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Physical Diagnosis 150

Complete Orthopedic and Neurological Examination of the Hip for the Busy Clinician

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The purpose of a hip examination and evaluation by a health care professional is to understand the function or dysfunction of the hip joint. This is accomplished by different methods of analysis and testing which can help determine structural and / or function deficits. Such deficits can manifest in patient complaints, location of symptoms, range of motion (ROM), movement / gait, posture, palpation, muscle strength, nerve function and special tests.

In orthopedic testing, the doctor’s goal is to reproduce the patient’s pain, and to reveal possible restriction, weakness, or laxity. The tissues are tested for stretch, compression and contraction to reveal possible deficits in the hip joint.

In neurologic testing, the doctor looks for neurologic signs and identifies the specific level(s) at which these occur. Neurological deficits are identified by manual muscle strength testing (motor nerve), pinwheel (sensory nerve), and various nerve pathway tests.

Additional tests can include myofascial evaluation (bursitis, trigger points), specialized imaging studies (MRI, X-ray, EMG, Blood Lab, etc.) and vascular examination (blood vessel occlusion). Health professionals will often have patients complaining of hip and / or leg problems which will lead to a hip examination. In this lesson we will cover the essentials of a hip exam.

Basic Anatomy:

The hip joint is a ball and socket joint formed by the nearly spherical head of the femur fitting into a deep acetabular cavity in the iliac bone. The socket is further deepened by the
cartilaginous acetabular labrum. The joint is meant for maximum stability during weight bearing as well as movement.

The capsule of the joint is attached around the brim of the acetabulum. The capsule is strengthened anteriorly by the strong illiofemoral ligament of Bigelow, on the medial side by the pubofemoral ligament, and on the posterior side by the ischiofemoral ligament.

The inferior side of the capsule is unsupported and is thereby the weakest portion. The muscles surrounding the joint are all strong and help in maintaining the stability of the joint.

Because it is a ball-and-socket joint, the hip joint is similar to the shoulder joint in having freedom of motion, but the hip joint is much more stable than the shoulder joint.

**Signs of Hip Disorder:**
The hip is rarely affected by traumatic disorders due to stability and freedom of motion but is a common site for degenerative joint disease (DJD) followed by rheumatoid arthritis (RA). When the patient first presents with signs and or symptoms of hip joint disorder, such as hip pain, loss of hip motion, weakness of the hip and or leg muscles, abnormal lower sensation, and or abnormal gait, a hip examination is in order. Before the examination is started a thorough history must be taken first.

Physical examination tests that use different range of motion, muscle strength, and pain replication will help pinpoint the cause of hip dysfunction. Beyond location, consider sudden vs. insidious onset, various motions and positions that reproduce pain, predisposing physical activities, and effect of walking or weight bearing. *Clinical note: Numerous disorders are capable of causing hip pain, and hip pathology can be involved in referred pain syndromes from or to other problem areas (such as stemming from the low back or knee area).*

**Differential diagnosis of Hip disorders:**
There are many potential sources and causes of hip pain and diagnosis of specific cause can be difficult at times. This is because symptoms can arise from different spinal levels that appear very similar and thereby are difficult to differentiate.

One potential source of back pain is skeletal muscle of the hip area. Causes of hip pain in muscle tissue include muscle strains (“pulled muscles”), muscle spasm, and muscle imbalances, which can lead to a limp. Limps always need to be evaluated. *Clinical Note: Imaging studies can often miss muscle damage. In addition, precise neurophysiology of muscle spasm and muscle imbalances is not well understood.*

Another possible source of low back pain is the zygapophysial joints or facet joints of the spine. These joints have been identified as the primary source of pain in approximately one third of people with chronic low back pain and also in patients suffering from whiplash. Evaluators need
to be aware and take into account the fact that patients often times describe low back pain as hip pain and vice versa due to patterns of referred pain.

Snapping hip syndrome (also known as coxa saltans or dancer’s hip) is the audible or palpable snap during movement of the hip joint. It has multiple etiologies and is classified based on the origin of the snapping. External snapping hip is the more common and involves the lateral hip due to the iliotibial band moving over the greater trochanter of the femoral head during movements such as flexion, extension, and external or internal rotation or may be due to other causes. Internal snapping hip is less common and involves the anterior hip and the iliopsoas tendon, snapping over the underlying bony prominences. Other causes include possible cysts and partial or complete bifurcation of the iliopsoas tendon. Close physical exam and imaging can differentiate the two. It should be noted, however, that in approximately 50% of internal snapping hip cases, an additional intra-articular hip pathology is identified.

Athletic groin pain can also lead to hip issues, as such injury remains a diagnostic challenge to diagnose. Possible causes include femoroacetabular impingement (FAI), athletic pubalgia, adductor-related pathology, inguinal pathology, and labral pathology, most common cause is FAI.

