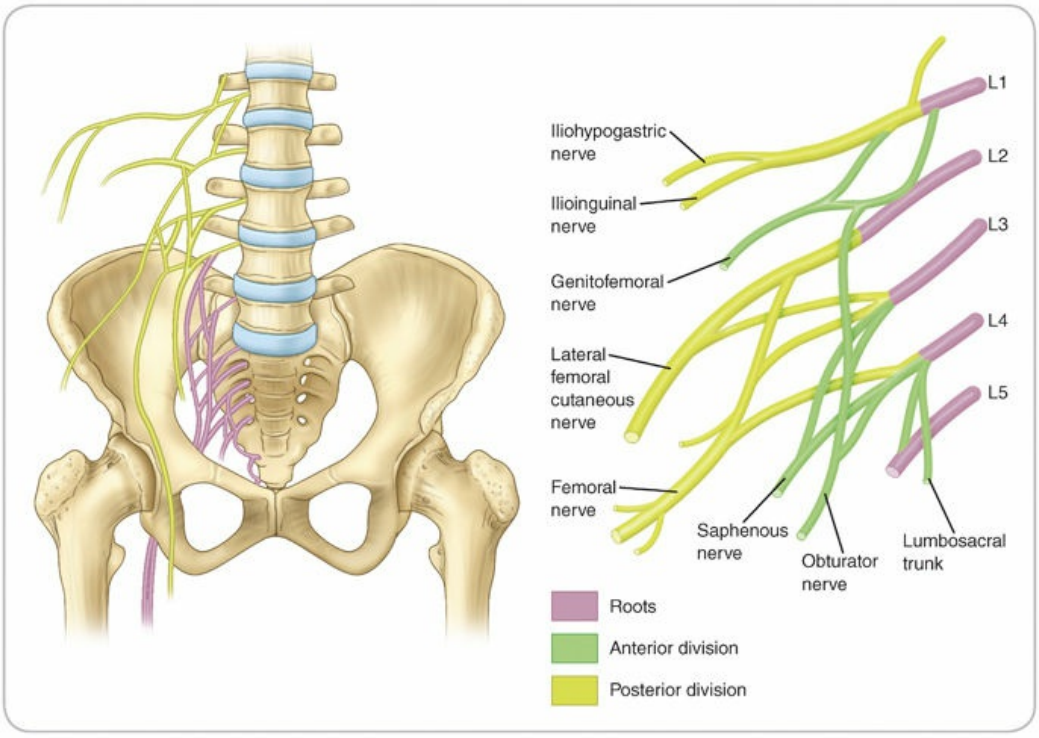


Figure 22.4. Lumbar plexus. The lumbar plexus is formed by the segmental nerves T12 through L5. The lower portion of the plexus merges with the upper portion of the sacral plexus to form the lumbosacral trunk.

The Sacral Plexus

A portion of the lumbar plexus (L4–L5) forms the lumbosacral trunk and courses downward to form the upper portion of the sacral plexus (Fig. 22.5). This plexus supplies the muscles of the buttock region and, through the sciatic nerve, the muscles of the posterior thigh and entire lower leg. The sciatic nerve is composed of two distinct nerves, the tibial nerve and the common peroneal nerve. The tibial nerve, formed by the anterior branches of the upper five nerve roots, innervates all the muscles on the posterior leg with the exception of the short head of the biceps femoris. The common peroneal nerve, formed by the posterior branches of the upper four nerve roots, innervates the short head of the biceps femoris and then divides in the vicinity of the head of the fibula into the deep peroneal nerve and the superficial peroneal nerve. These nerves innervate the anterior compartment of the lower leg and lateral compartments of the lower leg, respectively.

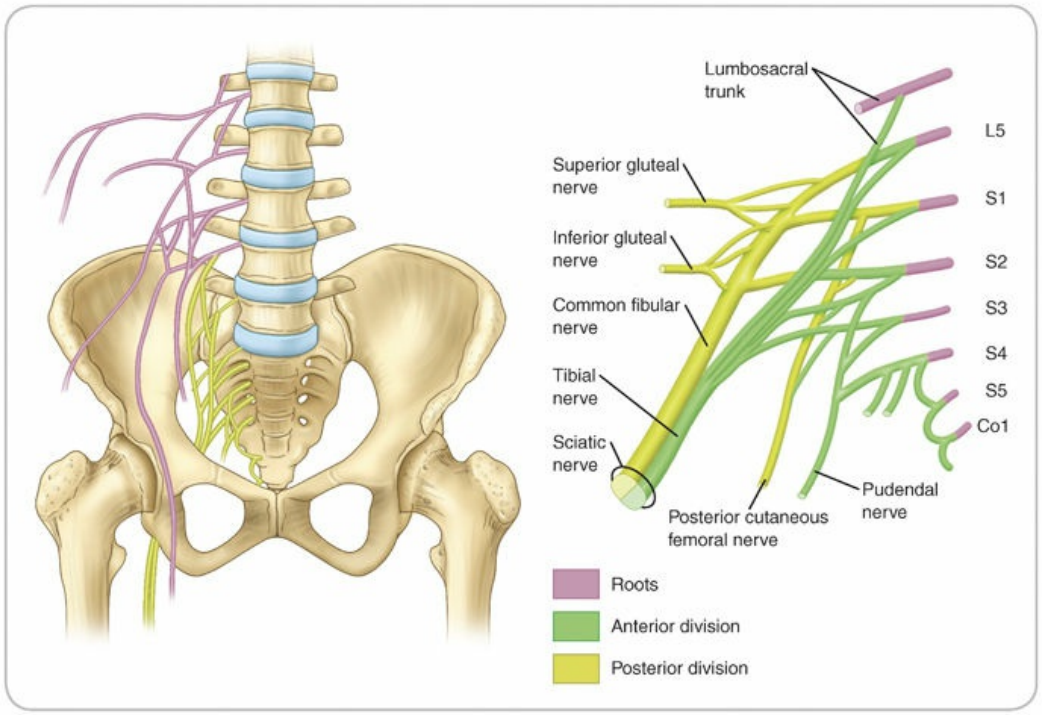


Figure 22.5. Sacral plexus. The sacral plexus is formed by the segmental nerves L4 through S5. This plexus innervates the lower leg, ankle, and foot via the tibial and common peroneal nerves.

KINEMATICS AND MAJOR MUSCLE ACTIONS OF THE LUMBAR SPINE

The vertebral joints enable motion in all planes of movement as well as circumduction. Because the motion allowed between any two adjacent vertebrae is small, spinal movements always involve a number of motion segments. The range of motion (ROM) allowed at each motion segment is governed by anatomical constraints that vary through the lumbar region of the spine.

Flexion, Extension, and Hyperextension

The flexion–extension capability of the lumbar spine is cumulatively approximately 83°, with more motion allowed at the L2–L3 motion segment and progressively diminishing through L4–L5.[5,6] It is important to avoid confusing spinal flexion with hip flexion or with forward pelvic tilt, although

all three motions occur during an activity such as touching the toes. Hip flexion (see **Figs. 16.15A** and **16.16D**) consists of anteriorly directed, sagittal plane rotation of the femur with respect to the pelvic girdle (or vice versa), and forward pelvic tilt (see **Fig. 16.13A**) is anteriorly directed movement of the anterior superior iliac spine (ASIS) with respect to the pubic symphysis.

When the spine is extended backward past anatomical position in the sagittal plane, the motion is termed **hyperextension**. The ROM for spinal hyperextension is considerable in the lumbar region, ranging as high as 21° at L5 through S1. The cumulative ROM for hyperextension is 54° in the lumbar region. Lumbar hyperextension is required in many sport skills, including several swimming strokes, the high jump and pole vault, wrestling, and numerous gymnastic skills. Repeated, extreme lumbar hyperextension is associated with increased risk of spondylolysis, a stress fracture of the pars interarticularis region of the spine.[7]

Lateral Flexion and Rotation

Movement of the spine away from anatomical position in a lateral direction in the frontal plane is termed lateral flexion. In the lumbar region, the cumulative ROM for lateral flexion to one side is approximately 18°.[5] Spinal rotation capability is small in the lumbar region, with only approximately 2° of motion allowed because of the interlocking of the articular processes.[6] The lumbosacral joint permits approximately 5° of rotation. Images depicting lumbar ROM are provided later in the chapter during the assessment discussion.

KINETICS OF THE LUMBAR SPINE

As discussed in Chapter 21, forces acting on the spine include body weight, tension in the spinal ligaments and paraspinal muscles, intra-abdominal pressure, and any applied external loads. When the body is upright, the major form of loading on the spine is axial, and the lumbar spine supports the weight of the body segments above it. Although most of the axial compression load on

the spine is borne by the vertebral bodies and disks, the facet joints, when the spine is in hyperextension, may bear as much as approximately 30% of the load. Under significant compressive loading, such as during a heavy lifting task, increases in intra-abdominal pressure occur that may help to stiffen the trunk to prevent the spine from buckling.[8] When the paraspinal muscles are fatigued, there are increased levels of co-contraction, which also help to stiffen the spine and increase spinal stability.[9]

The Effect of Body Position

One factor that can dramatically affect the load on the lumbar spine is body position. When the body is in an upright position, the line of gravity passes anterior to the spinal column (**Fig. 22.6**). As a result, the spine is under a constant, forward bending moment. As the trunk is progressively flexed, the line of gravity shifts farther away from the spine. The farther the line of gravity from the spine, the larger the moment arm for body weight and the greater the bending moment generated. To maintain body position, this moment must be counteracted by tension in the back muscles. The more tension that is required to maintain body position, the greater the compression load on the spine. Lifting with the trunk being erect minimizes the tension requirement for the lumbar muscles, because the moment arm for body weight is minimized. For the same reason, holding the load as close to the trunk as possible during lifting and carrying minimizes the load on the back.[10,11] In comparison to the load that is present during upright standing, compression on the lumbar spine increases with sitting, increases more with spinal flexion, and increases still further with a slouched sitting position (**Fig. 22.7**). When carrying a load, forces acting on the spine increase with walking, with carrying the load at shoulder height, and with asymmetric lifting.[10,11] **Box 22.1** lists guidelines for preventing lumbar spinal stress during the performance of daily activities.

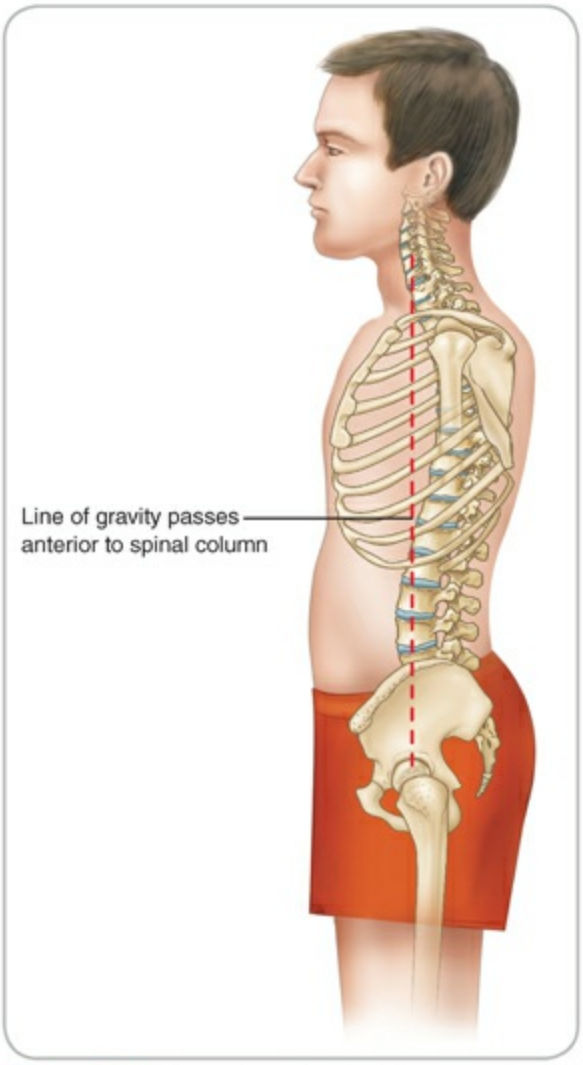


Figure 22.6. Line of gravity. The line of gravity for the head and trunk passes anterior to the spinal column during upright standing. The moment arm for head/trunk weight at any given vertebral joint is the perpendicular distance between the line of gravity and the spinal column.

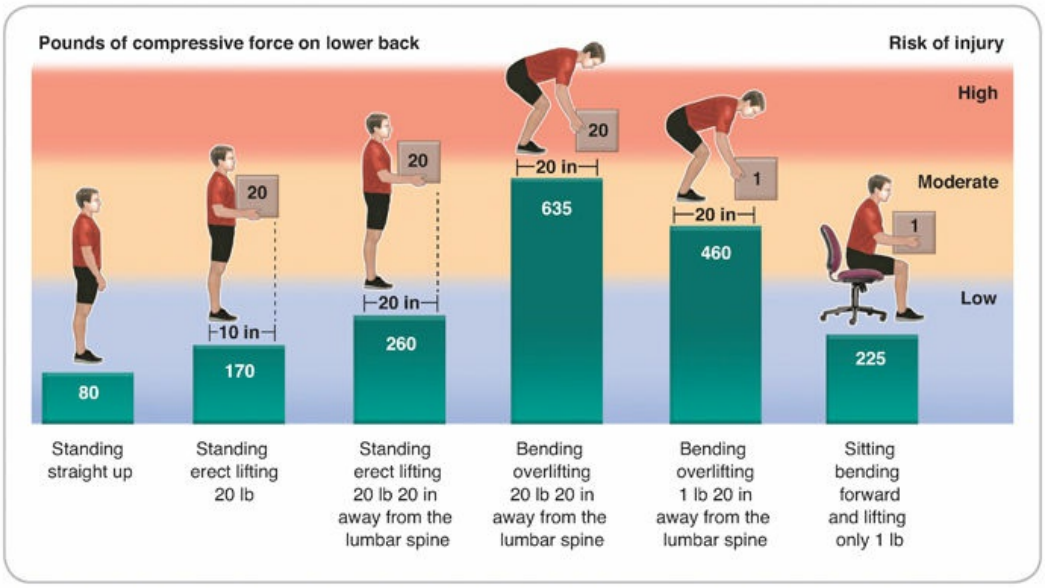


Figure 22.7. Comparison of load placed on lumbar spine in different body positions.

BOX 22.1 Preventing Low Back Injuries in Activities of Daily Living

Sitting

- Sit on a firm, straight-backed chair.
- Place the buttocks as far back into the chair as possible to avoid slouching.
- Sit with the feet flat on the floor, not extended and/or raised on a stool.
- Avoid sitting for long periods of time, particularly with the knees fully extended.

Driving

- Place the seat forward so that the knees are level with the hips and you do not have to reach for the pedals.
- If the left foot is not working the pedals, place it flat on the floor.
- Keep the back of the seat in a nearly upright position to avoid slouching.

Standing

- If you must stand in one area for an extended time,
  - Shift body weight from one foot to the other.
  - Elevate one foot on a piece of furniture to keep the knees flexed.
  - Perform toe flexion and extension inside the shoes.
  - Hold the chin up, keep the shoulders back, and relax the knees.
  - Avoid arching the back.

