Bibliography

Adams MA, McMillan DW, Green TP, Dolan P
Sustained loading generates stress concentrations in lumbar intervertebral discs.

Adams MA, Freeman BJ, Morrison HP, et al.
Mechanical Initiation of Intervertebral Disc Degeneration.

Anderson FC, Pandy MG
Individual muscle contributions to support in normal walking.

Aure OF, Nilsen JH, Vasseljen O
Manual therapy and exercise therapy in patients with chronic low back pain: a randomized, controlled trial with 1-year follow-up.

Beneck GJ, Kulig K
Multifidus atrophy is localized and bilateral in active persons with chronic unilateral low back pain


Boden SD, Davis DO, Dina TS, et al.
Abnormal Magnetic Resonance Scans of the Lumbar Spine in Asymptomatic Subjects: A Prospective Investigation.

Bousema EJ, Verbunt JA, Seelen HA, Vlaeyen JW, Knottnerus JA.
Disuse and physical deconditioning in the first year after the onset of back pain.

Bullock-Saxton JE, Janda V, Bullock MI
The Influence of Ankle Sprain Injury on Muscle Activation During Hip Extension,

Carnes D, Parsons S, Ashby D, Breen A, Foster NE, Pincus T, Vogel S, Underwood M
Chronic musculoskeletal pain rarely presents in a single body site: results from a UK population study.

Caragee EJ
Is Lumbar Discography a Determinate of Discogenic Low Back Pain: Provocative Discography Reconsidered.
Carragee EJ, Chen Y, Tanner CM, Truong T, Lau E, Brito JL.  
Provocative discography in patients after limited lumbar discectomy: A controlled, randomized study of pain response in symptomatic and asymptomatic subjects.  

Carragee EJ, Paragioudakis SJ, Khurana S.  
2000 Volvo Award winner in clinical studies: Lumbar high-intensity zone and discography in subjects without low back problems.  

Carragee E  
Surgical treatment of lumbar disk disorders.  

Centeno CJ, Elkins WL, Freeman M  
Waddell's signs revisited?  

Croft PR, Macfarlane GJ, Papageorgiou AC, Thomas E, Silman AJ,  
Outcome of low back pain in general practice: a prospective study.  

Damen L, Spoor CW, Snijders CJ, Stam HJ  
Does a pelvic belt influence sacroiliac joint laxity?  

Dangaria TR, Naesh O  
Changes in cross-sectional area of psoas major muscle in unilateral sciatica caused by disc herniation.  

Day CS, Ahn CS, Yeh AC, Tabrizi S  
Early assessment of a new integrated preclinical musculoskeletal curriculum at a medical school.  

Deyo R, Rainville J, Kent D  
What Can the History and Physical Exam Tell Us About Low Back Pain?  

Deyo RA, Weinstein JN.  
Low Back Pain,  

Deyo RA  
Diagnostic evaluation of LBP: reaching a specific diagnosis is often impossible.  
*Arch Intern Med* 2002 Jul 8; 162(13):1444-7; discussion 1447-8.

Ferreira PH, Ferreira ML, Hodges PW  
Changes in Recruitment of the Abdominal Muscles in People with Low Back Pain  
Session 110 Low Back Pain: Thinking Outside the Disc

Fishbain DA, Cole B, Cutler RB, Lewis J, Rosomoff HL, Rosomoff RS
A structured evidence-based review on the meaning of nonorganic physical signs: Waddell signs. 

Flicker PL, et. al.,
Lumbar Muscle Usage in Chronic Low Back Pain: Magnetic resonance Image Evaluation
Spine, Volume 18, Number 3, pp 582-586, 1993

Fredericson M, Cookingham CL, Chaudhari AM, Dowdell BC, Oestreicher N, Sahrmann SA
Hip abductor weakness in distance runners with iliotibial band syndrome.