Other common possible sources and causes of hip pain include spinal disc herniation of the low back, degenerative disc disease, isthmic spondylolisthesis, osteoarthritis (degenerative joint disease) and lumbar spinal stenosis, trauma, cancer, infection, fractures, and inflammatory disease.

**Childhood diseases** that affect the hip may include the following:

1) Slipped capital epiphysis
2) Congenital dysplasia
3) Legg-Perthes’ disease (osteochondrosis)
4) Back problems
5) Bursitis of either trochanteric or iliopectineal area

**Limp Evaluation:**

A limp is an uneven gait, due to some sort of asymmetrical abnormality. When pain is involved it is referred to as an antalgic gait, and in severe cases this results in an inability or refusal to walk. Hip deformities with muscular weakness may present with a Trendelenburg gait with the body shifted over the affect hip.

The diagnosis of the cause of a limp is often made based on history, physical exam findings, laboratory tests, and radiological examination. If a limp is associated with pain it should be investigated with priority versus non-painful limp, which is not as urgent.
A non-painful limp may be due to a number of conditions such as developmental dysplasia of the hip or leg length differences.

Clinical note - Young children often have difficulty determining the location of leg pain, so remember that ‘knee pain equals hip pain’.

Differential diagnosis of limp:
The there are many causes of limping, some serious and some less of a concern. It is usually from either pain, weakness, neuromuscular imbalance, or a skeletal deformity. However, the underlying cause in 30% of cases remains unknown. The most common cause of limping in children is minor trauma. With no history of trauma, 40% are from synovitis and rarely from Perthes' disease.

Infection:
Limp can be the result of septic arthritis or other infections such as Lyme disease or osteomyelitis. Aspiration of the hip joint may be required to rule out an infectious process.

Mechanical:
Trauma, either accidental or deliberate, can be from fracture, muscle bruising, or a contusion. This is the leading cause of a limp. Deliberate abuse needs to be ruled out. Elderly people are more prone to hip fractures, a recent study suggested a possible correlation between higher numbers of missing natural teeth and higher chance of hip fracture.

Inflammatory:
Transient synovitis is a form of reactive arthritis of the hip from unknown cause. Patients are usually able to walk and have either a normal or a low grade fever, otherwise looking healthy. This is usually diagnosed once all other potential serious causes are excluded. Juvenile rheumatoid arthritis (JRA) presents with early morning stiffness, fatigue, and weight loss over time.

Vascular:
Legg-Calve-Perthes disease - a degenerative disease of the head of the femur which results in bone loss and deformity. It usually presents as a chronic condition.

Neoplastic:
Various cancers may result in a gradual onset of limping in children. This will often present with night sweats, easy bruising, weight loss, and pain most prominent at night.

Hip Exam:
The hip examination is usually divided into the following sections:
- Position & Draping
- Inspection
- Palpation
- Motion
- Special maneuvers

**Position:**
For most of the exam the patient should be supine, and the bed or examination table should be flat. The patient's hands should remain at her sides with her head resting on a pillow. The knees and hips should be in the anatomical position (knee extended, hip neither flexed nor extended). Draping - both of the patient's hips can be exposed so that the quadriceps muscles and greater trochanter can be assessed.

**Inspection:**
Observe for scars, swelling, lesions, surgery, trauma signs, skin discoloration, trophic changes, and muscle atrophy. Check lumbar lordosis, levels ASIS, pes cavus, scoliosis, both patellae and malleoli and levels of both limbs.

*Clinical Note: Often, old injuries and childhood disease will become evident; I find it helpful to point out such issues to the patient. They will often respond that they forgot to mention it in the history section which can have a major effect on your working diagnosis.*

**Inspection:**
Look for antalgic position when standing or walking such as a lean to one side. Look for abnormal or antalgic gait which indicates difficulty in walking. The doctor may choose to rate such issues as mild, moderate, or severe difficulty in walking. Pain upon motion can be noted as well. If the patient is using a cane, walker, wheelchair or other assisted device this should also be noted.

*Clinical Note: When examining a patient, a doctor will sometimes ask them to pick up a small item off the ground or get up from the exam table and even observe them upon leaving the office. This will give a better assessment of their true ability to move around compared to their stated ability. Many times, in med-legal exams by a third party doctor, such differences can negatively affect the course of the case for the patient.*

**Observe:**
- Trendelenburg sign (pelvic sway/tilt, aka waddling gait if bilateral)
- Broad-based ataxia issues
- High-stepping (loss of proprioception/drop foot)
- Antalgic stance during movement phase
- Normal phases of gait cycle: stance, toe-off, swing and heel-strike
- In-toeing (“pigeon toe” - suggestive of femoral anteverision)
- Appropriate stride length
Normal flexion/extension at hip/knee ankle and foot – look for fixed contractures
Normal arm-swing and balance on turning around

Measurement:
- **True leg length** – From anterior superior iliac spine (ASIS) to medial malleolus, each side should be equal and level.
- **Apparent leg length** – From umbilicus to medial malleolus, each side should be equal and level.