Lifting and Carrying

- Use a lumbosacral belt or have assistance when lifting heavy objects.
- To lift an object,
  - Place the object close to the body.
  - Bend at the knees, not the waist, and keep the back erect.
  - Tighten the abdominal muscles and inhale before lifting the object.
  - Exhale during the lift.
  - Do not twist while lifting.
- To carry a heavy object,
  - Hold the object close to the body at waist level.
  - Carry the object in the middle of the body, not to one side.

Sleeping

- Sleep on a firm mattress. If needed, place a sheet of 0.75-in plywood under the mattress.
- Sleep on the side and place pillows between the legs.
- When sleeping supine, place pillows under the knees. Avoid sleeping in the prone position.
- Avoid sleeping with the arms extended overhead.

Effect of Movement Speed

Another factor that affects loading of the lumbar spine is body movement

speed. Executing a lift in a very rapid, jerking fashion dramatically increases compression and shear forces on the lumbar spine as well as tension in the paraspinal muscles.[12] This is one reason why isotonic resistance training exercises should be performed in a slow, controlled fashion.

ANATOMICAL VARIATIONS PREDISPOSING INDIVIDUALS TO SPINAL CONDITIONS

Mechanical stress derived from lateral spinal muscle imbalances or from sustaining repeated impact forces can cause back pain and/or injury. Excessive spinal curvatures can be congenital or acquired through weight training or sports participation. Defects in the pars interarticularis of the neural arch can be caused by mechanical stress, also placing a patient at risk for serious spinal injury. Excessive spine curvature and postural abnormalities were discussed in Chapter 8 and should be reviewed at this time in relations to predisposing individuals to spinal conditions.

PREVENTION OF SPINAL CONDITIONS

Although most of the load on the spine is borne by the vertebral bodies and disks, the facet joints assist with some load bearing. Protective equipment can prevent some injuries to the spinal region; however, physical conditioning plays a more important role in preventing injuries to this area. In addition, because the low back is subjected to a variety of stresses as part of normal daily activities, an awareness of proper posture is essential in minimizing the risk of injury.

Protective Equipment

Weight-training belts, abdominal binders, and other similar lumbar/sacral supportive devices support the abdominal contents, stabilize the trunk, and potentially can assist in preventing spinal deformity and damage. These

devices place the low back in a more vertical lifting posture, decrease lumbar lordosis, limit pelvic torsion, and lessen axial loading on the spine by increasing intra-abdominal pressure, which in turn reduces compressive forces in the vertebral bodies. Many of these protective devices are discussed in Chapter 3.

Physical Conditioning

Strengthening of the back muscles is imperative to stabilize the spinal column. Exercises to strengthen the low back area should involve back extension, lateral flexion, and rotation. In addition, it is important to strengthen the abdominal muscles to maintain appropriate postural alignment.

Normal ROM also is essential in stabilizing the spine and preventing injury. If warranted, stretching exercises should be used to promote and maintain normal ROM. In particular, it is advantageous to ensure maximal motion in lateral flexion, forward flexion, and rotation.

Proper Skill Technique

Poor posture during walking, sitting, standing, lying down, and running may lead to chronic low back strain or sprains. Cases of postural deformity should be assessed to determine the cause, and an appropriate exercise program should be developed to address the deficits.

Lifting techniques also can affect spinal loading. Executing a lift in a very rapid, jerking fashion dramatically increases compression and shear forces on the spine as well as tension in the paraspinal muscles. For this reason, isotonic resistance exercises should always be performed in a slow, controlled fashion. Breathing technique should be emphasized as well. Specifically, it is desirable to inhale deeply as a lift is initiated and exhale forcefully and smoothly at the end of the lift. Use of a supportive weight-training belt and a spotter also can potentially reduce the chance of injury to the lumbar region during heavy weight lifting.

ASSESSMENT OF LUMBAR SPINAL CONDITIONS

? A 17-year-old cheerleader reports to the athletic training room complaining of aching pain during trunk flexion that is aggravated with resisted hyperextension that produces sharp, shooting pains into the low back and down the posterior leg. How should the assessment of this injury progress to determine the extent and severity of injury?

Injury assessment of the lumbar spine is difficult and complex. In the event of an acute injury with possible nerve involvement, immobilization and immediate transportation to the nearest medical facility is warranted, regardless of whether a total assessment is completed. Box 22.2 identifies several red flags that warrant immobilization and immediate referral to a physician.

BOX 22.2 Red Flags That Warrant Immobilization and Immediate Referral to a Physician

- Severe pain, point tenderness, or deformity along the vertebral column
- Pain radiating into the extremities
- Trunk or abdominal pain that may be referred from the visceral organs
- Loss or change in sensation anywhere in the body
- Paralysis or inability to move a body part
- Any injury in which uncertainty exists regarding the severity or nature
- Diminished or absent reflexes
- Muscle weakness in a myotome

When the patient walks into the examination room and complains of low back pain, it is relatively safe to assume that a serious spinal injury is not present. Most of the examination will involve differentiating symptoms, including distinguishing the presence of radicular symptoms into the leg from a

space-occupying lesion or herniated disk, from other conditions, such as a strain, sprain, or facet problem more likely to cause localized low back pain. Even after a detailed and methodical assessment, a definitive determination of the source of pain may not be obvious. As such, referral to a physician for advanced testing and assessment may be necessary.

See **Application Strategy: Lumbar Spinal Injury Evaluation**, available on the companion Web site at thePoint, for a summary of the assessment procedure.

The assessment that follows focuses on a lumbar assessment for a conscious individual. Specific information related to an acute injury is included where appropriate.

HISTORY

The injury assessment of the cheerleader should begin with a history. What questions need to be asked to identify the cause and extent of injury?

A history of the injury should include information regarding the primary complaint, mechanism of injury, characteristics of the symptoms, disability resulting from the injury, previous injuries to the area, and family history that may have some bearing on this specific condition. In cases of lumbar spinal injury, questions should be asked about the location of pain (i.e., localized or radiating), type of pain (i.e., dull, aching, sharp, burning, or radiating), presence of sensory changes (i.e., numbness, tingling, or absence of sensation), and possible muscle weakness or paralysis. It also is important to determine the length of time the problem has been present. Acute back pain usually lasts 3 to 4 days. Subacute back pain lasts up to 12 weeks, however, and chronic back pain can extend longer than 3 months.[1]

See **Application Strategy: Developing a History for a Spinal Injury**, available on the

companion Web site at thePoint, for general questions related to a lumbar spinal injury.

The cheerleader should be asked questions that would assist in determining the cause and extent of injury. Questions should address the primary complaint (i.e., what, when, and how questions), mechanism of injury, location of pain (i.e., localized or radiating), type of pain (i.e., dull, aching, sharp, burning, or radiating), presence of sensory changes (i.e., numbness, tingling, or absence of sensation) and possible muscle weakness, unusual sensations (i.e., sound or feelings), onset of symptoms, related medical history, and past injuries/treatment.

OBSERVATION AND INSPECTION

The 17-year-old cheerleader has been participating in cheerleading for 5 years. The primary complaint is an aching pain during trunk flexion that is aggravated with resisted hyperextension that produces sharp shooting pains into the low back and down the posterior aspect of the right leg. The cheerleader reports the condition has been present for 2 weeks, and she cannot recall a traumatic episode that may have caused the condition. Would it be appropriate to do a scan examination to rule out other painful areas, and what specific factors should be observed to identify the injury?

The observation component of an assessment should be initiated as soon as the clinician sees the patient. Body language can signal pain, disability, and muscle weakness. It is important to note the individual's willingness or ability to move, general posture, ease in motion, and general attitude. Clothing and protective equipment may prevent visual observation of abnormalities in the spinal alignment. As such, the patient should be suitably dressed so that the back is as exposed as possible; for girls and women, a bra, halter top, or

swimsuit can be worn. The observation should begin with a postural assessment, progress through a scan examination and gait analysis, and end with an inspection of the injury site. Postural and gait assessments were discussed in Chapter 8.

See **Application Strategy: Postural Assessment of the Low Back Region**, available on the companion Web site at thePoint, for specific postural factors to observe in the head and spinal region.

Inspection of the Injury

Local inspection of the injury site should include observation for deformity, swelling, discoloration, muscle spasm, atrophy, hypertrophy, scars that might indicate previous surgery, and the general skin condition. A step deformity in the lumbar spine may indicate a spondylolisthesis (Fig. 22.8).

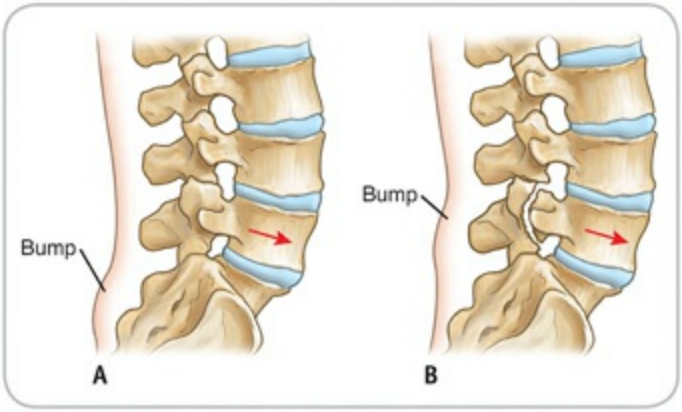


Figure 22.8. Step deformity in the lumbar spine. A step deformity occurs when the spinous process of one vertebra is more prominent than the vertebra below or above it. **A,** Spondylitis. **B,** Spondylolisthesis.

Gross Neuromuscular Assessment

During an acute on-site injury assessment, a posture assessment and scan may not be possible. It is beneficial, however, to perform a neuromuscular assessment prior to palpation to detect any motor and/or sensory deficits. This can be done without moving the patient by having the person perform a submaximal, bilateral hand squeeze and ankle dorsiflexion. These two actions assess the cervical and lumbar spinal nerves, respectively. Muscle weakness

and/or diminished sensation over the hands and feet indicate a serious injury. If any deficits are noted, the emergency care plan, including summoning emergency medical services (EMS), should be activated. If no deficits are noted, it does not rule out possible neurological involvement or fracture. Therefore, the palpation should be done with the patient maintained in the position found.

During a scan examination, trunk flexion and extension produced a dull pain in the low back. Lateral flexion to the right caused sharp pain to radiate into the right buttock and posterior leg. Gait analysis showed a shortened stride on the right side. Visual inspection showed no abnormalities. The injury is confined to the low back region.

PALPATION

What specific structures need to be palpated to determine if the injury is of bony or soft-tissue origin, and can neural involvement be ruled out during the palpation?

Bony and soft-tissue structures are palpated to detect temperature, swelling, point tenderness, deformity, crepitus, muscle spasm, and cutaneous sensation. In injuries that do not involve neural damage, fracture, or dislocation, palpation can proceed with the patient in a supine position. The umbilicus lies at the level of the L3–L4 disk space and is the center point for the intersection of the abdominal quadrants. Using careful deep palpation, the clinician may be able to palpate the anterior aspects of the L4, L5, and S1 vertebrae, disks, and accompanying anterior longitudinal ligament. The abdomen also should be palpated for pain and muscle spasms that may be responsible for referred pain into the lumbar region from internal organs. The inguinal area, iliac crest, and symphysis pubis also can be palpated for signs of infection (e.g., enlarged lymph nodes), hip pointers, apophysitis, or osteitis pubis.

When moving into the prone position, a pillow or blanket should be placed

under the hip region to tilt the pelvis back and relax the lumbar curvature. Muscle spasm in the lower erector spinae, lower trapezius, serratus posterior, quadratus lumborum, latissimus dorsi, or gluteus maximus can indicate dysfunction of the thoracic or lumbar spine. The following surface landmarks in the lumbar region can facilitate palpation:

- L4—top of iliac crest
- L5—demarcated by bilateral dimples
- S2—level of posterior superior iliac spine (PSIS)

In palpating the spinous processes of the lumbar spine, particular attention should be noted at the L4, L5, and S1 levels. A visible or palpable dip or protrusion can indicate spondylolisthesis (Fig. 22.8). If the fingers are moved laterally 2 to 3 cm (0.8 to 1.2 in), the facet joints can be palpated for signs of pathology. Because of their depth, it may be difficult to palpate the joints; however, a spasm in the overlying paraspinal muscles can be palpated. The spinous processes of the sacrum also can be palpated. Because no interposing soft-tissue spaces are between them, they may be harder to distinguish. The S2 spinous process is at the level of a line drawn between the two PSIS ("posterior dimples"). In moving to the PSIS, the clinician can palpate the iliac crest for signs of injury and then palpate the gluteal muscles for pain, spasm, or possible nodules. Having the patient flex the hip at 90° allows easier palpation of the ischial tuberosity, greater trochanter, and sciatic nerve, which is located midway between the ischial tuberosity and greater trochanter. Finally, the piriformis muscle should be palpated deep to the gluteal muscles for pathology. The following structures should be palpated:

The Anterior Aspect

1. **Umbilicus and abdominal area**. Note any abnormal tenderness or masses indicating internal pathology that is referring pain to the spinal region.
2. **Inguinal area**. Palpate for possible hernia, infection (enlarged lymph nodes), or other pathology.

3. **Iliac crest, ASIS, and symphysis pubis**. Palpate for pain, tenderness, or defect indicating pathology (e.g., avulsion fracture, hip pointer, apophysitis, or osteitis pubis).

The Posterior Aspect

1. **Spinous processes of the lumbar vertebrae**. Note any tenderness, crepitus, or presence of a step-off deformity (i.e., one vertebra is more anterior than the one below it). This indicates spondylolisthesis, which most commonly is seen between the L4 and L5 or the L5 and S1 vertebrae. Pain and tenderness without positive findings on muscle movement may indicate that the problem is not musculoskeletal in origin.
2. **Facet joints**. The facet articulations are approximately a thumb's breadth to either side of the spinous process. Point tenderness at these sites, especially with extension and rotation to the same side, suggests facet joint pain.
3. **Interspinous and supraspinous ligaments, paraspinal muscles, and quadratus lumborum**. Trigger points within specific muscles may refer pain to a more distal area. Tender points that increase with muscular contraction indicate a localized muscle strain. An area that is tender to palpation but is not painful during muscle contraction may indicate referred pain from another area.
4. **Iliac crest, PSIS, and sacrum**. The interspace between L4 and L5 lies at the same level as the top of the iliac crest. The S2 spinous process lies in the middle of a line drawn between the PSIS. Palpate for pain, tenderness, and other pathology (e.g., hip pointer or apophysitis).
5. **Ischial tuberosity, sciatic nerve, and greater trochanter**. Flex the hip to 90° for easier palpation of these structures. The sciatic nerve is located midway between the ischial tuberosity and greater trochanter (Fig. 22.9).

Figure 22.9. Sciatic nerve. To palpate the sciatic nerve, flex the hip, and locate the ischial tuberosity and greater trochanter. The sciatic nerve may be palpated at the midpoint. It is designated here by the *white dot.*

The palpation component of the assessment of the cheerleader should include bony and soft tissues of the lumbar region (i.e., spinous processes of the lumbar vertebrae; facet joints; interspinous and supraspinous ligaments, paraspinal muscles, and quadratus lumborum; iliac crest, PSIS, and sacrum; and ischial tuberosity, sciatic nerve, and greater trochanter). Palpation also should include anterior structures (i.e., umbilicus and abdominal area, iliac crest, and ASIS).