Freedman KB, Bernstein J
Educational Deficiencies in Musculoskeletal Medicine

Freeman MD, Woodham MA, Woodham AW
The role of the lumbar multifidus in chronic low back pain: a review.
PM R 2010 Feb; 2(2):142-6; quiz 1 p following 167.

Gooyers CE, McMillan RD, … Callaghan JP
The impact of posture and prolonged cyclic compressive loading on vertebral joint mechanics.

Gore M, Sadosky A, et. al.
The burden of chronic low back pain: clinical comorbidities, treatment patterns, and health care costs in usual care settings.

Graves JM, Fulton-Kehoe D, … Franklin GM


Greenman, PE
Syndromes of the Lumbar Spine, Pelvis, and Sacrum

Greenman PE
Clinical aspects of sacroiliac function in walking.

Greenman PE
Innominate shear dysfunction in the sacroiliac syndrome,
Manual Medicine (1986) 2: 114-121
Session 110 Low Back Pain: Thinking Outside the Disc

Hadler NM, Curtis P, Gillings DB, Stinnett S
A benefit of spinal manipulation as adjunctive therapy for acute low-back pain: a stratified controlled trial.

Hagen KB, Hilde G, Jamtvedt G, Winnem MF
The Cochrane review of advice to stay active as a single treatment for low back pain and sciatica

Hagen EM, Svensen E, Eriksen HR, Ihlebaek CM, Ursin H
Comorbid subjective health complaints in low back pain
*Spine* 2006 Jun 1; 31(13):1491-5.

Hides JA, Richardson CA, Jull GA.
Multifidus muscle recovery is not automatic after resolution of acute low back pain,

Hides JA, Stokes MJ, Saide M, Jull GA, Cooper DH.
Evidence of lumbar multifidus muscle wasting ipsilateral to symptoms in patients with acute/subacute low back pain,

Hides J, Gilmore C, Stanton W, Bohlscheid E
Multifidus size and symmetry among chronic LBP and healthy asymptomatic subjects.

Hides J, Stanton W, Mendis MD, Sexton M
The relationship of transversus abdominis and lumbar multifidus clinical muscle tests in patients with chronic low back pain.

Hodges PW, Cresswell AG, Daggfeldt K, Thorstensson A
In vivo measurement of the effect of intra-abdominal pressure on the human spine.

Hodges PW, Eriksson AE, Shirley D, Gandevia SC
Intra-abdominal pressure increases stiffness of the lumbar spine
*J Biomech* 2005 Sep; 38(9):1873-80.

Hodges PW, Mosely GL, Gabrielson AH et al.
Acute experimental pain changes postural recruitment of the trunk muscles in pain free humans,

Hodges PW, Richardson CA.
Ineffcient muscular stabilization of the lumbar spine associated with low back pain. A motor control evaluation of transversus abdominis.
*Spine* 1996, 21 (22):2640
Hodges PW, Richardson CA. 
Delayed Postural Contraction of Transversus Abdominis in Low Back Pain Associated with Movement of the Lower Limb. 

Hodges PW, Moseley GL, Gabrielsson A, Gandevia SC 
Experimental muscle pain changes feed forward postural responses of the trunk muscles. 

Hodges P, Holm AK, Hansson T, Holm S 
Rapid atrophy of the lumbar multifidus follows experimental disc or nerve root injury. 
*Spine* 2006 Dec 1; 31(25):2926-33.

Hodges P, Kaigle Holm A, Holm S, Ekström L, Cresswell A, Hansson T, Thorstensson A 
Intervertebral stiffness of the spine is increased by evoked contraction of transversus abdominis and the diaphragm: in vivo porcine studies. 

Hoehler FK, Tobis JS, Buerger AA, 
Spinal Manipulation for Low Back Pain. 

Holt Earl P Jr. 
The Question of Lumbar Discography. 

Hossain M, Nokes LD 
A model of dynamic sacro-iliac joint instability from malrecruitment of gluteus maximus and biceps femoris muscles resulting in low back pain. 