Types of Hip Pain:
Start your exam by determining whether pain is located in the anterior, lateral, or posterior hip. Each area suggests different underlying causes.

**Anterior hip pain:**
Anterior hip pain (which is the most common) usually indicates possible pathology of the hip joint stemming from DJD (degenerative arthritis), hip flexor muscle strains / strains, tendonitis, and Iliopsoas bursitis. The most common diagnosis of patients with hip complaints seen by doctors is osteoarthritis, most often found in patients over age 40.

Iliopsoas bursitis is a less common cause of anterior hip pain, which usually involves inflammation of the bursa found between the iliopsoas muscle and the iliopsoas bursa of the hip. This bursa is adjacent to the femur and works as a shock absorber and lubricant for the movement of the muscles adjacent to it.

Stress fractures typically occur in athletes due to structural demands from training that exceed bone remodeling (also known as fatigue fractures). Stress fractures can also occur in the setting of osteoporosis under normal physical loads (insufficiency fractures).

Labral tears can be the issue in younger athletic patients with unexplained hip joint pain and normal radiographic findings.

**Lateral hip pain:**
Lateral hip pain is usually associated with greater trochanteric pain syndrome, iliotibial band syndrome, or Bernhardt-Roth syndrome (also known as meralgia paresthetica).

**Greater trochanteric pain syndrome** (GTPS) includes greater trochanteric bursitis and gluteus medius issues. Greater trochanteric pain syndrome is also known as trochanteric bursitis, which is inflammation of the trochanteric bursa of the hip. This bursa is adjacent to the femur and works as a shock absorber and lubricant for the movement of the muscles adjacent to it.

Occasionally, this bursa becomes inflamed, painful, and tender. The cause can be rheumatoid arthritis or an injury (often from overuse or twisting motion), but sometimes arises for no obvious cause. The symptoms are pain in the hip region on walking, and tenderness over the upper part of the femur, which may result in the inability to lie on the affected side.
GTPS is most common in older women and often presents as chronic and debilitating pain which does not respond to conservative treatment. Other causes can include uneven leg length, iliotibial band syndrome, and weakness of the hip abductor muscles.

Greater trochanteric pain syndrome is often incorrectly diagnosed for years, due to the same pattern of pain as other musculoskeletal conditions, often having many ineffective treatments. It may be found along with low back pain, arthritis, and obesity issues. X-rays and magnetic resonance imaging may reveal tears or swellings in some cases, but frequently does not reveal any obvious abnormality in patients with greater trochanteric pain syndrome.

Female military service members have a greater incidence (five-fold) of greater trochanteric pain syndrome. Other risk factors include increasing age, enlisted rank groups, and service in the Army, Marines, or Air Force. This may be due to a wider pelvis, altered gait from knee or back pain, or abnormal muscle biomechanics of the gluteal muscles and the iliotibial band in the area of the greater trochanter. In classical ballet, knee and hip problems account for up to 40% of injuries. Many dancers, who appear to be flexible, seem to have tight iliotibial bands that can lead to lower limb problems.

**Iliotibial band syndrome** (ITBS or ITBFS, for iliotibial band friction syndrome) is more common in athletes. It is caused by repetitive movement of the iliotibial band over the greater trochanter, from activities such as running, cycling, hiking or weight-lifting (especially squats). The iliotibial band helps stabilize the knee and is one of the leading causes of lateral knee pain in runners. The continual rubbing over the lateral femoral epicondyle, with flexion and extension of the knee during running can cause the area to become inflamed over time.

TBS symptoms can vary from a stinging sensation above the knee joint or along the entire length of the iliotibial band, to swelling or thickening of the tissue at the point where the band moves over the femur. The pain may or may not occur immediately during activity, but may intensify over time, especially as the foot strikes the ground. Pain can persist after activity. Pain may also be present below the knee to the tibia attachment.

ITBS can also affect the elderly or women during pregnancy (the connective tissues loosen along with weight gain causing additional pressure to the area).

ITBS can result from one or more of the following exercises, anatomical abnormalities (short leg, bowleg issues, foot over-pronation, etc.), or muscular imbalances:

- Running on a banked surface (circular indoor track, slated beach sand) which bends the downhill leg slightly inward and causes extreme stretching of the band against the femur
• Not enough warm-up or cool-down
• Excessive up or down-hill running
• Excessive feet "toed-in" (such as cycling)
• Running stairs up and down
• Hiking long distances
• Rowing

Clinical Note: With proper time given to a careful history review, patients may just be able to recall and report such one-sided or repetitive physical activities which can help lead to proper diagnosis of this hip condition. But for the most part, patients are unaware of such one-sided activities that over time can lead to ITBS and as a result, it is often missed by doctors.