Because the cheerleader is younger than 18 years, palpation can only be performed with permission from the parent or guardian. It also is important to recognize that the cheerleader may feel uncomfortable being touched by a health care provider of the opposite gender. If a same-gender clinician is not available, the evaluation should be observed by a third party (e.g., another clinician, parent, or guardian).

PHYSICAL EXAMINATION TESTS

? In the palpation component of the assessment of the cheerleader, point tenderness was elicited in the low back region between the L3 and S1 vertebrae, with increased pain in the L4–L5 region. A muscle spasm was present on either side of the lumbar region. Pain also was elicited with palpation midway between the ischial tuberosity and greater trochanter. Based on the information obtained through the history, observation, and palpation, what tests should be performed to determine nerve root impingement, and what tests should be conducted as part of a neurological assessment of the cheerleader's condition?

It is imperative to work slowly through the tests that are used to assess low back conditions, because injuries to the lumbar region can be very complex. If, at any time, movement leads to increased acute pain or change in sensation, or if the patient resists moving the spine, a significant injury should be assumed and the emergency plan should be activated.

Functional Tests

The completion of gross movement patterns in a standing position is adequate to determine normal and pain-free ROM. Further assessment can be conducted if motion is limited or the patient is unwilling to do the movements.

Active Movement

If active movement of the spine was conducted during the scan examination, it need not be repeated. The individual's willingness to perform the movement should be noted. It is important to note if movement is fluid and complete or if pain, spasm, or stiffness blocks the full ROM. The presence of a painful arc, particularly a lightning-like pain, present during forward flexion and extension should be noted as well. This often indicates a space-occupying lesion (e.g., herniated disk), but it also may be caused by instability. Movements to the left and right should be compared bilaterally. The ROM listed usually is the

summation of the entire lumbar spine, not just at one level, along with hip movement. Basic active movements of the lumbar spine (**Fig. 22.10**) include the following:

1. Forward trunk flexion (40° to 60°)
2. Trunk extension (20° to 35°)
3. Lateral trunk flexion (left and right; 15° to 20°)
4. Trunk rotation done in a standing and sitting position (3° to 18°)

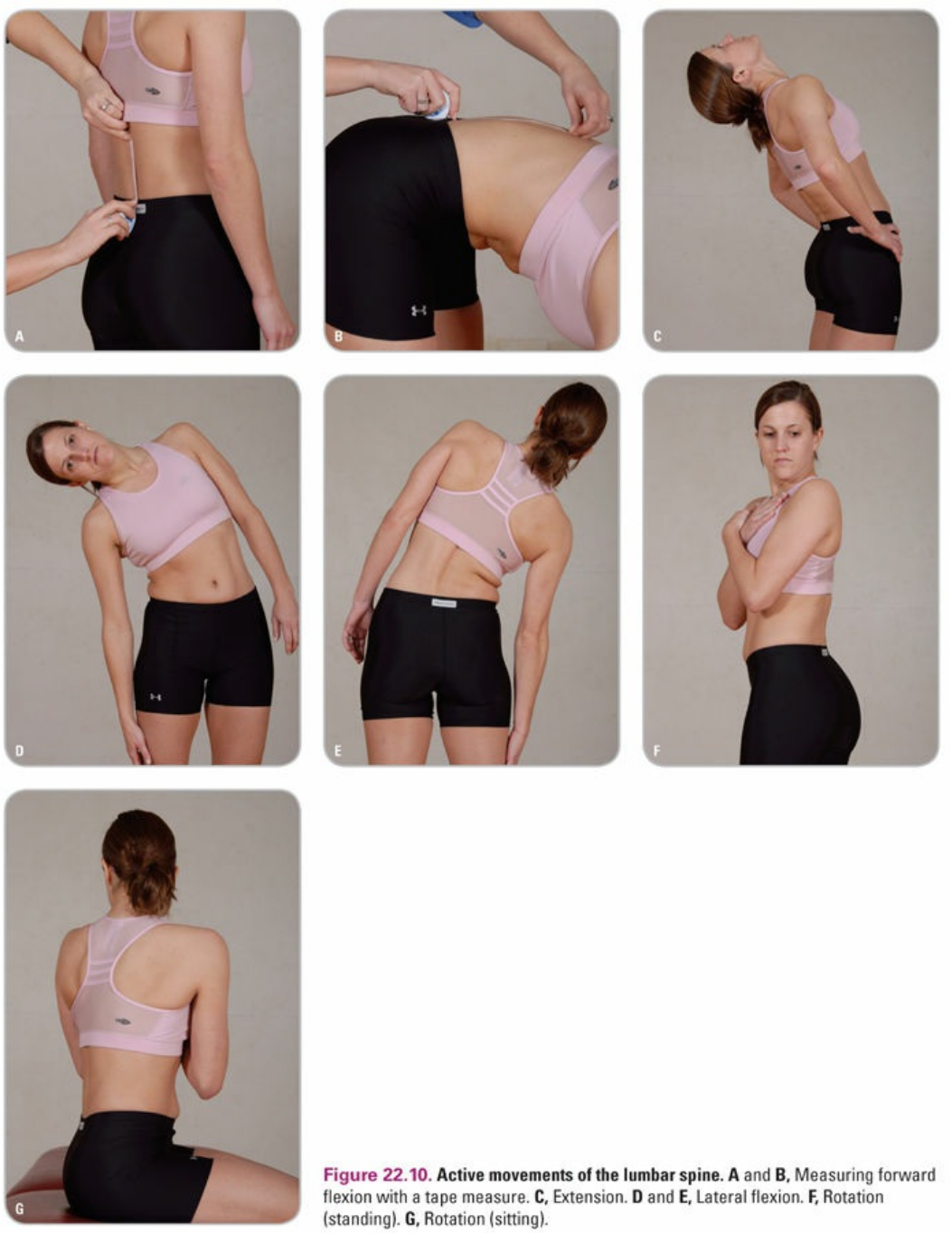


Figure 22.10. Active movements of the lumbar spine. A and **B,** Measuring forward flexion with a tape measure. **C,** Extension. **D** and **E,** Lateral flexion. **F,** Rotation (standing). **G,** Rotation (sitting).

Because spinal injuries seldom occur during a single motion, combined motions of the spine should be included in the examination. These movements include lateral flexion in flexion, lateral flexion in extension, flexion and rotation, and extension and rotation (Fig. 22.11). These movements may lead to signs and symptoms different from the basic motions and are indicated if these motions reproduce the patient's symptoms. For example, extension and rotation

are more likely to reproduce symptoms in a facet syndrome compared with only extension or only rotation.

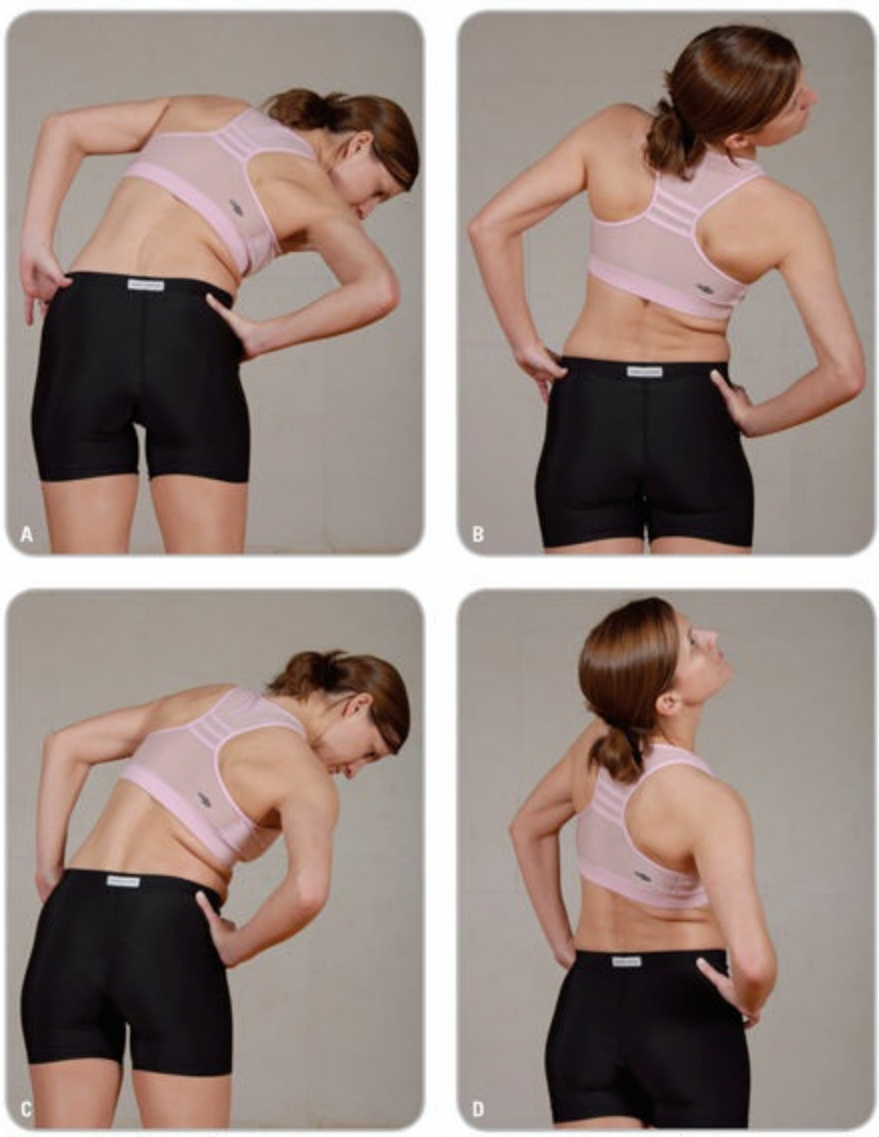


Figure 22.11. Combined active movements. A, Lateral flexion in flexion. **B,** Lateral flexion in extension. **C,** Rotation and flexion. **D,** Rotation and extension.

Passive Range of Motion

Passive movements are difficult to perform in the lumbar region. If active movements are full and pain-free, gentle overpressure may be applied as the patient reaches the full range of active motion.[13] Extreme care must be exercised in applying the overpressure, because the upper body weight is already being applied to the lumbar joints by virtue of gravity (i.e.,

compressive forces) and their position (i.e., shear forces). While sustaining the position at the end of the ROM for 10 to 20 seconds, the patient should be asked if the symptoms increase. Likewise, if symptoms increased during the active combined movements, these movements should be repeated, but only after the patient has completed the basic movements. The normal end feels for the lumbar movements are tissue stretch.[13]

Resisted Muscle Testing

Resisted movement is initially performed in a neutral position with the patient seated to stabilize the hip. The patient is instructed to not allow the clinician to move the body part being tested by applying a maximal isometric contraction in flexion, extension, lateral flexion, and rotation. By repetitively loading the patient's resisting muscle with rapid, consecutive impulses, more subtle weakness can be detected. Lumbar movements to be tested are shown in **Figure 22.12**.

Figure 22.12. Resisted isometric movements of the lumbar spine. A, Flexion. **B,** Extension. **C,** Lateral flexion. **D,** Rotation to the right.

Goniometry

Goniometry measurements of the spine are difficult to assess when using a universal goniometer. Spinal motion is less difficult to measure when using an inclinometer (**Fig. 22.13**).[14] The American Medical Association recommends using double inclinometers for assessing spinal ROM.[15] However, the most reliable method for measuring lumbar ROM is radiography.[14] **Table 22.1** provides directions for using inclinometers to measure lumbar ROM: flexion (**Fig. 22.14**), extension (**Fig. 22.15**), and lateral bending (**Fig. 22.16**).[16]

Figure 22.13. Inclinometers are fluid filled measurement instruments that use gravity's effect to measure joint position and motion. Because universal goniometers and inclinometers use different systems to measure joint motion, it is recommended that the two not be used interchangeably. (From Norkin CC, White DJ. *Measurement of Joint Motion: A Guide to Goniometry*. 4th ed. Philadelphia, PA: FA Davis; 2009.)

TABLE 22.1 Measuring Lumbar Range of Motion Using Inclinometers

MOTION	1. Lumbar flexion (approximately 60° degrees) 2. Lumber extension (ranges from 20° to 38°, depending on age and gender) 3. Lumber lateral flexion (approximately 25°–30°)
STARTING POSITION	Patient in standing
INCLINOMETER PLACEMENT	Two inclinometers are needed. The upper inclinometer is placed over the *spinous process of T12*, and the second inclinometer is placed over the *sacrum at the S2* level. In the starting position, both inclinometers should be set at the zero position.
PATIENT INSTRUCTIONS	1. "Please bend forward as far as possible while keeping knees straight." 2. "Please bend backward as far as possible." 3. "Please bend to the side but do not rotate your trunk. Please keep both feet flat on the ground and knees straight."
ENDING POSITION	1. Flexion 2. Extension 3. Lateral flexion
MEASURING RANGE OF MOTION	Subtract the degrees recorded on the sacral inclinometer from the degrees recorded on the inclinometer at the T12 level.
MOTION	1. Thoracolumbar lateral flexion 2. Thoracolumbar rotation
STARTING POSITION	1. Patient in standing 2. Patient in forward flexion
INCLINOMETER PLACEMENT	Two inclinometers are needed. The upper inclinometer is placed over the *spinous process of T1* and the second inclinometer is placed over the sacrum at the *S2 level*. In the starting position, both inclinometers should be set at the zero position.
PATIENT INSTRUCTIONS	1. "Please bend to the side as far as possible, keeping both feet flat on ground and knees straight." 2. "Please rotate trunk as far as possible without moving out of extension."
ENDING POSITION	1. Laterally flexed 2. Lateral rotation
MEASURING RANGE OF MOTION	Subtract the degrees recorded on the sacral inclinometer from the degrees recorded on the inclinometer at the T1 level.

Adapted from Norkin CC, White DJ. *Measurement of Joint Motion: A Guide to Goniometry*. 4th ed. Philadelphia, PA: FA Davis; 2009.

Figure 22.14. Using inclinometer to measure active lumbar flexion. A, Starting position with double inclinometers placed over the spinous process of T12 and second inclinometer over the sacrum at the S2 level. **B,** Ending position.

Figure 22.15. Using inclinometer to measure active lumbar extension. A, Starting position with double inclinometers placed over the spinous process of T12 and second inclinometer over the sacrum at the S2 level. **B,** Ending position.

Figure 22.16. Using inclinometer to measure active lumbar lateral flexion. A, Starting position with double inclinometers placed over the spinous process of T12 and second inclinometer over the sacrum at the S2 level. **B,** Ending position.

Stress and Functional Tests

Several stress tests can be used in a spinal assessment. Only those deemed to be relevant should be performed. Because many of these tests are designed to put stress on neurological tissue, they often cause pain or discomfort, which may be bilateral. For a test to be positive, however, the patient's symptoms must be reproduced; otherwise, the test is considered to be negative. Tests are grouped on the basis of patient position.

Lumbar Tests in a Seated Position

Slump Test

This test is a neural tension test designed to assess potential lumbar nerve root irritation. While in a seated position on an examining table, the patient is instructed to "slump" so that the spine flexes and the shoulders sag forward.