Hungerford B, Gilleard W, Hodges P, 


Jacob HA, Kissling RO 
The mobility of the sacroiliac joints in healthy volunteers between 20 and 50 years of age. 

Janda V 
Motor Learning Impairment and Back Pain. 

Janda V 
Jarvik JG, Deyo RA
Diagnostic evaluation of low back pain with emphasis on imaging

Jensen M, Brant-Zawadzki M, et al.
Magnetic Resonance Imaging of the Lumbar Spine in People Without Back Pain,

Kamaleri Y, Natvig B, Ihlebaek CM, Bruusgaard D
Localized or widespread musculoskeletal pain: does it matter?

Kharrazi FD, Rodgers WB, Kennedy JG, Lhowe DW
Parturition-induced pelvic dislocation: a report of four cases.

Keeney BJ, Turner JA, … Franklin GM

Kidd R
Pain localization with the innominate upslip dysfunction

Laasonen EM
Atrophy of sacrospinal muscle groups in patients with chronic, diffusely radiating lumbar back pain.

Leboeuf-Yde C
Body weight and low back pain. A systematic literature review of 56 journal articles reporting on 65 epidemiologic studies.

Lee D, *Instability of the sacroiliac joint and the consequences for gait*.

MacDonald DA, Moseley GL, Hodges PW
The lumbar multifidus: does the evidence support clinical beliefs?

Machado LA, de Souza MS, Ferreira PH, Ferreira ML

Main CJ, Waddell G,
Spine Update: Behavioral Responses to Examination: A Reappraisal of the Interpretation of Nonorganic Signs.
*Spine* 1998; Vol. 23, No. 21, p. 2367-2371
Marras WS, Davis KG, Ferguson SA, Lucas BR, Gupta P
Spine Loading Characteristics of Patients With Low Back Pain Compared With Asymptomatic Individuals,

A forty-year follow-up of the Dallas Bed Rest and Training study: the effect of age on the cardiovascular response to exercise in men

Mehling WE, Gopisetty V, … Avins AL

Mens JM, Vleeming A, Snijders CJ, Stam HJ, Ginai AZ
The active straight leg raising test and mobility of the pelvic joints


Mens JM, Vleeming A, Snijders CJ, Koes BW, Stam HJ
Reliability and validity of the active straight leg raise test in posterior pelvic pain since pregnancy.

Mens JM, Vleeming A, Snijders CJ, Koes BW, Stam HJ
Validity of the active straight leg raise test for measuring disease severity in patients with posterior pelvic pain after pregnancy.

Mens JM, Vleeming A, Snijders CJ, Stam HJ, Ginai AZ
The active straight leg raising test and mobility of the pelvic joints.

Meyers T W. Anatomy Trains: Myofascial Meridians for Manual and Movement Therapists,

Missiuro W, Kozlowski S:
Investigations on adaptive changes in reciprocal innervation of muscle.

Mixter WJ, Barr JS
Rupture of the intervertebral disc with involvement of the spinal canal.
Mohamed MA; Webster BS; et al.
Clinical Management and the Duration of Disability for Work-Related Low Back Pain.

Mok NW, Brauer SG, Hodges PW
Hip strategy for balance control in quiet standing is reduced in people with low back pain


Niemistö L, Lahtinen-Suopanki T, Rissanen P, Lindgren KA, Sarna S, Hurri H
A randomized trial of combined manipulation, stabilizing exercises, and physician consultation compared to physician consultation alone for chronic low back pain.

O’Sullivan PB, Beales D, Beetham JA, Cripps J, et al.
Altered Motor Control Strategies in Subjects With Sacroiliac Joint Pain During Active Straight-Leg-Raise Test

O’Sullivan PB, Twomey L, Allison G.
Dysfunction of the Neuro-Muscular System in the Presence of Low Back Pain – Implications for Physical Therapy Management

Pel JJ, Spoor CW, Pool-Goudzwaard AL, Hoek van Dijke GA, Snijders CJ Biomechanical analysis of reducing sacroiliac joint shear load by optimization of pelvic muscle and ligament forces.