Bernhardt-Roth syndrome is numbness or pain in the outer thigh due to nerve injury of the lateral cutaneous nerve of the thigh, not due to direct injury but other conditions lending to compression of this nerve, occurring more frequently in middle-age patients.

Symptoms of Bernhardt-Roth syndrome include pain, burning sensation, tingling, or numbness on the lateral side of the thigh, occasionally extending to the lateral side of the knee, usually constant in nature. Occasionally, the patient reports aching in the groin area or pain spreading across the buttocks. The patient is more sensitive to light touch than to firm pressure. The patient notes increased sensitivity to heat (“burning the area”) while taking a warm shower.

Posterior hip pain:
Posterior hip pain is the least common pain pattern, and it usually suggests a source outside the hip joint. Posterior pain is typically referred from such disorders of the lumbar spine as degenerative disc disease, facet arthropathy, and spinal stenosis. Posterior hip pain is also caused by disorders of the sacroiliac joint, hip extensor and external rotator muscles, or, rarely, vascular occlusive disease.

Pain of the hip joint origin can be perceived by the patient from the L3 level, usually starting in the middinguinal region (“groin pull”). This pain can spread into the anterior thigh and knee area. Sometimes the patient will feel the knee is at fault, not the hip. If pain has spread into the lateral thigh this suggests possible trochanteric bursitis. Pain in the buttocks spreading into the posterior or lateral thigh is more suggestive of lower spine disorder.
Clinical Note: Often in practice I will have a patient present with middinguinal pain, concerned that he/she has an inguinal hernia or appendix issue. This is often a hip problem and knowledge of clinical anatomy can help rule out these other issues.

Low back problems can mimic hip problems and vice versa, due to their segmental relationship. Of course, low back issues can also have a biomechanical effect on the hip and vice versa as well.
Clinical Note: Patients will comment they have been treated by other doctors for low back or hip issues without help, so I always check out both areas due to the relationship noted above.
Hip Fracture:

Pain on palpation of the Ischial spines and Pubic rami can indicate possible fracture. The following are the two major types of fracture of the hip area:

1. Fracture dislocation with an intact weight-bearing articular surface.
2. Comminuted, displaced fractures of the floor of the acetabulum ("bag of bones").

Additional types of fractures affecting the hip joint need to be ruled out:

Femoral neck fractures are usually seen in the military due to a physical activity that is new, strenuous, and highly repetitive. Contact sports such as football or soccer are usually the cause of most fractures of the hip. Such stress fractures occur in normal bone undergoing repeated submaximal stress, which can lead to stress fractures in the hip area.

Femoral neck fractures are also found in young patients, caused by high-energy trauma. These fractures are often found with a history of multiple injuries and high rates of avascular necrosis and nonunion of bone area in question. Due to the disabling complications of this condition, recognition of a femoral neck fracture requires close attention in their management.

Subtrochanteric fractures are more often found in geriatric patients, usually from minor slips or falls. This can lead to direct lateral hip trauma which is the most frequent mechanism of injury. This age group is also susceptible to metastatic disease that can lead to pathologic fractures. In younger patients, the cause of injury is almost always high-energy trauma, either from direct lateral trauma (such as motor vehicle accident) or from direct axial loading (such as fall from height). Interestingly enough, gunshot wounds cause approximately 10% of high-energy subtrochanteric femur fractures.

These fractures can be verified by X-ray. In hip fractures, look for the affected leg to be shortened and externally rotated. An MRI study has a higher degree of accuracy than a CT study in helping to detect hip fractures. In seniors, hip fractures are the most common form of injury, which in turn can lead to additional physical restrictions.

Clinical Note: The number of people participating in athletic activities is on the rise. These individuals are either highly competitive athletes or weekend sports enthusiasts. Stress fractures of the femoral neck are generally uncommon but can be found in young, active individuals with unaccustomed strenuous activity or major changes in activity (such as long distance running), and elderly individuals with osteoporosis. Elderly individuals may also sustain femoral neck stress fractures; however, hip fractures are much more common and are often devastating injuries.

Clinical Note: Hip fractures account for approximately 3.5 million hospital days in the United States; more hospital days accounted than even tibial, vertebral and pelvic fractures combined. Hip fractures account for more than half of the total hospital admissions of all fractures and more than half of ambulance calls for fractures.
Cardiovascular:
Check for temperature, tenderness, swelling, and femoral pulse in the hip area. Note that a feeble femoral pulse suggests developmental hip disorder known as vascular sign of Narath).