Initially, the clinician maintains the position of the patient's head in a neutral position (**Fig. 22.17A**). The presence of any symptoms that are produced by the slump should be noted. If no symptoms are present, the patient flexes the neck and the clinician places pressure on the shoulders of the patient (**Fig. 22.17B**). If no symptoms are produced, slight overpressure of neck flexion is applied by the clinician (**Fig. 22.17C**). If no symptoms are elicited, one of the patient's knees is passively extended, and the foot of the same leg is passively dorsiflexed, to see if any symptoms occur (**Fig. 22.17D**). If no symptoms are reported, the patient is asked to extend the neck. The presence or lack of symptoms should be noted (**Fig. 22.17E**). This process is repeated with the opposite leg. A test is positive if symptoms of sciatic pain are reproduced, indicating impingement of the dura and spinal cord or nerve roots. The pain usually is produced at the site of the lesion. Specificity scores for the slump test range from 55% to 73% with sensitivity scores ranging from 42% to 83%.[17,18] The wide range of scores may be attributed to the fact that many modifications have been made to the slump test, with different sequencing order as well as altering whether the patient is actively or passively engaged in the motions.

Figure 22.17. Slump test. The test is performed in several stages. **A,** While sitting on a table, the clinician asks the person to "slump" so that the spine flexes and the shoulders sag forward while the clinician holds the head in a neutral position. **B,** If no symptoms are present, the clinician applies light pressure, pushing down on the shoulders while the patient holds the head in a neutral position. **C,** If no symptoms are produced, overpressure is applied to the cervical spine. **D,** If no symptoms occur, the clinician passively extends one of the patient's knees and dorsiflexes the ankle of the same leg. **E,** The patient is instructed to extend the neck. The test is considered to be positive if symptoms of sciatic pain are reproduced, indicating impingement of the dura and spinal cord or nerve roots.

Valsalva Test

The Valsalva maneuver is used to determine the presence of space-occupying lesions (e.g., herniated disk, tumor, or osteophytes). While seated, the patient is asked to take a deep breath and hold it while bearing down, as if moving the bowels. It is important for the clinician to exercise caution with this test, because the maneuver increases intrathecal pressure, which can slow the pulse, decrease venous return, and increase venous pressure, each of which actions may cause fainting. A positive test is indicated by increased pain radiating from low back. The Valsalva maneuver has very strong sensitivity (95%) as well as strong specificity (73%), making this a clinically useful

test.[17]

Lumbar Tests in a Supine Position

Straight Leg Raising Test

Also known as Lasègue test, this examination is used to differentiate the source of the patient's pain: SI joint pain, irritation of the sciatic nerve, disk herniation, or tight hamstrings. Although the straight leg raising (SLR) test has had sensitivity ratings as high as 97%,[18] other sources state it as low as 33%.[17,19] Specificity findings seem to be varying also, ranging from 57% to 87%.[17–19] This variability may be due to the many modifications that are made when performing the SLR and calls into question the clinical usefulness of this test.[20] Therefore, it is important to obtain a solid history and consider findings discovered through inspection and palpation combined with the findings from the SLR test.

The test should be performed in stages, and at each stage, asking the patient for presence of pain and to describe the type and location of the pain being experienced. To perform the SLR test, the patient is placed in a relaxed, supine position with the hip medially rotated and the knee extended. The clinician should grasp the individual's heel with one hand and place the other on top of the patella to prevent the knee from flexing. The leg is passively and slowly raised until the patient complains of pain or tightness. Ask the patient to describe the location and type of pain being felt. The leg is then lowered until the pain is relieved. The leg should not be lowered further. Next, the clinician passively dorsiflexes the patient's foot and again asks the patient for presence, location, and type of pain experienced. If no pain is experienced, further modification includes asking the patient to flex the neck onto the chest while the clinician continues to dorsiflex the foot (**Fig. 22.18**).

Figure 22.18. Straight leg raising test. The clinician passively flexes the patient's hip while keeping the knee extended until pain or tension is felt. Next, the leg is lowered slowly until the pain or tension disappears. Next, the clinician dorsiflexes the ankle. If no pain occurs, patient is asked to flex the neck, while the clinician continues to passively dorsiflex the ankle.

If the patient does not experience pain until between 70° and 90° of hip flexion, with no neurological symptoms, the pain may be caused by SI joint dysfunction. Pain that is experienced prior to reaching 70° of hip flexion originates in the lumbar spine and radiates may suggest presence of disk involvement. If pain is experienced at 30° of hip flexion and originates in the buttock area, SI nerve irritation should be suspected.

Pain that is reproduced when the ankle is passively dorsiflexed helps to rule out tight hamstrings as the cause of the pain. Passive dorsiflexion places tension on the dural sheath by stretching it. Pain in the hamstring region that is relieved by lowering the leg and that is not reproduced with passive ankle dorsiflexion suggests tight hamstrings.

Well Straight Leg Raising Test

The well SLR test differs from the previous test in that the unaffected leg is raised. A positive sign is pain on the side opposite the leg being raised, indicating a space-occupying lesion (e.g., a herniated intervertebral disk).

Bowstring Test (Tension or Popliteal Pressure Sign)

The bowstring or tension sign test is designed to assess tension or pressure on the sciatic nerve and is a modification of the SLR test. The clinician passively

flexes the patient's hip while maintaining full knee extension until the patient complains of pain. Ask the patient to describe the type of pain experienced and the location. If pain is experienced, the clinician then flexes the knee slightly (20°), reducing the symptoms. Thumb or finger pressure is then exerted over the tibial portion of the sciatic nerve as it passes through the popliteal space to reestablish the painful radiating symptoms (Fig. 22.19). Replication of tenderness or radiating pain is a positive sign for sciatic nerve irritation.

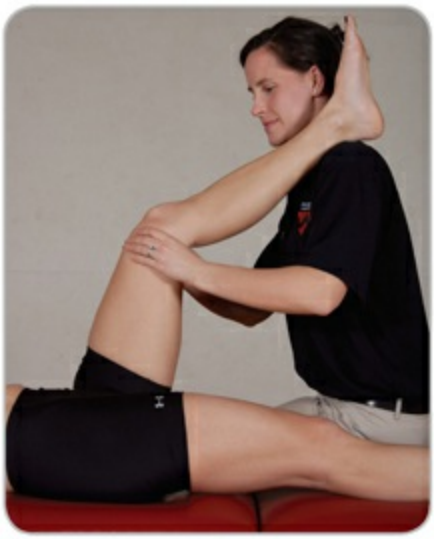


Figure 22.19. Bowstring test. After pain results in an SLR test, the clinician flexes the knee slightly (20°) to reduce the symptoms. Thumb pressure is then exerted in the popliteal area to reproduce the painful radicular symptoms.

Brudzinski Test

This test is similar to the SLR test, but the movements are actively performed by the patient. The patient is supine, with the hands cupped behind the head (Fig. 22.20A). The test is positive if the patient complains of neck and low back discomfort and attempts to relieve the meningeal irritation by involuntarily flexing the knees and hips. Positive findings suggest possible dural sheath irritation.

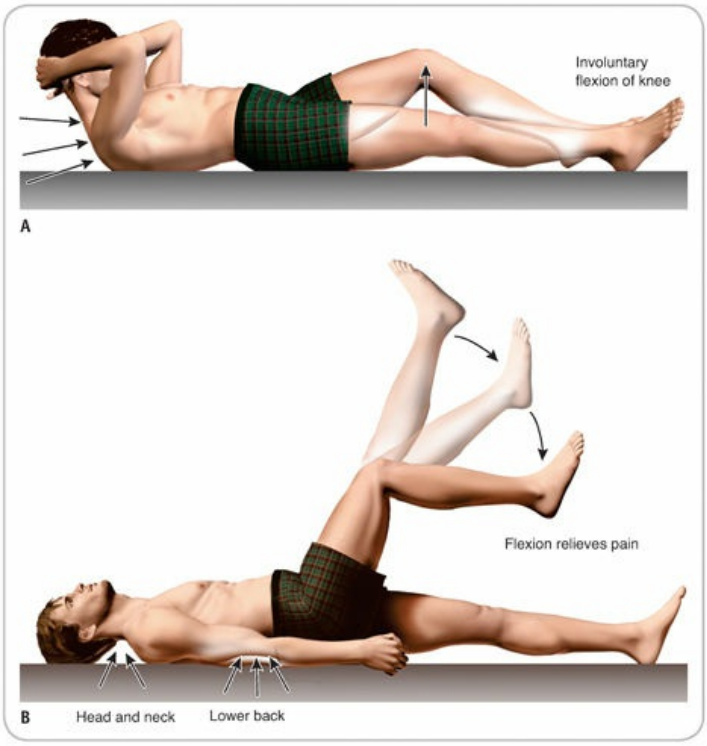


Figure 22.20. Brudzinski and Kernig tests. A, In Brudzinski test, the individual lays supine and dorsiflexes the neck. **B,** In Kernig test, the individual actively flexes the hip, with the knee extended. The test is considered to be positive if knee extension leads to head, neck, or low back pain that is relieved with knee flexion.

Kernig Test

This test can aid in identifying the presence of a bulging disk, nerve root impingement, inflammation of the dural sheath, or irritation of the meninges. In Kernig's position, the patient lies supine, with the hip flexed and the knee extended (Fig. 22.20B). Pain in the head, neck, or lower back suggests meningeal irritation, which may indicate presence of meningitis. If the pain is relieved when the patient flexes the knee, it is considered to be a positive test, indicating meningeal irritation, nerve root involvement, or dural irritation. The Brudzinski and Kernig tests may be done either separately or together.

Milgram Test

This test attempts to increase intrathecal pressure, resulting in an increased bulge of the nucleus pulposus, primarily in the lumbar spine. The patient lies supine, simultaneously lifts both legs off the table by 2 in to 6 in, and holds this position for 30 seconds (Fig. 22.21). The test is considered to be positive if the affected limb or limbs cannot be held for 30 seconds or if symptoms are reproduced in the affected limb. This test should be performed with caution,

because it places a high stress load on the lumbar spine.

Figure 22.21. Milgram test. The patient is instructed to raise both legs 2–6 in and hold the position for 30 seconds. The test is considered to be positive if the affected limb or limbs cannot be held for 30 seconds or if symptoms are reproduced in the affected limb.

Piriformis Syndrome Tests

Because the piriformis muscle may impinge or entrap the sciatic nerve, symptoms associated with piriformis syndrome are similar to symptoms experienced by patients with lumbar disk herniation. Therefore, it is important to distinguish the cause of the patient's sciatic pain so that proper treatment is provided.

Pace Sign and FAIR Test

When performing the FAIR (flexion, adduction, and internal rotation) test, recreation of symptoms is referred to as a positive **pace sign**. To perform the **FAIR** test, the patient is placed in a supine or recumbent position (Fig. 22.22). The clinician passively moves the limb of the affected side into 60° of hip flexion with the knee flexed to an angle of 60° to 90°. The hip of the affected side is then internally rotated and adducted, applying a downward pressure at the end range of the maneuver. The hip of the noninvolved side should be stabilized throughout the process. A positive pace sign implies that the pain may be caused by the piriformis syndrome.[21] The FAIR test has been found to be a clinically useful test for identifying piriformis syndrome with a reported 88% sensitivity and 83% specificity.[22]

Figure 22.22. FAIR test and pace sign. A, The patient is placed in supine position, and the clinician passively moves the limb of the affected side into 60° of hip flexion with the knee flexed to an angle of 60° to 90°. **B,** The hip of the affected side is then internally rotated and adducted, applying a downward pressure at the end range of the maneuver. Reproduction of symptoms (pace sign) indicates a positive finding.

Piriformis Muscle Stretch Test

However, there are many different piriformis muscle stretch tests described within the literature, often with the same name, but with varying techniques described.[21] The description that follows is the one most frequently used to describe the piriformis muscle stretch test. The patient lies supine, with the knees flexed and the feet flat on the table. The foot/ankle of the affected leg is crossed and placed on top of the unaffected knee. The patient grasps the uninvolved knee and pulls to the chest (**Fig. 22.23**). The test is positive if symptoms are reproduced. Be aware that it is also the same maneuver one would use to *stretch* the piriformis muscle and is therefore also a therapeutic exercise.

Figure 22.23. Piriformis muscle stretch test. Starting in a supine position, the patient slightly flexes the hip and knee of the uninvolved side. The ankle of the involved side is placed on the knee of the uninvolved side. The patient then passively (using both hands) pulls the thigh of the uninvolved leg to his or her chest, thereby stretching the piriformis and lateral rotators of the involved side. Reproduction of pain is a positive finding.

Piriformis Sign

A positive piriformis sign indicates that the piriformis and lateral rotators are excessively tight. To assess for the presence of a piriformis sign, place the patient in a supine position. View the patient from a caudal or feet-first perspective. The presence of external rotation of the lower extremity present only on the involved side in an otherwise relaxed patient is a positive finding (**Fig. 22.24**).[21]

Figure 22.24. Piriformis sign. View the patient from a caudal or feet first perspective. The presence of external rotation of the lower extremity present only on the involved side in an otherwise relaxed patient is a positive finding.

Lumbar Tests in a Prone Position

Femoral Nerve Stretch Test

This test is used to assess nerve root lesions at the L2, L3, or L4 level. The femoral nerve stretch test (FNST) has been found to be one of the most reliable (88% to 100%) clinical test in screening for midlumbar nerve root impingement and has a reported 97% sensitivity.[18,23] This test is also referred to as the prone knee bend test, although some variation between the two tests does exist. The description that follows is specific to the FNST. The patient is prone, and the knee is passively flexed until the foot rests against the buttock, or until the onset of symptoms, making sure the hip is not rotated. If the knee cannot be flexed beyond 90° because of a pathological condition, passive extension of the hip, with the knee flexed as much as possible, is performed (Fig. 22.25). Unilateral pain in the lumbar region indicates an L2 or L3 nerve root lesion. Pain in the anterior thigh indicates tight quadriceps or stretching of the femoral nerve.

Figure 22.25. Femoral nerve stretch test. With the patient prone, the clinician passively flexes the knee as far as possible toward the buttocks. Unilateral pain in the lumbar area, buttock, and/or posterior thigh may indicate an L2 or L3 nerve root lesion.

Spring Test for Facet Joint Mobility

Hypomobility of the vertebrae, especially at the facet joint, may be assessed with the spring test (Fig. 22.26). With the patient prone, the clinician stands over the patient with the thumbs placed over the spinous process to be tested. The clinician carefully pushes the spinous process anteriorly, feeling for a springing of the vertebrae. The test is considered to be positive if pain is elicited or if the vertebra does not move ("spring").

Figure 22.26. Facet joint spring test. While placing the thumbs directly over the spinous process, the clinician carefully pushes the spinous process anteriorly, feeling for the springing of the vertebrae. If pain is elicited or the vertebra is hypomobile, facet joint pathology is present.