Session 110 Low Back Pain: Thinking Outside the Disc

Radebold A, Cholewicki J, Panjabi M, Patel T.
Muscle Response Pattern to Sudden Trunk Loading in Healthy Individuals and in Patients with Chronic Low Back Pain.
*Spine, Volume 25, Number 8, pp 947-954, 2000.*

The lumbar multifidus muscle five years after surgery for a lumbar intervertebral disc herniation.


Richardson CA, Snijders CJ, Hides JA, et al.
The Relation Between the Transversus Abdominis Muscles, Sacroiliac Joint Mechanics and Low Back Pain,

Richardson CA, Snijders CJ, Hides JA, Damen L, Pas MS, Storm J
The relation between the transversus abdominis muscles, sacroiliac joint mechanics, and low back pain.

Rosomoff HL, Fishbain D, Goldberg M, et al
Myofascial findings in patients with "chronic intractable benign pain" of the back and neck.

Shaw WS, Tveito TH, Woiszwillo MJ, Pransky G
The effect of body mass index on recovery and return to work after onset of work-related low back pain.

Sherrington CS. 1907.
On reciprocal innervation of antagonistic muscles.
*Proc R Soc Lond [Biol]* 79B:337.

Siegel J, Templeman DC, Tornetta P.
Single-Leg-Stance Radiographs in the Diagnosis of Pelvic Instability

C.J. Snijders, PhD, A. Vleeming, PhD, R. Stoeckart, PhD
Transfer of lumbosacral load to iliac bones and legs: Part 1: Biomechanics of self-bracing of the sacroiliac joints and its significance for treatment and exercise
*Clinical Biomechanics Volume 8, Issue 6, November 1993, Pages 285–294*

Snijders CJ, Vleeming A, Stoeckart R, Mens J, Kleinrensink G
Biomechanical Modeling of Sacroiliac Joint Stability in Different Postures
*Spine: State of the Art Reviews, Vol. 9, No.2, May 1995*
Snijders CJ, Hermans PF, Niesing R, Spoor CW, Stoeckart R
The influence of slouching and lumbar support on iliolumbar ligaments, intervertebral discs and sacroiliac joints

Souza RB, Draper CE, Fredericson M, Powers CM
Femur rotation and patellofemoral joint kinematics: a weight-bearing magnetic resonance imaging analysis.

Stadnik TW, Lee RR, Coen HL, Neirynck EC, Buisscret TS, Osteaux MJC.
Annular tears and disk herniation: Prevalence and contrast enhancement on MR images in the absence of low back pain or sciatica.

Sturesson B, Selvik G, Udén A
Movements of the sacroiliac joints. A roentgen stereophotogrammetric analysis.

Takasaki H, Iizawa T, Hall T, Nakamura T, Kaneko S
The influence of increasing sacroiliac joint force closure on the hip and lumbar spine extensor muscle firing pattern.


Tsao H, Hodges PW
Immediate changes in feedforward postural adjustments following voluntary motor training.

On the course of low back pain in general practice: a one year follow-up study,

van Wingerden JP, Vleeming A, Buyruk HM, Raissadat K
Stabilization of the sacroiliac joint in vivo: verification of muscular contribution to force closure of the pelvis.
*Eur Spine J* 2004 May; 13(3):199-205.

van Wingerden JP, Vleeming A, Snijders CJ, Stoeckart R
A functional-anatomical approach to the spine-pelvis mechanism: interaction between the biceps femoris muscle and the sacrotuberous ligament.

van Wingerden JP, Vleeming A, Buyruk HM, Raissadat K
Stabilization of the sacroiliac joint in vivo: verification of muscular contribution to force closure of the pelvis.
*Eur Spine J* 2004 May; 13(3):199-205.
Session 110 Low Back Pain: Thinking Outside the Disc

Vergheze A
Culture shock--patient as icon, icon as patient.