Movement Tests:
Check for ranges of motion (ROM) of the hip joint:
- Internal rotation of hip - knee and hip both flexed at 90 degrees the hip is abducted of motion. Normal ROM is 35°.
- External rotation of hip - knee and hip both flexed at 90 degrees the hip is adducted of motion. Normal ROM is 45°.
- Flexion of hip – knee and hip both flexed at 90 degrees the knee is brought to chest. Normal ROM is 135° of motion.
- Extension of hip - have patient lay on their side. Alignment needs to be assessed by palpation of the ASIS, PSIS and greater trochanter of motion. Normal ROM is 15°.
- Abduction - assessed whilst palpating the contralateral ASIS° with motion. Normal ROM is 45° of motion.
- Adduction - assessed whilst palpating the ipsilateral ASIS with motion. Normal ROM is 45° of motion.

Clinical Note: Always compare both sides with active and passive ranges of motion of the hip joint as well as any deformity present. Be aware of age, physical conditioning (or lack of) and health histories of the patient as these tests are performed. An older person that sits all day at a desk job usually will have more restriction of motion in the hip joint than a dance instructor. A younger person would be expected to have greater range of motion then a geriatric patient in general.

Special Tests:
Assessment for a hidden flexion contracture of the hip - hip flexion contractures may be hidden due to compensation by the back. To rule this out you can perform the following:
1. Place a hand on the posterior lumbar region of back.
2. Get the patient to fully flex the contralateral hip.
3. The hand placed on the lumbar region is used to confirm the back is flexed relative to the anatomic position. In flexion contracture the ipsilateral hip would appear flexed.

Trendelenburg test: This test is performed with the patient standing. The patient is asked to raise one knee; the test is positive if the hip on the raised side drops. A positive test suggests weakness of the abductors of the opposite hip. In chronic low back pain cases, gluteus medius weakness and gluteal muscle tenderness are common symptoms noted. A positive Trendelenburg test is
suggestive of a hip disorder. Loss of power of resisted abduction and the presence of gait deviation on initial evaluation of patients with possible gluteus medius tears increases the likelihood of surgical intervention.

**Ober's test** is used to identify contracture of the iliotibial band. During the test the patient lies on their side with the unaffected leg on the bottom and bent and the affected leg on top and straight. The doctor places a stabilizing hand on the patient's upper iliac crest and then lifts the straight upper leg, extends it at the hip and slowly lowers it behind the bottom leg, allowing it to adduct below and behind the examining table. The test result is positive if the patient can't adduct the leg past the table.

**Thomas test** is used to rule out hip flexion contracture. The patient lies supine on the examination table and brings one knee in to the chest, while the other leg remains extended. Thomas test is said to be positive if the patient cannot keep the opposing leg extended during the test. Please note that hip flexion contracture is physiologic in the first 3 months of life and if it is absent in this period it may be a sign of developmental dysplasia of the hip.

**Allis sign** (known as Galeazzi test), is used in the assessment of congenital dislocation/developmental dysplasia of the hip. It is performed by flexing an infant's knees in the supine position so that the ankles touch the buttocks. If the knees are not level then the test is positive, indicating a potential congenital hip malformation.

**Muscle girth at mid leg and mid-thigh** can be measured, up to ¼ inch larger on the dominant leg is within normal limits.

**Other tests:**

A knee examination should be undertaken in the ipsilateral knee to rule-out knee pathology. Abdomen, rectal, low back and foot areas can be evaluated for possible pathology affecting the hip as well.

**Neurological exam of the hip:**

Examine the patient to rule out possible upper motor neuron lesions. Signs include: General muscle weakness, spasticity, hyperreflexia, primitive reflex signs (grasp, suck and snout reflexes), and Babinski sign. Lower motor neuron lesions are characterized by general weakness, hyporeflexia, muscle hypotonia, atrophy and fasciculations (fine movements of the muscle under the skin).

Note the position of the body that the patient assumes when moving, walking, and sitting on the examination table. Examine the patient for tics, tremors and fasciculations (Note their location and quality). Also note if they are related to any specific body position or emotional state.
Note any paralysis or weakness when a patient assumes an abnormal body position. Usually a central lesion shows greater weakness in the extensors than in the flexors of the upper extremities, but opposite in the lower extremities - greater weakness in the flexors than in the extensors.

Clinical Note: While rare in a chiropractic practice to find such neurological lesions, they are important to be aware of, especially in patients with progressive neurological disease processes.