Lumbar Tests in a Standing Position

Single-Leg Stance Test

This test can aid in the assessment of spondylolysis, spondylolisthesis, and SI joint irritation. The patient stands on one leg and extends the spine while balancing on the single leg (stork position) (**Fig. 22.27**). The clinician stands nearby providing support for the patient and may aid in providing overpressure at an end ROM. The test is then repeated with the opposite leg. If pain is elicited when the opposite leg is lifted, a unilateral lesion to the pars interarticularis should be suspected; if pain is elicited when either leg is lifted, a bilateral pars interarticularis fracture should be suspected. If rotation is combined with extension and pain results, possible facet joint pathology is indicated on the side to which rotation occurs. The single-leg stance test (also known as stork test) has good interrater reliability (88% to 100%) and both moderate sensitivity (55%) and sensitivity (46% to 68%).[17]

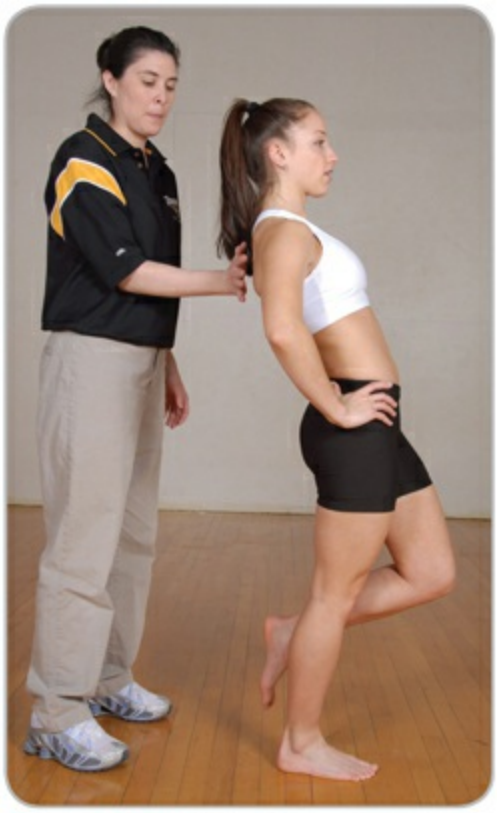


Figure 22.27. Single-leg stance test. The clinician needs to stand behind the patient to support the shoulder region as the patient balances on one leg and then hyperextends the spine. A test is positive when pain is evoked in the back when the opposite leg is raised, indicating a pars interarticularis stress fracture. Bilateral pars fractures result in pain when either leg is lifted.

Quadrant Test

This test can screen for various pathologies of the lumbar spine, such as dural irritation, facet joint compression, and SI joint dysfunction. The clinician stands behind the patient. The patient extends the spine while the clinician controls the movement by stabilizing the patient's shoulders. If needed, the clinician may use his or her shoulder to support the weight of the patient's head. Overpressure is applied in extension while the patient laterally flexes and rotates toward the painful side. This movement pattern causes maximum narrowing of the intervertebral foramen and stresses the facet joints on the side

where rotation occurs. The presence of radicular pain suggests impingement of the lumbar nerve roots. In comparison, localized pain is indicative of facet joint pathology; SI joint dysfunction would be suggested if pain is specific to the area of the PSIS (Fig. 22.28).

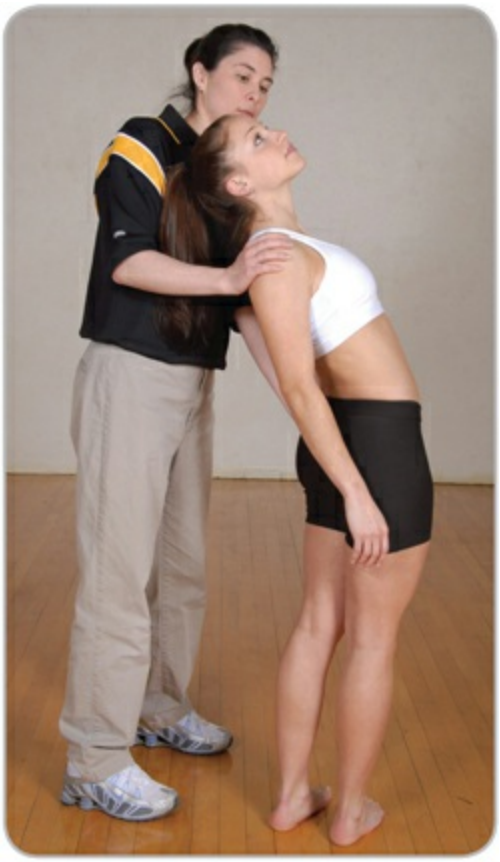


Figure 22.28. Quadrant test. The patient extends the spine while the clinician controls the movement by holding the shoulders. The clinician applies over-pressure in extension while the patient laterally flexes and rotates toward the painful side. This movement is continued until symptoms are reproduced or the end of the ROM is reached.

Lumbar Tests for Malingering

Hoover Test

Because the assessment of lumbopelvic disorders is difficult to perform objectively, the Hoover test is used to determine if the patient is a malingerer.

The clinician's hands cup each heel of the supine patient while the legs remain relaxed on the examining table (Fig. 22.29). The patient is then asked to lift one leg off the table while keeping the knees straight, as in an active SLR test. If the patient does not lift the leg or the clinician does not feel pressure under the opposite heel, the patient may not be trying to lift the leg or may be a malingerer. Pressure under the normal heel increases, however, if the lifted limb is weaker because of the increased effort to lift the weak leg. A bilateral comparison then is made to determine any differences.

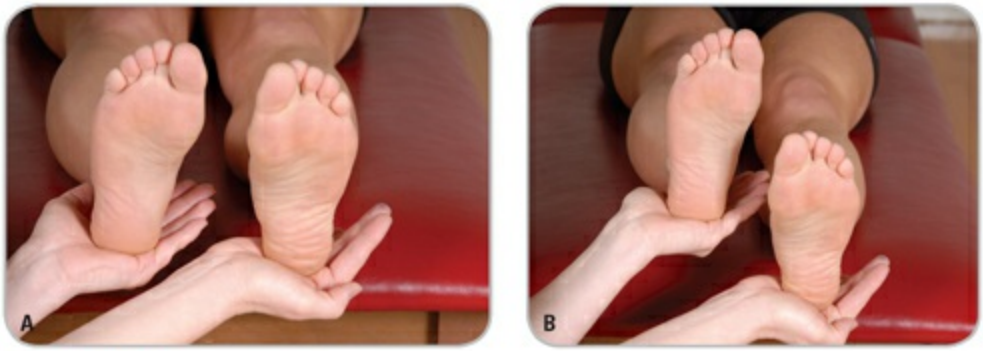


Figure 22.29. Hoover test. A, Under normal conditions, when an individual tries to elevate one leg, the action is accompanied by downward pressure on the opposite leg. **B,** When the individual attempts to elevate the "weak" leg but the opposite (asymptomatic) leg does not "help," at least some of the weakness probably is feigned.

Neurological Tests

Injury to the lumbar region and spinal cord can be reflected in **hyperreflexia**, muscle weakness, loss of sensation, and ataxia. Several tests should be performed to assess lower motor neuron lesions. Lower quarter neurological screening tests the L1–S2 nerve roots. Neurological integrity can be assessed through special tests, segmental dermatomes, myotomes, reflexes, and peripheral nerve cutaneous patterns.

Cutaneous Patterns

The wide variation of dermatomal innervation and the subjectivity of the test make it less useful than motor or reflex testing. The segmental nerve dermatome patterns and peripheral nerve cutaneous patterns are demonstrated in Figure 6.7. Testing should be performed bilaterally.

Myotomes

Isometric muscle testing is performed in the upper and lower extremities to test specific myotomes (**Table 22.2**). These were originally discussed in Chapter 6. The ankle movements should be performed with the knee flexed approximately 30°, especially if the patient is complaining of sciatic pain, because full dorsiflexion is considered to be a provocative maneuver for stretching neurological tissue. Similarly, a fully extended knee increases the stretch on the sciatic nerve and may result in false signs, such as weakness that results from pain rather than from pressure on the nerve root.

TABLE 22.2 Myotomes Used to Test Selected Nerves

NERVE ROOT SEGMENT	ACTION TESTED
L1–L2	Hip flexion
L3	Knee extension
L4	Ankle dorsiflexion
L5	Toe extension
S1	Plantar flexion of the ankle, foot eversion, and hip extension
S2	Knee flexion

Reflexes

Repetitive tapping of the reflexes may show a gradual decline in the reflex response not otherwise noted in a single tap. Absent or decreased reflexes are not necessarily pathological, especially in individuals who have well-developed muscles. Upper limb reflexes can be increased by having the patient perform an isometric contraction, such as squeezing the knees together during the test. In the lower extremity, the two major reflexes are the patella (L3–L4) and Achilles tendon (S1) (**Table 22.3**). Asymmetry between sides should raise suspicion of an abnormality.

TABLE 22.3 Deep Tendon Reflexes in the Lower Extremity

REFLEX	SEGMENTAL LEVELS
Patellar	L2, L3, and L4
Posterior tibial	L4 and L5
Medial hamstring	L5 and S1
Lateral hamstring	S1 and S2
Achilles	S1 and S2

Referred Pain

Pain can be referred to the thoracic spine from various abdominal organs. Figure 6.1 demonstrates the area that the pain is commonly referred to in the torso.

Activity-Specific Functional Testing

Before a return to play, the patient must have a normal neurological exam, with pain-free ROM and normal bilateral muscle strength, cutaneous sensation, and reflexes. If pain is present, the patient should not return to competition. Sport-specific functional tests that should be performed include walking, bending, lifting, jogging, running, figure eight running, carioca running, and sport-specific skills. All must be performed pain-free and with unlimited movement.

In assessing the cheerleader, the special tests that are used to determine nerve root impingement may include Valsalva test, Milgram test, Hoover test, slump test, SLR test, well SLR test, bilateral SLR test, Brudzinski test, Kernig test, tension (bowstring) test, FNST, and single-leg stance test. Performing all tests may not yield more usable information than utilizing a few clinically relevant tests. When deciding which battery of tests to use, consideration should be given to the patient's age, activity level, degree of distress, dysfunction, and pain. Neurological testing for the cheerleader should include myotomes, reflexes, and dermatomes.

CONDITIONS OF THE LUMBAR SPINE

What criteria should be used to determine whether a patient who reports low back pain should be referred to a physician?

The lumbar spine must support the weight of the head, trunk, and arms as well as any load held in the hands. In addition, the two lower lumbar motion

segments (i.e., L4–L5 and L5–S1) provide a large ROM in flexion–extension. As such, it is not surprising that mechanical abuse often results in episodes of low back pain or that the lower lumbar disks are injured more frequently than any others in the spine. Many patients will sustain injury that may respond positively to conservative treatment, but it is important to determine which patients need to be referred for diagnostic testing and imaging and those that do not.

Lumbar Contusions, Strains, and Sprains

Etiology

An estimated 75% to 80% of the population experiences low back pain stemming from mechanical injury to muscles, ligaments, or connective tissue. Common causes of low back pain are presented in Box 22.3. Although low back pain typically strikes adults, nearly 30% of children experience low back pain up to the age of 16 years.[24] Several known pathologies may cause low back pain, but reduced spinal flexibility, repeated stress, and activities that require maximal extension of the lumbar spine are most associated with chronic low back pain.

BOX 22.3 Causes of Low Back Pain

- Muscle strains and sprains
- Spinal infections (e.g., tuberculosis)
- Sciatica
- Neoplastic tumor (i.e., primary or metastatic)
- Protruded or herniated disk
- Ankylosing spondylitis (arthritis of the spine)
- Pathological fracture
- Benign space-occupying lesions
- Disk space infections
- Abdominal aortic aneurysm

Muscle strains may result from a sudden extension action with trunk rotation on an overtaxed, unprepared, or underdeveloped spine. Chronic strains may stem from improper posture, excessive lumbar lordosis, flat back, or scoliosis.

Signs and Symptoms

Pain and discomfort can range from diffused to localized. Pain associated with lumbar contusions, strains, and sprains does not radiate into the buttocks or posterior thigh and show no signs of neural involvement, such as muscle weakness, sensory changes, or reflex inhibition. If a muscle strain is present, pain will increase when the structure is passively stretched and with active concentric contraction. Ruling in the presence of a contusion, strain, or sprain usually also involves ruling out disk or nerve involvement. Tests such as the Valsalva maneuver, the straight leg raise, single-leg stance, and quadrant test should be negative in that there is no onset of neurological symptoms, and if pain is produced, it will be localized to the facet joint, ligament, or muscle that has been injured.

Management

Acute protocol is followed to control pain and hemorrhage. In the initial treatment phase, patients with low back pain have responded well to cryotherapy, nonsteroidal anti-inflammatory drugs (NSAIDs), and muscle relaxant medication.[2] However, there is concern regarding the potential side effects of using these medications as well as the potential for violating guidelines regarding banned substances for athletes participating in National Collegiate Athletic Association (NCAA) sporting events.[2] Following cold treatment, superficial heat and spinal manipulation therapy have been found to be strongly supported in the literature as very effective in treating low back conditions that do not involve the disks or nerve roots.[2] Any treatment plan selected should be designed to address the cause of the pain. For example, a weak core resulting in poor posture may be the underlying cause of the patient's pain, and thus, the therapeutic exercise program should address strengthening the core and focusing on posture training.

Low Back Pain in Runners

Etiology

Many runners develop muscle tightness in the hip flexors and hamstrings. Tight hip flexors tend to produce a forward body lean, which leads to anterior pelvic tilt and hyperlordosis of the lumbar spine (see **Fig. 16.13A**). Because the lumbar muscles develop tension to counteract the forward bending moment of the entire trunk when the trunk is in flexion, these muscles are particularly susceptible to strain. Coupled with tight hamstrings, a shorter stride often emerges.

Signs and Symptoms

Symptoms include localized pain that increases with active and resisted back extension, but radiating pain and neurological deficits are not present. During postural assessment, anterior pelvic tilt and hyperlordosis of the lumbar spine also may be observed. When assessing the patient's passive ROM, limited and restricted ROM may be noted with pathological end feel found. Gait analysis may reveal a forward lean and shortened gait pattern.

Management

Treatment focuses on avoiding excessive flexion activities and a sedentary posture (**Box 22.4**). Flexion causes the mobile nucleus pulposus to shift posteriorly and press against the annulus fibrosus at its thinnest, least buttressed place. In most cases, this just leads to pain, but in others, it may lead to a herniated disk. In addition, physical activity is necessary to pump fluid through the spinal disks to keep them properly hydrated; by interfering with this process, immobility can prolong pain.

BOX 22.4 Reducing Low Back Pain in Runners

- Wear properly fitted shoes that control heel motion and provide maximum shock absorption.
- Increase flexibility at the hip, knee, ankle plantar flexors, and trunk extensors.

- Increase strength in the abdominal and trunk extensor muscles.
- Avoid excessive body weight.
- Warm up before and after running.
- Run with an upright stance rather than with a forward lean.
- Avoid excessive side-to-side sway.
- Run on even terrain and limit hill work. Avoid running on concrete.
- Avoid overstriding to increase speed because this increases leg shock.
- Gradually increase distance, intensity, and duration. Do not increase any parameter more than 10% in 1 week.
- If orthotics are worn and pain persists, check for wear and rigidity.
- Consider alternatives to running, such as cycling, rowing, or swimming.