Videman T, Battie MC, Gill K, Manninen H, Gibons LE, Fisher LD.
Magnetic Resonance Imaging Findings and Their Relationships in the Thoracic and Lumbar
Spine: Insights Into the Etiopathogenesis of Spinal Degeneration,
_Spine, Volume 20, Number 8, pp 928-935, 1995._


Vleeming A, Pool-Goudzwaard AL, Hammudoglu D, Stoeckart R, Snijders CJ, Mens JM
The function of the long dorsal sacroiliac ligament: its implication for understanding low back pain.

Von Korff M, Deyo RA, Cherkin D, Barlow W.
Back Pain in Primary Care: Outcomes at 1 Year,
_Spine, Volume 18, Number 7, pp 855-862, 1993_.

Von Korff M, Saunders K,
The Course of Back Pain in Primary Care,
_Spine, Vol. 21, Number 24, pp.2833-2839, 1996._

Waddell G, McCulloch JA, Kummel E, Venner RM
Nonorganic physical signs in low-back pain.

Wallwork TL, Stanton WR, Freke M, Hides JA
The effect of chronic low back pain on size and contraction of the lumbar multifidus muscle.
_Man Ther 2009 Oct; 14(5):496-500._

Architectural analysis and intraoperative measurements demonstrate the unique design of the
multifidus muscle for lumbar spine stability

Wedderkopp Neils,
Preventing back pain: Advice to stay active may not be appropriate for people in manual jobs.
_BMJ, 2008;336:398_.

Weishaupt D, Zanetti M, Hodler J, Boos N.
MR imaging of the lumbar spine: prevalence of intervertebral disk extrusion and sequestration,
nerve root compression, end plate abnormalities, and osteoarthritis of the facet joints in
asymptomatic volunteers.
_Radiology 1998; 209:661-666._

Wiesel S, Tsourmas N, et al.
A Study of Computer-Assisted Tomography: The Incidence of Positive CAT Scans in an
Asymptomatic Group of Patients,
_Spine, Vol. 9, Number 6, p. 549-551, September 1984._
Wu WH, Meijer OG, Uegaki K, Mens JM, van Dieën JH, Wuisman PI, Ostgaard HC
## Low Back Pain Examination

<table>
<thead>
<tr>
<th>Examination</th>
<th>Normal/ Abnormal</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standing Examination</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Observe Gait</strong></td>
<td>Normal gait, equal arm swing. <em>Abnormal gait.</em></td>
<td>A leg length inequality may cause a posting gait, with greater arm swing on the side of the short leg. SI joint dysfunction may restrict normal hip swing. Patient may be unwilling to weight bear on side of severe dysfunction.</td>
</tr>
<tr>
<td>Observe patient walking back and forth several times in the exam room or hallway.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Observe Posture</strong></td>
<td>Normal upright posture. <em>Scoliosis, increased or decreased lumbar lordosis or thoracic kyphosis. Fallen arches.</em></td>
<td>Forward flexed posture may be due to a posteriorly nutated sacral base, FRS dysfunctions, tight hip flexors, stenosis or a combination of the above. Scoliosis may be secondary to a leg length inequality. Fallen arches may be a perpetuating factor in low back pain.</td>
</tr>
<tr>
<td>Observe from front, behind and from the side. Observe feet for fallen arches and/or bowing of the Achilles tendon.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Examine Iliac Crest Height</strong></td>
<td>Iliac crests should be absolutely level. <em>Iliac crests not level.</em></td>
<td>If one iliac crest is higher than the other, suspect leg length inequality, symphysis pubis dysfunction, innominate rotation, pelvic subluxation, or a small hemi-pelvis.</td>
</tr>
<tr>
<td>Bring hands in from the side above the waist and press downward until you contact the iliac crest.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Standing Flexion Test</strong></td>
<td>Thumbs move upward in tandem. <em>One thumb moves upward before the other.</em></td>
<td>The thumb that moves upward first indicates the side of abnormal SI joint motion. False positives may be due to hamstring muscle tightness on the opposite side. False negatives are common.</td>
</tr>
<tr>
<td>From behind, examiner places right thumb over right PSIS and left thumb over left PSIS and asks patient to slowly bend forward.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Standing Examination (cont.)