As you examine the major muscle groups of the hip and leg note the following:
1. Overall appearance of the muscle (wasted, highly developed, or normal)
2. Tone quality of the muscle (flaccid, clonic, or normal)
3. Strength of each muscle group in the hip and leg

Manual muscle testing of hip muscles:
Use the following scale to evaluate major muscle group’s strength:
0 - No muscle contraction is detected.
1 - A trace contraction is noted in the muscle by palpating the muscle while the patient attempts to contract it.
2 - The patient is able to actively move the muscle when gravity is removed.
3 - The patient may move the muscle against gravity but not against resistance from the examiner.
4 - The patient may move the muscle group against some resistance from the examiner.
5 - The patient moves the muscle group and overcomes the resistance of the examiner. This is considered normal muscle strength.

Note – Always repeat each muscle test twice on both sides. Always compare both sides for muscle weakness and symmetry.

Major Muscle Tests of the Hip:
In general, the following nerves control the major muscle groups of lower back and legs:
L2 wraps around the hip.
L3 extends the knee.
L4 pulls the foot up.
L5 moves the toes.
S1 moves the foot down.
S3, 4, 5 supply the bladder, bowel and sex organs, the anal and other pelvic muscles.
To test the flexion of the hip, have the patient supine and raise each leg separately while the examiner resists. This tests the iliopsoas.
Nerve Root Tested - Hip flexion is innervated by the L2 and L3 nerve roots via the femoral nerve.

Test the adduction of the legs by placing your hands on the inner thighs of the patient and asking them to squeeze both legs together. This tests the adductors of the medial thigh.

Nerve Root Tested - Adduction of the hip is mediated by the L2, L3 and L4 nerve roots. Test the abduction of the legs by placing your hands on the outer thighs and asking the patient to push their legs apart. This tests the gluteus maximus and gluteus minimus.

Nerve Root Tested - Abduction of the hip is mediated by the L4, L5 and S1 nerve roots. Next, test the extension of the hip by instructing the patient to press down on the examiner's hand which is placed underneath the patient's thigh. Repeat and compare to the other leg. This tests the gluteus maximus.

Nerve Root Tested - Hip extension is innervated by the L4 and L5 nerve roots via the gluteal nerve.

Test extension at the knee by placing one hand under the knee and the other on top of the lower leg to provide resistance. Ask the patient to extend the lower leg at the knee. This tests the quadriceps.

Nerve Root Tested - Knee extension by the quadriceps muscle is innervated by the L3 and L4 nerve roots via the femoral nerve.

Test flexion at the knee by holding the knee from the side and applying resistance under the ankle and instructing the patient to pull the lower leg towards their buttock as hard as possible. This tests the hamstrings.

The hamstrings are innervated by the L5 and S1 nerve roots via the sciatic nerve.

Test dorsiflexion of the ankle by holding the top of the ankle and have the patient pull their foot up towards their face (“toes to your nose”) as hard as possible as you push down. This tests the anterior muscles of the lower leg.

Ankle dorsiflexion is innervated by the L4 / L5 nerve roots via the peroneal nerve.

While holding the bottom of the foot, ask the patient to "press down to the floor" as hard as possible. Repeat with the other foot and compare. This tests both the gastrocnemius and soleus.

Ankle plantar flexion is innervated by the S1/ S2 nerve roots via the tibial nerve.
Ask the patient to move the large toe against the examiner's resistance "up towards the patient's face". The extensor hallucis longus muscle is almost completely innervated by the L5 nerve root via the extensor hallucis longus.

Clinical Note: Another way of testing L4 / L 5 and S1 / S 2 nerve roots is to have the patient walk on their heels (L4 / L 5) then toes (S1 / S2) while standing.

Clinical Note: Most patients tend to test at the 4 and 5 number range on this scale; in my experience you will find a correlation between major muscle group muscle weakness and associated motor nerve involvement. This in turn will often correlate with the patient’s current complaints.

Sensory dermatomes of the lower back / Hip:
A dermatome is defined as a patch of skin that is innervated by a given spinal cord level. After an injury, the dermatomes can expand or contract, depending on plasticity of the spinal cord.

For the Lumbar plexus, T12/L1 - L4 nerves innervate the dermatome of the thigh area.
For the sacral plexus, L4 - S4 nerves innervate the dermatome of the leg and foot area.
To test for nerve root damage, the corresponding dermatomes supplied by that nerve root may be tested for abnormal sensation. To test a dermatome, you can use a pinwheel, cotton ball, paper clip, or even a pin. The patient should be asked to provide feedback regarding their response according to the stimuli.

Scale of responses to abnormal sensation:

Hyperesthesia - excessive sensation
Hypoesthesia - decreased sensation
Anesthesia - loss of sensation
Parasthesia - numbness, tingling, burning sensation

The doctor can assess which dermatomes have abnormal sensation:

L1 to L5. The cutaneous dermatome of the hip girdle and groin area is innervated by L1 spinal cord, L2 and 3 cover the front part of the upper legs, and L4 and L5 cover medial and lateral sides of the lower leg.