Ice, NSAIDs, muscle relaxants, transcutaneous electrical nerve stimulation (TENS), and electrical muscle stimulation may be used to reduce pain and inflammation. Lumbar stabilization exercises can be combined with extension exercises, progressive activity, and early mobilization. Aerobic exercise, such as walking, swimming, or biking, should be included in all programs. If symptoms do not improve within a week, the patient should be referred to a physician to rule out a more serious underlying condition. In an effort to decrease the incidence of low back pain, training techniques should allow for the adequate progression of distance and intensity and should include extensive flexibility exercises for the hip and thigh region.

Myofascial Pain

Etiology

Myofascial pain is referred pain that emanates from a myofascial trigger point, which is a hypersensitive, localized nodule within a taut band of muscle tissue and its surrounding fascia. When compressed or palpated, pain is produced in a predictable distribution of referred pain. In the lumbar area, the piriformis muscle and quadratus lumborum are common trigger point sites associated

with extended sitting, standing, running, and walking activities. The piriformis, in particular, can impact the sciatic nerve as it courses through, above, or below the muscle on its path into the posterior leg. Individuals who slip unexpectedly and catch themselves also can irritate the trigger points.

Signs and Symptoms

Aggravation of the piriformis can lead to referred pain in the SI area, the posterior hip, and the upper two-thirds of the posterior thigh. Aching and deep pain increases with activity or with prolonged sitting with the hip adducted, flexed, and internally rotated. If the sciatic nerve is impinged, pain and possible changes in sensation may extend into the leg. Piriformis syndrome is described at length in Chapter 16. If the patient's pain is originating from the piriformis, a trigger point may be palpable within the piriformis and the FAIR test; the piriformis muscle stretch test should be positive. The piriformis sign and pace sign may or may not be present.[21]

Referred pain from the quadratus lumborum (QL) often gives a false sign of a disk syndrome and often is overlooked as a source of low back pain. The superficial fibers can refer a sharp, aching pain to the low back, iliac crest, or greater trochanter or can extend it to the abdominal wall. The deep fibers may refer pain to the SI joint or lower buttock region. Pain increases during lateral bending toward the involved side, while standing for long periods of time, and during coughing or sneezing. To screen for myofascial pain originating from the QL, carefully observe the patient while in a prone position. The iliac crest on the involved side may appear elevated due to spasm of the QL. During palpation, assess for the presence of a trigger point. Activation of the trigger point will recreate the patient's symptoms.

Management

Trigger point treatment involves stretching the involved muscle back to its normal resting length as a way to relieve the irritation that led to the initial pain. The patient should be placed in a comfortable position on the uninvolved side if the piriformis is involved or prone if the QL is involved. Three potential techniques can be used. One technique involves the application of

pressure slowly and progressively over the trigger point. Pressure is maintained until the tenderness is gone. Another technique involves ice massage applied over the length of the muscle and then over the referred pain pattern. The ice is applied in longitudinal, parallel strokes in only one direction while a passive stretch is applied progressively to the involved muscle. The third technique involves a deep-stroking massage over the length of the muscle, moving in a distal to proximal direction. As the massage continues, the taut band should relax, the tender nodules soften, and the pain decrease.

Facet Joint Pathology

Etiology

Throughout the longitudinal axis of the spine, three distinct anatomical columns can be defined at any spinal motion segment—namely, the anterior, middle, and posterior columns. The posterior column contains the pars interarticularis, facet joints, and spinous processes and is supported by the ligamentum flavum and interspinous ligaments (Fig. 22.30A). The facet joint is a synovial joint richly innervated via the medial branch of the posterior primary rami of at least two adjacent spinal nerves. The facet joint capsules act as passive restraints against excessive lumbar rotation and flexion and serve as a protective mechanism for the intervertebral disk (Fig. 22.30B).

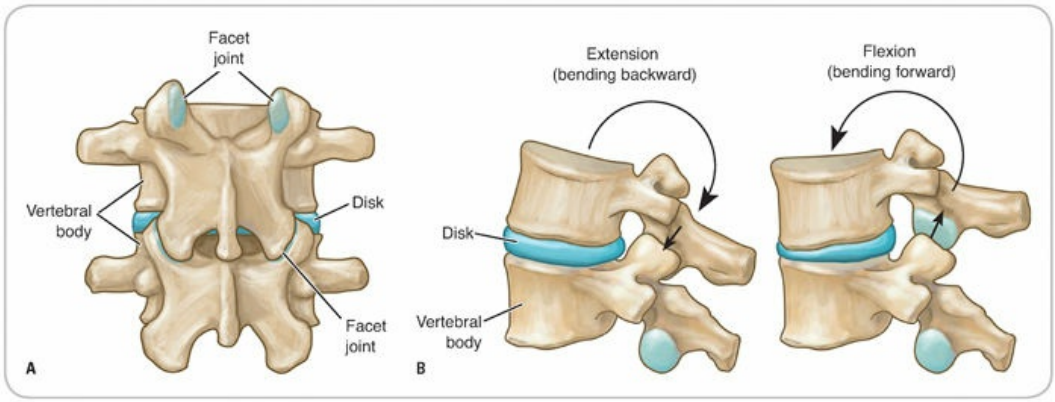


Figure 22.30. Posterior column of the spine. A, Normal facet orientation. **B,** Stress placed on facets during flexion and extension.

Lumbar facet pathology may involve subluxation or dislocation of the facet, but more often, the facet pain is due to facet joint syndrome (i.e.,

inflammation), or degeneration of the facet itself (i.e., arthritis). **Facet syndrome** is characterized by pain, soreness, and stiffness that increase with active extension and in periods of prolonged sitting. Some patients only experience pain or discomfort in the morning. The exact pathophysiology is unclear. Theories include possible mechanical irritation of the nearby nerve root, chemical irritation arising from the inflammatory process (e.g., capsular and synovial inflammation), meniscoid entrapment, synovial impingement, joint subluxation, chondromalacia facette, mechanical injury to the joint's capsule, and restriction to normal articular motion from soft or articular causes.

Signs and Symptoms

Signs and symptoms can include nonspecific low back, hip, and buttock pain with a deep and achy quality. The pain may radiate into the posterior thigh, but it does not radiate below the knee. Some patients describe their pain as being worse in the morning, aggravated by rest and hyperextension, and relieved by repeated motion. Flattening of lumbar lordosis may be visible. Point tenderness may be elicited to a unilateral or bilateral paravertebral area. Pain often is exacerbated by trunk rotation, stretching into full extension, lateral bending toward the involved side, and with torsion. Sensory alternations usually are absent unless the nerve root is secondarily involved.

Limited flexibility of the pelvic musculature can directly impact the mechanics of the lumbosacral spine. If facet joint pathology is present, an abnormal pelvic tilt and rotation of the hip secondary to tight hamstrings, hip rotators, and quadratus may be or may not be evident. Palpation may reveal increased tension of the musculature in the area of the dysfunction as well as increased tenderness. The spring test may be positive for restricted motion. Typically, resisted ROM testing is normal; however, a subtle weakness in the erector spinae and hamstring muscles may contribute to pelvic tilt abnormalities. This subtle weakness may be appreciated with trunk, pelvic, and lower extremity extension asymmetry. If facet hypertrophy narrows the neural foramen, causing nerve root impingement, an SLR test may elicit a positive response. Typically, this maneuver is normal.

Management

If facet joint syndrome is suspected, conservative treatment options should result in improved patient outcomes. The initial treatment should focus on education, relative rest, pain relief, and maintenance of positions that provide comfort, exercises, and some modalities. Therapeutic exercises should include instruction regarding proper posture and body mechanics in activities of daily living that protect the injured joints, reduce symptoms, and prevent further injury. Positions that cause pain should be avoided. Modalities such as superficial heat and cryotherapy may help to relax the muscles and reduce pain. In addition, medications such as NSAIDs can be advantageous. Spinal manipulation and mobilization also can be used to reduce pain. Once the painful symptoms are controlled during the acute phase of treatment, stretching and strengthening exercises of the lumbar spine and associated muscles can be initiated. If the patient does not respond to conservative therapies, the patient should be referred for radiographs or magnetic resonance imaging. The facet may also be injected with an anesthetic, which should result in reduction of symptoms.

Lumbar Spinal Stenosis

Etiology

Lumbar spinal stenosis (LSS) involves narrowing of the spinal canal with cord or nerve impingement resulting in symptoms of radiculopathy or pseudoclaudication. The narrowing can occur in the vertebral canal, the lateral recess, or the neuroforamina. The condition may further be subdivided into central or lateral stenosis that can occur focally or diffusely throughout several spinal levels. Stenosis may also be divided by its etiology into the following groups: degenerative, spondylolisthetic, iatrogenic (postsurgical), posttraumatic, and metabolic (Paget disease). The degenerative form is most common (**Fig. 22.31**).[25]

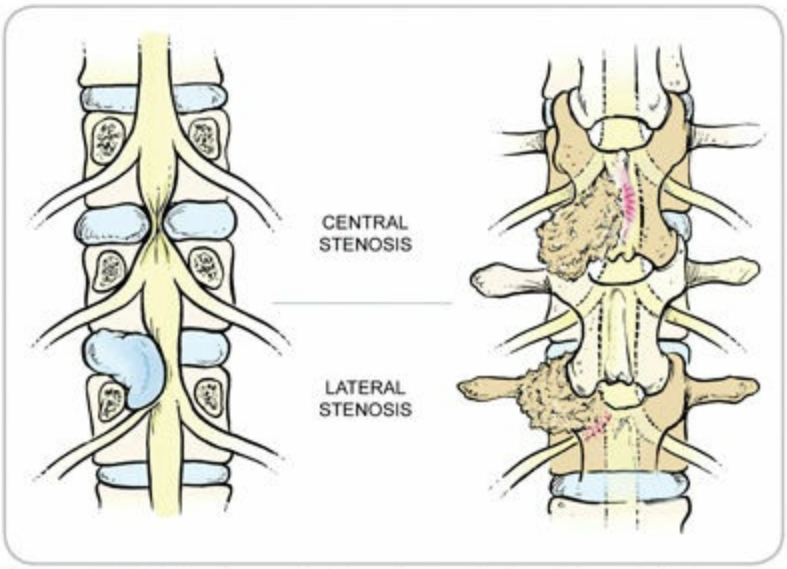


Figure 22.31. Spinal stenosis. Central stenosis (top, left, and right) usually develops at the disk level from a bulging disk with facet joint overgrowth from the inferior articular process of the lumbar vertebrae and thickening and redundancy of the ligamentum flavum. Lateral stenosis (bottom, left, and right) includes both the lateral recess and foraminal stenosis resulting from overgrowth from the superior articular process of the vertebra and other degenerative changes similar to those of central stenosis. Lateral recess stenosis affects the spinal nerve root at the disk level.

Signs and Symptoms

LSS is seen more often in older patients but should be a consideration for patients who have a long history of participating in sports that require extended periods of flexion into extension movements, such as football linemen. Symptoms gradually appear and worsen over time. Typical symptoms of LSS are leg pain, with or without back pain, which is aggravated by walking. Other symptoms include one or a combination of the following: pain and/or numbness in the lower extremities, and neurogenic claudication (pain and numbness with walking), which occurs secondary to narrowing of the spinal canal, nerve root canal, or intervertebral foramina.[26] The patient may describe a relief of symptoms when sitting or leaning forward. Standing and extension may increase severity of symptoms. Because symptoms extend into the leg when walking and are aggravated by walking, peripheral vascular disease should be considered as a differential diagnosis for LSS. Whereas symptoms associated with LSS will decrease when seated or with forward leaning, pain

originating from peripheral vascular disease dissipates only when the patient stops activity.[26] Physical examination alone does not yield a conclusive lumbar stenosis diagnosis. Therefore, if LSS is suspected, the patient should be referred for a conclusive diagnosis using imaging studies from a magnetic resonance imaging scan or a computed tomographic scan with myelogram (using an X-ray dye in the spinal sack fluid).

Management

To date, there is a dearth of evidence-based research on the most effective treatment of LSS. Individuals with mild symptoms respond well to conservative treatment, which may involve analgesics, therapeutic exercise, treadmill walking, ultrasound, or epidural steroid injections. Surgical treatment is suggested in patients with severe symptoms of LSS.

Sciatica

Etiology

Sciatica, an inflammatory condition of the sciatic nerve, is classified in terms of four levels of severity, each with its own management strategy (Box 22.5). The condition can be caused by a herniated disk, annular tear, myogenic or muscle-related disease, spinal stenosis, facet joint arthropathy, or compression of the nerve between the piriformis muscle.

BOX 22.5 Classification and Management of Sciatica

- **Sciatica only:** No sensory or muscle weakness. Modify activity appropriately and develop rehabilitation and prevention program. Any increased pain requires immediate reevaluation.
- **Sciatica with soft signs:** Some sensory changes, mild or no reflex change, normal muscle strength, and normal bowel and bladder function. Remove from sport participation for 6–12 weeks.
- **Sciatica with hard signs:** Sensory and reflex changes, and muscle weakness caused by repeated, chronic, or acute condition. Normal bowel and bladder function. Remove from participation for 12–24

weeks.

- **Sciatica with severe signs:** Sensory and reflex changes, muscle weakness, and altered bladder function. Consider immediate surgical decompression.

See **Signs and Symptoms of Sciatica**, available on the companion Web site at thePoint, for the common signs and symptoms that accompany the various etiologies of sciatica.

Signs and Symptoms

If related to a herniated disk, radiating leg pain is greater than back pain and increases with sitting and leaning forward, coughing, sneezing, and straining. Pain is reproduced during an ipsilateral SLR test (see **Fig. 22.18**).

In an annular tear, back pain is more prevalent and is exacerbated with SLR. Morning pain and muscular stiffness that worsens if chilled or when the weather changes (arthritic-like symptoms) are characteristic of myogenic or muscle-related disease. Pain typically radiates into the buttock and thigh region.

If LSS is present, back and leg pain develop after the patient walks a limited distance and concomitantly increase as the distance increases. Pain is not reproduced with an SLR test, but it can be reproduced with prolonged spine extension, which is relieved with spine flexion. If a facet joint is involved, pain is localized over the joint on spinal extension and is exacerbated with ipsilateral lateral flexion. If the sciatic nerve is compressed by the piriformis muscle, pain increases during internal rotation of the thigh.

Management

Referral to a physician is necessary to check for a potentially serious underlying condition. Under normal circumstances, bed rest usually is not indicated, although side lying with the knees flexed may relieve symptoms. Lifting, bending, twisting, and prolonged sitting and standing aggravate the condition and, therefore, should be avoided. When asymptomatic, abdominal and extensor muscle strengthening exercises can begin, with a gradual return to

activity. If symptoms resume, however, activity should cease, and the patient should be referred back to the physician. Occasionally, extended rest is needed for symptoms to resolve totally, and if a significant disk protrusion is present, surgery may be indicated.

Conditions of the Lumbar Disk

Etiology

Prolonged mechanical loading of the spine can lead to microruptures in the annulus fibrosus, resulting in degeneration of the disk (Fig. 22.32). Bulging or protruded disks refer to some eccentric accumulation of the nucleus with slight deformity of the annulus. When the eccentric nucleus produces a definite deformity as it works its way through the fibers of the annulus, it is called a **prolapsed disk**. It is called an **extruded disk** when the material moves into the spinal canal, where it runs the risk of impinging on adjacent nerve roots. Finally, with a **sequestrated disk**, the nuclear material has separated from the disk itself and, potentially, can migrate. The most commonly herniated disks are the lower two lumbar disks at L4–L5 and L5–S1, followed by the two lower cervical disks. Most ruptures move in a posterior or posterolateral direction as a result of torsion and compression, not just compression.