<table>
<thead>
<tr>
<th>Examination How to Perform</th>
<th>Normal/ Abnormal</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stork Test (Gillet Test)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place one thumb in the midline over the sacrum at the level of the PSIS, and the other over the PSIS on one side. Instruct the patient to lift their knee on the tested side “like they are marching”.</td>
<td>The thumb on the PSIS should move downward with hip flexion. <em>Thumb on PSIS moves upward during hip flexion on side of dysfunction.</em></td>
<td>If the thumb on the PSIS stays level or moves upward during hip flexion, it indicates abnormal SI joint motion on that side. False negatives are common. The patient may have difficulty balancing on side of dysfunctional joint.</td>
</tr>
</tbody>
</table>
### Seated Examination
(from behind, patient seated on stool)

<table>
<thead>
<tr>
<th>Examination</th>
<th>Normal/Abnormal</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seated Flexion Test</strong></td>
<td>Thumbs move upward in tandem. <em>One thumb moves upward before the other.</em></td>
<td>Similar to standing flexion test. The thumb that moves upward first indicates abnormal SI joint motion on that side. Seated position removes potential influence of a unilaterally tight hamstring.</td>
</tr>
<tr>
<td>Place right thumb over right PSIS, left thumb over left PSIS, and ask patient to slowly bend forward.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sacral Position in Flexion</strong></td>
<td>Thumbs should be absolutely level at both locations. <em>Thumbs not level at either location.</em></td>
<td>Any deviation from absolutely level indicates a sacral malposition. Anterior sacral torsions will appear rotated to the right or left in flexion. Nutations will appear “warped”. Posterior sacral torsions will appear level in flexion.</td>
</tr>
<tr>
<td>Place thumbs on each side of the sacral base (between the right and left PSIS) and then on each side of the inferior lateral angles (lower corners) of the sacrum. Assess the relative depth of each thumb at the sacral base and inferior lateral angle.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Spinal Alignment in Flexion</strong></td>
<td>The entire spine should be aligned with the sacral base. <em>Small right or left rotational changes (approximately 10 degrees) in the orientation of the transverse processes.</em></td>
<td>Any alteration in alignment indicates an ERS dysfunction at that vertebral level. The inferior facet joint on the side of the more anterior transverse process does not open normally at that level during flexion.</td>
</tr>
<tr>
<td>Using both thumbs, assess the relative depth of the transverse processes at each lumbar and thoracic vertebrae. Observe for rotational deviation from the sacral base to L5, and between vertebral levels.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Multifidus Muscle</strong></td>
<td>Firm, equal muscle mass along both sides of the spinous processes. <em>Focal areas of muscle atrophy, may feel like soft depressions in the muscle, “no meat on the bone”.</em></td>
<td>Segmental atrophy of multifidus muscle is common, and can be a risk factor for recurrent back pain if untreated.</td>
</tr>
</tbody>
</table>
### Seated Examination
(from the front, patient seated on exam table)