S1 to S5. S1 covers the heel and the middle part of the leg. S2 covers the posterior thighs. S3 covers the medial side of the buttocks. S4-5 covers the perineal region. S5 dermatome covers the skin immediately at and adjacent to the anus.

Spinal Cord Injuries:
Direct injury to the spinal cord can be most devastating to the patient, often needing increase management and referral among different health professionals. Evaluation, documentation, and report writing need to communicate clearly among all parties involved.
In report writing, please note the difference between neurological and rehabilitation definitions of spinal cord injury levels. Given the same neurological examination and findings, different health professionals will assign different spinal cord injury level. In general, neurologists define the level of injury as the first spinal segmental level that shows abnormal neurological loss. In contrast, other health professionals will define level of injury as the lowest spinal segmental level that is normal. Most orthopedic surgeons tend to use the bony level of injury as the level of injury.

Clinical Note: In your exam notes and report writing, it is best to write out the lowest level of normal findings followed by injury level and observed abnormal findings to avoid confusion.

Cauda Equina Injuries:
Injuries to the spinal column at L2 or lower will often damage the tip of the spinal cord (conus) or the descending spinal roots that exit the spinal canal to the caudal equina. Any injuries to this area can effect these roots (both sensory and motor fibers) leading from these segments.

The spinal roots are part of the peripheral nervous system (as opposed to the spinal cord). Peripheral nerves are known to be able to regenerate to some extent as compared to the spinal cord. However, a spinal root injury damages the central branch of the sensory nerve whereas a peripheral nerve injury damages the peripheral branch. Because of this fact, it is more difficult for the body to repair damaged nerve roots in a cauda equina injury than in a peripheral nerve injury.

Trigger points
Often used by chiropractors, trigger points (trigger sites) are described as hyperirritable spots in skeletal muscle that have palpable nodules in taut bands (“knots”) of muscle fibers. This usually is a common source of pain to the patient. Direct compression of a trigger point can elicit local tenderness, referred pain, or local twitch response (no muscle contraction).

The following characteristics are found in trigger points:
- Pain is tied to an irritable focal point in skeletal muscle or fascia, not caused by trauma, inflammation, degeneration, neoplasm or infection.
- This painful point is felt as a band in the muscle, and a local twitch response can be elicited on stimulation of the trigger point.
- Palpation of the trigger point reproduces the patient's complaint of pain, and the pain radiates in a distribution typical of the specific muscle harboring the trigger point.
- Findings on neurological examination cannot explain the patient’s pain complaints.

Myofascial pain syndrome:
Myofascial (muscle and fascia) pain syndrome is a focal hyperirritability in muscle that can strongly modulate central nervous system functions. Fibromyalgia is widespread pain and deep tissue and muscle tenderness. In the majority of cases, myofascial pain is a primary cause of
regional pain. Myofascial pain is muscle tenderness that arises from hyper sensitive trigger or focal points, found at multiple sites in a muscle and the fascia of muscle tissue.

**Qualities of trigger points:**

Trigger points have a number of qualities - potential, active, latent, and also as key/satellites (either primary or secondary). Trigger point maps can be made that are relative accurate for that patient’s complaints.

*Active trigger point* is one that refers pain either locally or to another location (usually in the body along nerve pathways). *Latent trigger point* is one that exists but does not refer pain until pressure or strain is applied to the myoskeletal structure containing the trigger point. Latent trigger points can influence muscle activation patterns, resulting in poor muscle coordination and balance. Active and latent trigger points are also known as "Yipe" or “ouch” points, when found they provoke such sounds from the patient.

*Key trigger point* is a pain referral pattern along a nerve pathway that either creates or activates a latent trigger point on the pathway. *Satellite trigger point* is one which is activated by a key trigger point. Successful treatment of a key trigger point will often affect the satellite trigger point, resolving it or changing it from active to latent.

*Primary trigger point* - These can cause activation of a secondary trigger point in another structure. Treating such a primary trigger point does not affect the secondary trigger point. Activation of such trigger points can be caused by a number of factors such as muscle overload, activation by other trigger points (key/satellite, primary/secondary), disease, psychological stress, direct trauma to the area, accident trauma (i.e. - car accident which over stresses many muscles and causes instant trigger points), radiculopathy, infections and such health issues as smoking.