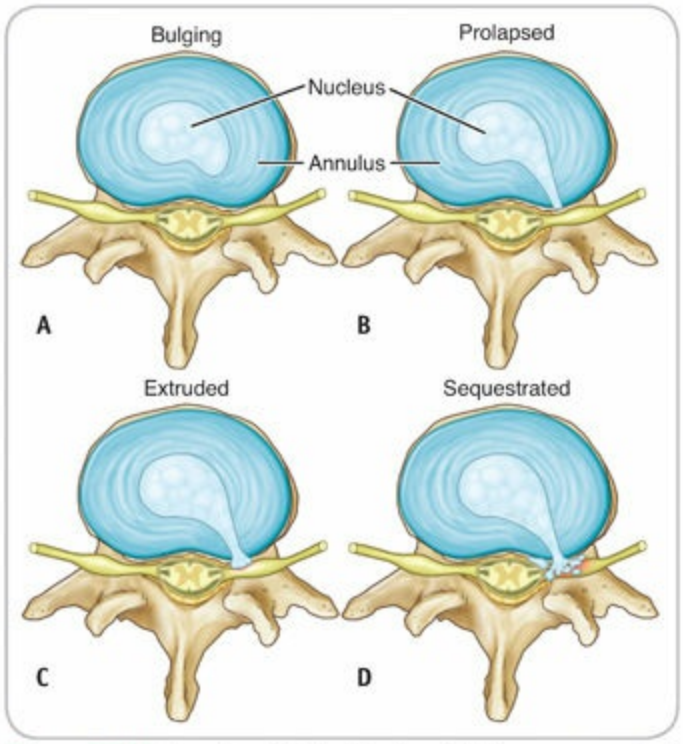


Figure 22.32. Herniated disks. Herniated disks are categorized by severity as an eccentrically loaded nucleus progressively moves from **(A)** protruded, **(B)** prolapsed, and **(C)** extruded, culminating in **(D)** sequestrated when the nuclear material moves into the canal to impinge on the adjacent spinal nerves.

Signs and Symptoms

Because the intervertebral disks are not innervated, the sensation of pain does not occur until the surrounding soft-tissue structures are impinged. When compression is placed on a spinal nerve of the sciatic nerve complex (L4–S3), sensory and motor deficits are reflected in the myotome and dermatome patterns associated with the nerve root (Fig. 22.33). In addition, an alteration in tendon reflexes is apparent. A disk need not be completely herniated to give symptoms, which include sharp pain and muscle spasms at the site of herniation that often shoot down the sciatic nerve into the lower extremity. The patient may walk in a slightly crouched position, leaning away from the side of the lesion. Forward trunk flexion may exacerbate symptoms while active extension relieves symptoms. The Valsalva maneuver, the straight leg rise test (see Fig. 22.18), bowstring test (see Fig. 22.19), and the Brudzinski/Kernig (see Fig. 22.20) may exacerbate pain and increase distal symptoms. Significant

signs indicating the need for immediate referral to a physician include muscle weakness, sensory changes, diminished reflexes in the lower extremity, and abnormal bladder or bowel function. Table 22.4 outlines physical findings associated with disk herniation in the low back region.

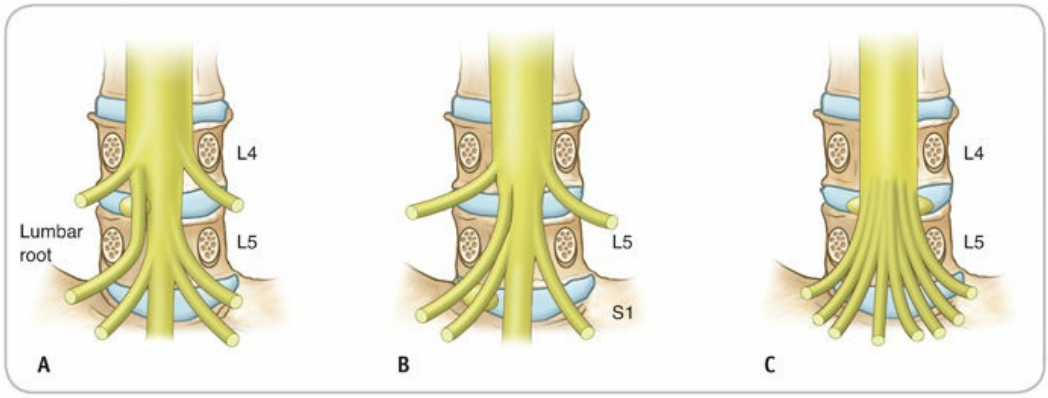


Figure 22.33. Possible effects on the spinal cord and spinal nerves according to the level of herniation. **A,** Herniation between L4 and L5 compresses the L5 nerve root. **B,** Herniation between L5 and S1 can compress the nerve root crossing the disk (S1) and the nerve root emerging through the intervertebral foramina (L5). **C,** A posterior herniation at the L4–L5 level can compress the dura mater of the entire cauda equina, leading to bowel and bladder paralysis.

TABLE 22.4 Physical Findings Associated with a Herniated Disk

SIGNS AND SYMPTOMS	L3–L4 (L4 ROOT)	L4–L5 (L5 ROOT)	L5–S1 (S1 ROOT)
Pain	Lumbar region and buttocks	Lumbar region, groin, and SI area	Lumbar region, groin, and SI area
Dermatome and sensory loss	Anterior midthigh over patella and medial lower leg to great toe	Lateral thigh, anterior leg, top of foot, and middle three toes	Posterior lateral thigh and lower leg to lateral foot and fifth toe
Myotome weakness	Ankle dorsiflexion	Toe extension (extensor hallux)	Ankle plantar flexion (gastrocnemius)
Reduced deep tendon reflex	Quadriceps	Medial hamstrings	Achilles tendon
SLR test	Normal	Reduced	Reduced

Management

In mild cases, treatment consists of minimizing load on the spine by avoiding activities that involve impact, lifting, bending, twisting, and prolonged sitting and standing. Painful muscle spasms can be eliminated with ice and/or heat, the administration of prescribed NSAIDs and/or muscle relaxants, ultrasound, TENS, passive exercise, and gentle stretching. Following the resolution of spasms and acute pain, rehabilitation should include spine and hamstring flexibility, spinal strength and stabilization exercises, and functional

stabilization control in sports and daily activities.

Lumbar Fractures and Dislocations

Etiology

Transverse or spinous process fractures are caused by extreme tension from the attached muscles or from a direct blow to the low back during participation in contact sports, such as football, rugby, soccer, basketball, hockey, and lacrosse. These fractures often lead to an additional injury of the surrounding soft tissues but are not as serious as compression fractures. Compression fractures more commonly involve the L1 vertebra at the thoracolumbar junction.

Hyperflexion, or jack-knifing of the trunk, crushes the anterior aspect of the vertebral body. The primary danger with this injury is the possibility of bony fragments moving into the spinal canal and damaging the spinal cord or spinal nerves. Because of the facet joint orientation in the lumbar region, dislocations occur only when a fracture is present. Fracture dislocations resulting from sports participation are rare.

Signs and Symptoms

Symptoms include localized, palpable pain that may radiate down the nerve root if a bony fragment compresses a spinal nerve. Because the spinal cord ends at approximately the L1 or L2 level, fractures of the lumbar vertebrae below this point do not pose a serious threat but, rather, should be handled with care to minimize potential nerve damage to the cauda equina. Confirmation of a possible fracture is made with a radiograph or CT scan.

Management

Conservative treatment consists of initial bed rest, cryotherapy, and minimizing mechanical loads on the low back until symptoms subside, which may take 3 to 6 weeks.

Pars Interarticularis Fractures

The pars interarticularis is the weakest bony portion of the vertebral neural arch, the region between the superior and inferior articular facets. Fractures in this region are termed spondylolysis and spondylolisthesis (Fig. 22.34). Although some pars defects may be congenital, they also may be caused by mechanical stress from axial loading of the lumbar spine during repeated weight loading in flexion, hyperextension (i.e., back arching), and rotation. These repetitive movements cause a shearing stress to the vertebrae, resulting in a stress fracture.

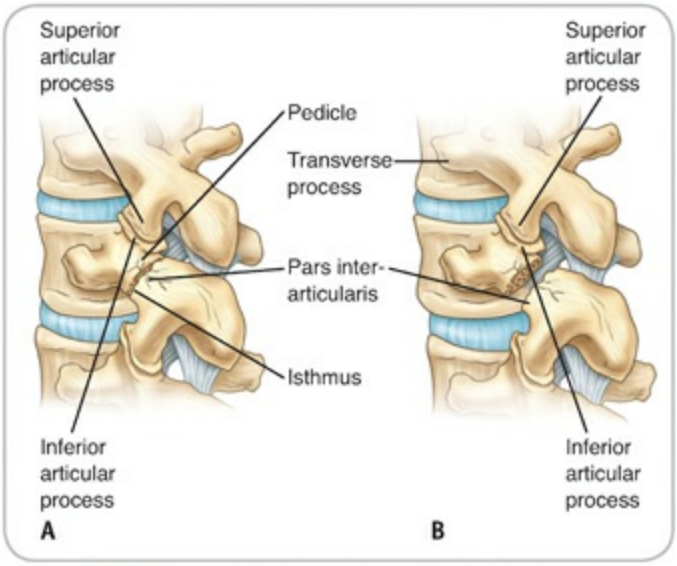


Figure 22.34. Spondylolysis and spondylolisthesis.
A, Spondylolysis is a stress fracture of the pars interarticularis. **B,** Spondylolisthesis is a bilateral fracture of the pars interarticularis accompanied by anterior slippage of the involved vertebra.

Fractures of the pars interarticularis may range from hairline to complete separation of the bone. A bony defect in spondylolysis tends to occur at an earlier age, typically before 8 years of age, yet often does not produce symptoms until 10 to 15 years of age. The fracture may heal with less periosteal callus and tends to form a fibrous union more often than fractures at other sites.

A bilateral separation in the pars interarticularis, called **spondylolisthesis**, results in the anterior displacement of a vertebra with respect to the vertebra below it (Fig. 22.35). The most common site for this injury is the lumbosacral joint (L5 through S1), with 90% of the slips occurring at this level.

Spondylolisthesis often is diagnosed in children between the ages of 10 and 15 years and is more common in boys than in girls. High-degree slips, however, are seen more commonly in females than in males.[27] Unlike most stress fractures, spondylolysis and spondylolisthesis do not typically heal with time but, rather, tend to persist, particularly in cases with no interruption in participation in sport and physical activity. Those who are particularly susceptible to this condition include female gymnasts, interior football linemen, weight lifters, volleyball players, pole vaulters, wrestlers, and rowers.

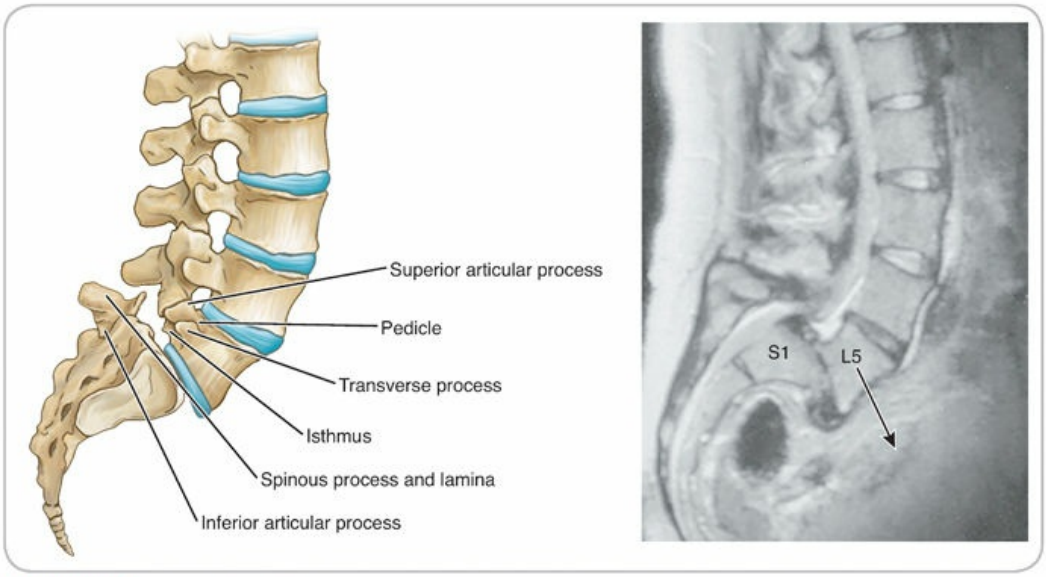


Figure 22.35. Spondylolisthesis. This magnetic resonance imaging scan of spondylolisthesis demonstrates an anterior shift of the L5 vertebra.

Although most spondylitic conditions are asymptomatic, low back pain and associated neurological symptoms are likely to occur when the underlying cause is repeated mechanical stress. The patient may complain of unilateral, dull backache aggravated by activity, usually hyperextension and rotation. Standing on one leg and hyperextending the back aggravates the condition. Demonstrable muscle spasm occurs in the erector spinae muscles or hamstrings, leading to flattening of the lumbosacral curve, but no sciatic nerve symptoms usually are present. Pain may radiate into the buttock region or down the sciatic nerve if the L5 nerve root is compressed. This patient should be referred to a physician.

Slippage is measured by dividing the distance the superior vertebral body has displaced forward onto the inferior by the anteroposterior dimensions of the inferior vertebral body. In mild cases (i.e., slippage of 0% to 25%), modifications in training and technique can permit the patient to continue to participate in physical activity. In moderate cases (i.e., slippage from 25% to 50%), however, most physicians do not begin active rehabilitation until the patient has been asymptomatic for 4 weeks. Following that period, the focus of rehabilitation is the development of flexibility in the hamstrings and gluteal muscles, combined with strengthening the abdomen and back extensors. If the slip is greater than 50%, the patient presents with flat buttocks, tight hamstrings, and alterations in gait and a palpable step-off deformity may be present at the level of the defect. This patient should be excluded from participation in contact sports unless the condition is asymptomatic and absence of continued slippage has been documented.

If a fracture or dislocation is suspected, the emergency plan, including summoning EMS for transport to the nearest medical facility, should be activated.

If assessment of a low back injury reveals signs of nerve root involvement (i.e., sensory or motor deficits and diminished reflexes) or disk injury, physician referral is warranted.

SACRUM AND COCCYX CONDITIONS

A 40-year-old man initiated a training program to improve his cardiovascular fitness. His workout for the past month has consisted of running on a treadmill. Over the past week, he began to develop pain in the sacral region during his workout. The pain has now become so persistent and chronic that it hurts to sit for an extended period of time. What injury may be present, and what recommendations can be made to this person relative to caring for the injury?

Because the sacrum and coccyx are essentially immobile, the potential for mechanical injury to these regions is dramatically reduced. In many cases, injuries result from direct blows and stress on the SI joint.