<table>
<thead>
<tr>
<th>Examination</th>
<th>How to Perform</th>
<th>Normal/ Abnormal</th>
<th>Significance</th>
</tr>
</thead>
</table>
| Deep Tendon Reflexes | Use reflex hammer to test reflexes at knees (L4) and ankles (S1). | Symmetrical reflexes. 
*Reflexes not symmetrical from side to side.* | A unilaterally decreased deep tendon reflex at the knee indicates impairment of the L4 nerve; asymmetry at the ankle indicates an impairment of the S1 nerve. |
| Babinski Test      | Stroke the lateral aspect of the sole from the heel to the ball of the foot with sharp object. | Flexion of toes. 
*Dorsiflexion of great toe and fanning of the other toes* | Abnormal Babinski response indicates upper motor neuron disease. |
| Sensory Exam       | Examine autonomous sensory zones for light touch: 
Lateral foot and lower ½ of lateral calf(S1) 
Second toe and upper ½ of lateral calf (L5) 
Knee and supra-patellar region (L4) 
Anterior mid thigh (L3) | Normal sensation 
*Alteration in sensation.* | Altered sensation suggests impairment of nerve function at the corresponding level. |
| Motor Testing      | Ask patient to: 
Plantar flex ankle (S1) or stand on toes 
Dorsiflex ankle (L5) or stand on heels 
Extend great toe (L5) 
Extend knee (L2, L3, L4) or squat and rise 
Flex knee (S1, S2) 
Flex hip (L1) | Symmetrical strength 
*Unilateral or bilateral weakness* | Weakness suggests impairment of nerve function at corresponding level. Pain inhibition may simulate weakness. |
| Measure for Atrophy | Measure the circumference of calf at its widest part, measure circumference of thigh 10 cm above superior pole of patella. | Circumference should be roughly equal from right to left. 
*Difference in circumference of more than 2 cm is significant.* | Atrophy of the calf muscle suggests denervation of the S1 nerve; atrophy of the thigh suggests denervation of the L4 nerve. |
### Supine Examination

<table>
<thead>
<tr>
<th>Examination How to Perform</th>
<th>Normal/Abnormal</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Actual Leg Length</strong></td>
<td>Legs should measure the same length. Legs of different measured length.</td>
<td>A leg length difference of greater than 4 mm is considered significant and should be treated with a trial of lift therapy.</td>
</tr>
<tr>
<td>Use a tape measure to measure from the ASIS to the medial malleolus</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Apparent Leg Length</strong></td>
<td>Legs should appear the same length. Legs appear different lengths.</td>
<td>Causes of apparent leg length differences in a supine position include: a true leg length inequality, innominate rotation, or pelvic subluxation. If leg length is different by measurement, but the legs appear the same length, there must be some compensation in the pelvis (innominate rotation, pelvic subluxation, or small hemipelvis.).</td>
</tr>
<tr>
<td>Line the legs up and place your thumbs below the inferior aspect of the medial malleolus. Observe for any apparent difference in length.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Symphysis Pubis Alignment</strong></td>
<td>Symphysis pubis should be level and rectus abdominus contraction should feel symmetrical. Asymmetry in pubic tubercles and/or asymmetry in the contraction of the rectus abdominus.</td>
<td>Symphysis pubis dysfunctions are common in patients with low back pain. A symphysis pubis dysfunction will affect normal gait. Patients with a symphysis pubis dysfunction will rarely have an awareness of, or complain of pubic pain, but there may be tenderness on palpation of the symphysis pubis.</td>
</tr>
<tr>
<td>Place index fingers over the right and left pubic tubercles and assess A-P alignment. Hook index fingers over superior aspect of symphysis pubis to assess cephalad-caudal alignment. Ask patient to raise head to assess symmetry of contraction of the rectus abdominus muscle.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Straight Leg Raising (passive)</strong></td>
<td>No pain with SLR at 70 degrees or less. Radiating pain below the knee at 70 degrees or less, aggravated by ankle dorsiflexion (increases neural tension).</td>
<td>A positive straight leg raising test suggests neural tension from nerve root impingement. Most sensitive for L4, L5, and S1 levels.</td>
</tr>
<tr>
<td>Passively raise patient’s leg.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Active Straight Leg Raising</strong></td>
<td>Patient reports no change in the ease or difficulty of raising legs with or without compression. Leg raising is easier or harder with pelvic compression in front or back, or both.</td>
<td>If leg raising is easier with anterior pelvic compression, it suggests weakness of the transverses abdominus; if easier with posterior compression, it suggests weakness of the multifidus.</td>
</tr>
<tr>
<td>Have patient raise right leg 6” and then left leg 6”. Repeat while adding compression to the pelvis anteriorly, and again while adding compression posteriorly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examination</td>
<td>Normal/ Abnormal</td>
<td>Significance</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Palpation of Iliopsoas Muscles</strong></td>
<td>No pain, only a sense of pressure. <em>May be exquisitely tender. Patient often exhibits a “jump sign” when a trigger point is palpated.</em></td>
<td>The iliopsoas muscle is frequently tender and shortened in low back pain, and is usually more symptomatic on the same side as an SI joint dysfunction.</td>
</tr>
<tr>
<td>Palpation of Iliopsoas Muscles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palpate deeply lateral to the rectus abdominus at the level of the umbilicus, moving you hand medially until contacting the muscle. Palpate the insertion of the iliopsoas distil to the inguinal ligament. With their leg straight, have the patient raise their leg a few inches to feel the muscle engage. Palpate the iliacus along the inner side of the ilium about one inch medial to and one inch inferior to the ASIS.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Prone Examination