*Clinical note: I have found a strong correlation between extended periods of sitting posture combinde with mouse / keyboard computer use and trigger points found in the hip and back areas. This is often due to a combination of poor body posture, muscle fatigue and bad ergonomic setup, leading to a creation of trigger points, in my opinion.*

Trigger points form only in muscles, found as a local contraction in a small number of muscle fibers in a larger muscle or muscle bundle. This in turn can pull on such tendons and ligaments associated with the muscle, causing pain deep within a joint, even where there are no muscles. When such muscle fibers contract, they use up the biochemical energy, which can become fatigue over time, resulting in a build-up of toxins such as lactic acid. In addition, such tightened muscle fibers end up constricting capillaries and prevent them from carrying off the fatigue toxins to the body's organ systems to be recycled. This buildup of toxins in a muscle bundle or muscle feels like a tight muscle or band.
When trigger points are present in muscles, pain and weakness are often present in the associated structures. These pain patterns in muscles follow specific nerve pathways and have been mapped. This allows for identification of the causative pain factor. Many trigger points have pain patterns that do overlap, and some create reciprocal cyclic relationships that need to be treated to resolve them.

**Diagnosis of trigger points:**

When there is a taut band in muscles and a hard nodule can be felt, a trigger point can be identified. A twitch response upon **goad** (finger running back and forth perpendicular to the muscle's direction) will often activate the "all or nothing" response in a muscle that causes it to contract. Pressing same point on an affected muscle can often refer pain. Clusters of trigger points are not uncommon in some of the larger muscles, such as the gluteus group. **Heat differential** in the local area of a trigger point is usually present, which can be felt or imaged, which can also aid in the diagnosis of a trigger point.

Referred pain from trigger points can often mimic the symptoms of a long list of common patient complaints, but health professionals rarely consider a myofascial cause. Most of the common everyday pain can be caused by myofascial trigger points and that failure to diagnose can lead to ineffective treatment and patient frustration.

**Additional Hip Tests:**

Usually a thorough history taking and physical examination will help diagnose many hip conditions. However, when additional medical information is needed or pathology needs to be ruled out, specialized tests can be performed. These additional tests may include X – Ray studies, Computerized tomography (CT), Magnetic resonance imaging (MRI), Sensory evoked potentials (SEPs), and Electromyography (EMG).

**Arthrography** is often used to help diagnose unexplained joint pain. A contrast iodine solution is injected into the joint area to outline the joint structures, such as the ligaments, cartilage, tendons and joint capsule. Several X-rays of the joint are then taken in different positions, using a fluoroscope, to analyze the joint structural integrity.

**Laboratory studies** of blood, urine or joint (synovial) fluids are used to identify the presence and amount of substances which can rule in or rule out red flags such as infection or tumor. For example, a high amount of uric acid in the blood can indicate gout. High white blood cell count in joint fluid may indicate severe inflammation or infection.

**Bone Scans** can rule out various bone disorders. One type tests the density of the bone and is used to help diagnose osteoporosis. The second type of bone scan is used to identify areas where there is abnormal bone formation, usually due to stress fractures, arthritis, infection, or cancer.

**CT scan** (computed tomography) is an X-ray combined with computer technology to produce a more detailed, cross-sectional image of your body. CT scan is useful to rule out tumor or a
fracture that is not visible on plain film X-rays or if history of severe trauma to the abdomen, pelvis or spinal cord has occurred.

**Dual-energy X-ray absorptiometry** (DEXA) is the most widely used test for measuring bone density. It can monitor changes in bone density in patients with osteoporosis who are undergoing treatments. This test takes a picture of the bones in the spine, hip, total body and wrist and calculates their density. Your bone density and risk of fracture are compared to the "normal" range for people your age as well as to the **maximum bone density possible**.

**MRI** (magnetic resonance image) - MRI can be used to help diagnose the integrity of the muscles, ligaments and cartilage, herniated disks, and to rule out major pathology.

*Clinical Note: MRI is usually diagnostic if plain x-rays and conservative therapy prove to be ineffective.*

**Electromyography (EMG)** (also known as nerve conduction studies) can be useful to separate motor unit problems. An electromyograph detects the electrical potential generated by muscle cells when these cells are stimulated electrically or neurologically. The signals can be analyzed to detect certain medical abnormalities such as **neuropathic or myopathic diseases** and to assess tissue insult or nerve impairment.

**Neuropathic disease** has the EMG findings of abnormal action potential amplitude due to reinnervation of denervated fibres. The action potential amplitude is twice normal due to the increased number of fibres per motor unit. An increase in duration of the action potential along with a decrease in the number of motor units in the muscle is also found.

**Myopathic disease** has a decrease in duration of the action potential, a reduction in the area to amplitude ratio of the action potential and a decrease in the number of motor units in the muscle (found in extremely severe cases only).

*Clinical Note: This type of testing (EMG) is helpful to identify local neurological dysfunction in patients with low back symptoms lasting more than three to four weeks.*

Of course, because of the individuality of each patient and disease, some of these characteristics may not appear in every case. Abnormal results may be caused by certain medical conditions as well as improper testing.
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