Sacroiliac Joint Sprain

Etiology

Sprains of the SI joint may result from a single traumatic episode that involves bending and/or twisting, repetitive stress from lifting, a fall on the buttocks, excessive side-to-side or up-and-down motion during running and jogging, running on uneven terrain, suddenly slipping or stumbling forward, or wearing new shoes or orthoses. The injury may irritate or stretch the sacrotuberous or sacrospinous ligament, or it may lead to an anterior or posterior rotation of one side of the pelvis relative to the other. Hypermobility results from rotation of the pelvis. During healing, the joint on the injured side may become hypermobile, allowing the joint to subluxate in either an anterior- or posterior-rotated position.

Signs and Symptoms

Symptoms may involve unilateral, dull pain in the sacral area that extends into the buttocks and posterior thigh. On observation, the ASIS or PSIS may appear to be asymmetrical when compared bilaterally. A leg length discrepancy may be present, but muscle spasm is not often seen. Standing on one leg and climbing stairs may increase the pain. Forward bending reveals a block to normal movement, with the PSIS on the injured side moving sooner than on the uninjured side. Lateral flexion toward the injured side increases pain, as do straight leg raises beyond 45°.

Management

Treatment for SI sprains includes cryotherapy, prescribed NSAIDs, and gentle stretching to alleviate stiffness. As the conditions improves, flexibility, pelvic stabilization exercises, mobilization of the affected joint, and strengthening exercises for the low back should be initiated.

Coccygeal Conditions

Etiology

Direct blows to the region can produce contusions and fractures of the coccyx.

Signs and Symptoms

Pain resulting from a fracture may last for several months. Prolonged or chronic pain in the region also may result from irritation of the coccygeal nerve plexus. This condition is termed coccygodynia.

Management

Treatment for coccygeal pain includes analgesics, use of padding for protection, and a ring seat to alleviate compression during sitting.

This patient has probably irritated the SI joint from repeated stress while running on the treadmill. This patient should ice the region to control inflammation and pain and should stretch the low back and buttock region. A detailed assessment (including a gait analysis while running) should be performed to determine the potential cause of the injury so that a proper rehabilitation program and, subsequently, an appropriate cardiovascular conditioning regimen can be developed.

REHABILITATION

The findings from the special tests and neurological testing revealed increased pain in the right lumbar region on resisted trunk extension, lateral flexion, and rotation to the right; diminished quadriceps reflex on the right side; muscle weakness apparent with knee extension and ankle dorsiflexion; and pain elicited down the right leg during an SLR test. These signs and symptoms suggest the possibility of sciatica resulting from an extruded disk at the L4 level.

The cheerleader was seen by a physician who prescribed NSAIDs, muscle relaxants, and rest until the symptoms subside. When the patient begins rehabilitation, what exercises should be included in the general program?

Rehabilitation programs must be developed on a patient basis and address the specific needs of the patient. Exercises to relieve pain related to postural problems may not address sciatic pain. Therefore, a variety of exercises are listed in this section to allow selection of those that are appropriate for the patient. The program should relieve pain and muscle tension; restore motion and balance; develop strength, endurance, and power; and maintain cardiovascular fitness. Patient education also is critical in teaching the skills and techniques that are needed to prevent recurrence.

Relief of Pain and Muscle Tension

Maintaining a prolonged posture can lead to discomfort. This can be avoided by doing active ROM exercises to relieve stress on supporting structures, to promote circulation, and to maintain flexibility. For example, in the lower thoracic and lumbar region, exercises such as back extension, side bending in each direction, spinal flexion (avoiding hip flexion), trunk rotation, and walking a short distance may relieve discomfort in the lumbar region. With nerve root compression injuries, however, extension exercises may increase discomfort and may be contraindicated. In some cases, conscious relaxation training can relax a patient who generally is tense or release tension in specific muscle groups. In addition, grade I and II mobilization exercises can be initiated early in the program to relieve pain and stretch tight structures to restore accessory movements to the joints.

Restoration of Motion

Once pain and muscle guarding are relieved, grade III and IV mobilization exercises can begin. In addition to mobilization exercises, flexibility and ROM exercises also can be initiated. Flexion exercises stretch the lumbar fascia and back extensors, open the intervertebral foramen and facet joints to reduce nerve compression, relieve tension on lumbar vertebrae caused by tight hip

flexors, and increase intra-abdominal pressure by strengthening the abdominals. Examples of flexion exercises (Application Strategy 22.1) include the single- and double-knee to the chest stretches, hamstring stretch, hip flexor stretch, lateral rotator stretch, crunch curl-ups, and diagonal crunch curl-ups. Exercises to stretch the upper thoracic and pectoral region; trunk rotators and lateral flexors; and hip adductors, abductors, extensors, and medial and lateral rotators also should be added to improve flexibility. Other exercises include bringing both knees to the chest and gently rocking back and forth in a cranial/caudal direction and, in a standing position, shifting the hips from one side to another; lateral trunk flexion; and rotation exercises. Flexion-based exercises should be avoided if hypermobility or instability is suspected or if the maneuvers increase low back pain.

APPLICATION STRATEGY 22.1

Flexibility and Strength Exercises for the Lumbar Region

Flexibility Exercises

1. **SI angle knee-to-chest stretch.** In a supine position, pull one knee toward the chest with the hands. Keep the back flat. Switch to the opposite leg and repeat.

2. **Double-knee-to-chest stretch.** In a supine position, pull both knees to

the chest with the hands. Keep the back flat.

3. **Hamstring stretch, seated position.** Place the leg to be stretched straight out, with the opposite foot tucked toward the groin. Reach toward the toes until a stretch is felt.

4. **Hip flexor stretch (lunge).** Extend the leg to be stretched behind you. Place the contralateral leg in front of you. While keeping the back straight, shift your body weight forward.

5. **Lateral rotator stretch, seated position.** Cross one leg over the thigh and place the elbow on the outside of the knee. Gently stretch the buttock muscles by pushing the bent knee across the body while keeping the pelvis on the floor.

6. **Lower trunk rotation stretch.** In a supine position, rotate the flexed knees to one side, keeping the back flat and the feet together.

7. **Angry cat stretch (posterior pelvic tilt).** Kneel on all fours, with the knees hip-width apart. Tighten the buttocks and arch the back upward while lowering the chin and tilting the pelvis backward. Relax the buttocks and allow the pelvis to drop downward and forward.

Strengthening Exercises

1. **Crunch curl-up.** In a supine position with the knees flexed, flatten the back, and curl up to elevate the head and shoulders from the floor. Alternate exercises include diagonal crunch curl-ups and hip crunches.

2. **Prone extension.** In a prone position, rise up on the elbows. Progress to rising up onto the hands.

3. **Alternate arm and leg lift.** In a fully extended prone position, lift one arm and the opposite leg off the surface at least 3 in. Repeat with the opposite arm and leg.

4. **Double-arm and leg lift.** In a fully extended prone position, lift both arms and legs off the surface at least 3 in. Hold and return to starting position.

5. **Alternate arm and leg extension on all fours.** Kneel on all fours; raise one leg behind the body while raising the opposite arm in front of the

body. Ankle and wrist weights may be added for additional resistance.

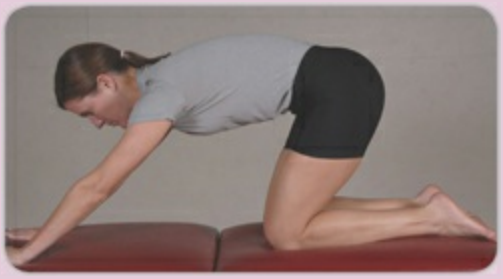
6. **Back extension.** Use a back extension machine or have another individual stabilize the feet and legs. Raise the trunk into a slightly hyperextended position.

Extension exercises improve spinal mobility, reduce load on the intervertebral disks, strengthen the back extensors, and allow self-mobilization of the motion segments. Back extension exercises described in **Application Strategy 22.1** include prone extension exercises, beginning with raising to the elbows and then to the hands, the alternate arm and leg lift, double-arm and leg lift, and alternate arm and leg extension on all fours. Other extension exercises may include prone single-leg hip extension and double-leg hip extension while holding onto a table, beginning with the knee or knees flexed and then with the knee or knees extended.

Pelvic and abdominal stabilizing exercises are used to teach a patient to place the hip in a neutral position to maintain the spine in the most comfortable position and control the forces that are exerted during repetitive microtrauma. During each exercise, the patient concentrates on maintaining the hip in a neutral position by contracting and relaxing the abdominal muscles. During functional activities, the patient can initiate stabilization contractions before starting any movement. This presets the posture and can reduce stress on the back. Many of these exercises are demonstrated in **Application Strategy 22.2**. Pelvic tilt maneuvers can help to reduce the degree of lumbar lordosis and, initially, can be performed with bent-knees standing, straight leg standing, and sitting.

APPLICATION STRATEGY 22.2

Pelvic Stabilization and Abdominal Strengthening Exercises



1. **Stabilization in a neutral position.** With the back in a neutral position, slowly shift forward over the arms, adjusting pelvic position as you move. A tendency exists to "sag" the back; therefore, progressively tighten and relax the abdominal muscles during forward movement and backward movement, respectively.

2. **Stabilization in "two-point" position.** Balance on the right leg and left arm. Slowly move forward and back without losing a neutral position. Switch to the opposite arm and leg.

3. **Leg exercise.** Without arching the back, lift one leg out behind you. Do not lift the foot more than a few inches from the floor. A variation is to move a flexed knee sideways, away from the body and then back to the original position.

4. **Half-knee to stand (lunges).** Move to a standing position while maintaining a neutral hip position. Push evenly with both legs. Repeat several times and then switch the forward leg.

5. **Pelvic tilt.** With the hips and knees bent and the feet on the floor, do an isometric contraction of the abdominal muscles (posterior pelvic tilt) and hold. Using the phrase "tuck the stomach in" may convey the correct motion. Then, arch the back by doing an anterior pelvic tilt. Alternate between the two motions until the individual can control pelvic motion.

6. **Bridging.** Keeping the back in a neutral position, raise the hips and back off the floor (contract the abdominal muscles to hold the position). Hold for 5–10 seconds, drop down, and relax. Repeat. Variations include adding pelvic tilt exercises, lifting one leg off the floor

(keeping the back in neutral position), and combining pelvic tilts and one-leg lift with bridging.

Restoration of Proprioception and Balance

Proprioception and balance are regained through lower extremity closed chain exercises. For example, squats, leg presses, lunges, or exercises on a StairMaster, Pro Fitter, or slide board can restore proprioception and balance in the hip and lower extremity. Stabilization exercises on all fours and use of surgical tubing through functional patterns also can restore proprioception and balance. These exercises should be performed in front of a mirror or videotaped, if possible, so that the patient can observe proper posture and mechanics. In addition, constant verbal reinforcement from the supervising clinician can maximize feedback.

Muscular Strength, Endurance, and Power

Abdominal strengthening exercises, such as those described in **Application Strategy 22.2**, should begin with pelvic tilts and progress to crunch curl-ups and diagonal crunch curl-ups to reduce functional lordosis. Progressive prone extension exercises and resisted back extension exercises can increase strength in the erector spinae.

Cardiovascular Fitness

Aquatic exercises are very beneficial, because buoyancy can relieve the load on sensitive structures. Deep water allows the patient to exercise all muscle groups through a full ROM without the pain associated with gravity. Performing sport-specific skills against water resistance can apply an equal and uniform force to the muscles, similar to that in isokinetic strengthening. With low back pain, an upper body ergometer, stationary bicycle, StairMaster, or slide board may be incorporated as tolerated. Jogging can begin after all symptoms have subsided.

As acute symptoms subside, pain and muscle tension should be relieved. The following exercises should be included in the rehabilitation program for the cheerleader: stretching of the piriformis, gluteals, and hamstrings, which should be combined with extension exercises to strengthen the back extensors; stretching of the abdominals; and a reduction of pressure on the intervertebral disks; and stabilization exercises, including abdominal strengthening, and strengthening of the medial rotators of the hip through proprioceptive neuromuscular facilitation and Thera-Band exercises. As strength is regained, functional activities can be incorporated, with a gradual return to full activity.

SUMMARY

1. Anatomical variations in the low back region that can predispose a patient to spinal injuries include lordosis, sway back, flat back, and pars interarticularis fractures, which can lead to spondylolysis or spondylolisthesis.
2. Runners are particularly prone to low back pain resulting from tight hip flexors and hamstrings. Symptoms include localized pain that increases with active and resisted back extension, but radiating pain and neurological deficits are not present. Anterior pelvic tilt and hyperlordosis of the lumbar spine also may be present.
3. Sciatica may be caused by a herniated disk, annular tear, myogenic or muscle-related disease, spinal stenosis, facet joint arthropathy, or compression of the nerve between the piriformis muscle.
4. The most commonly herniated disks are the lower two lumbar disks at L4–L5 and L5–S1, followed by the two lower cervical disks. Most ruptures move in a posterior or posterolateral direction as a result of torsion and compression.
5. The assessment of a spinal injury should begin with a thorough history of

the injury and should include neurological tests to determine possible nerve involvement. The severity of pain and the presence or absence of neurological symptoms, spasms, and tenderness can indicate when a backboard and stabilization are needed.

6. If, at any time, a patient complains of acute pain in the spine, mentions a change in sensation anywhere on the body, a careful and thorough examination should be conducted prior to moving the patient to determine if activation of EMS is warranted.
7. A rehabilitation program should focus on reducing pain and spasms; restoring motion and balance; developing strength, endurance, and power; and maintaining cardiovascular fitness.

APPLICATION QUESTIONS

1. A 21-year-old cross-country runner reports to the athletic training room with low back pain. What questions should be asked concerning the runner's training and conditioning regimen?
2. A 24-year-old female high jumper is complaining of pain in the low back and SI region that is aggravated by flexion and hyperextension of the trunk during jumping. What questions should be asked to develop a thorough medical history of this individual?
3. A 21-year-old track and field athlete reported to the athletic training room complaining of low back pain. He is a shot put thrower and says that the twisting motion of the throw causes pain in his low back that is sharp and shooting. How would you differentiate between an SI joint sprain and sciatica? What other possible conditions must be considered?
4. A 15-year-old female gymnast reported to the clinic complaining of low back pain. The pain has increased over the past 2 weeks, particularly during activities involving lumbar hyperextension. Based on the history, inspection, and palpation components of an assessment, you suspect

spondylosis. What findings from the testing component of an assessment would confirm your suspicion?

5. A 30-year-old male recreational basketball player reports to the orthopedic clinic complaining of low back pain. Your assessment suggests facet joint pathology. How should this condition be managed?
6. A 45-year-old professional golfer is complaining of low back pain. Your assessment suggests a herniated disk. How would you differentiate between involvement of the L3–L4 (L4) root and the L4–L5 (L5) root?
7. A distance runner complains of pain when sitting for long periods of time, which increases when leaning forward. Pain is also present when running up hills and when running on concrete. The pain has started to radiate into the posterior leg. What indicators would suggests that this patient needs to be referred to a physician for follow-up care?
8. In using some of the equipment in the weight room, the athletes are expected to move weight plates from the floor and place them on machines. What instructions would you provide to the athletes to reduce the incidence of low back injury while moving the weight plates?
9. An 18-year-old male lacrosse player has chronic low back pain. What flexibility exercises would you recommend to decrease the pain?

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