<table>
<thead>
<tr>
<th>Examination</th>
<th>Normal/Abnormal</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prone Leg Length</strong></td>
<td>Equal/Not equal</td>
<td>Differences may be due to: a true leg length inequality, a sacral dysfunction, a pelvic subluxation, or a small hemipelvis (rare).</td>
</tr>
<tr>
<td>Bring heels together, place your thumbs below the inferior aspect of the medial malleolus and assess for equality of leg length.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Iliac Crests</strong></td>
<td>Level/Not level</td>
<td>Unleveling of the iliac crests strongly suggests a pelvic subluxation. Interpret in the context of other findings. Unilateral tightness in the quadratus lumborum may also cause unleveling of the iliac crests.</td>
</tr>
<tr>
<td>Bring hands in from the side in the lumbar region and press downward until you contact the iliac crest.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ischial Tuberosities</strong></td>
<td>Level/Not level</td>
<td>Unleveling of the ischial tuberosities strongly suggests a pelvic subluxation. Interpret in the context of other findings.</td>
</tr>
<tr>
<td>Press thumbs upward in gluteal fold until you contact the ischial tuberosities.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sacrotuberous Ligaments</strong></td>
<td>Equal tension in both ligaments. Unequal tension in the ligaments.</td>
<td>The sacrotuberous ligament will be slack on the affected side in an upward subluxation because the ilium is shifted superiorly, shortening the distance between the two attachments of the ligament (the ischial tuberosity and sacrum).</td>
</tr>
<tr>
<td>Starting from the ischial tuberosities, move your thumbs superiorly and medially to palpate the tension in the sacrotuberous ligaments (the ligaments run from the sacrum to the ischial tuberosities).</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gluteus Maximus Inhibition</strong></td>
<td>Hip extension is initiated by the gluteus maximus. <em>Hip extension is initiated by the hamstrings and activation of the gluteus maximus is delayed, weak, or absent.</em></td>
<td>Most common causes are SI joint dysfunction or reciprocal inhibition. Usually accompanied by trigger points in the gluteus medius and piriformis. May secondarily result in piriformis syndrome, and/or overload of contralateral lat. dorsi.</td>
</tr>
<tr>
<td>Monitor the hamstring and gluteus maximus, then instruct the patient to raise their leg (extend the hip) at the hip with the knee straight.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Prone Prop-up Examination

<table>
<thead>
<tr>
<th>Examination How to Perform</th>
<th>Normal/ Abnormal</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sacral Position in Extension</strong></td>
<td>Place thumbs on each side of the sacral base (between the right and left PSIS) and then on each side of the inferior lateral angles (lower portion) of the sacrum. Assess the relative depth of each thumb at the sacral base and inferior lateral angle.</td>
<td>Thumbs should be level at both locations. <em>Thumbs not level at either location.</em></td>
</tr>
<tr>
<td><strong>Spinal Alignment in Extension</strong></td>
<td>Using both thumbs, assess the relative depth of the transverse processes at each vertebra. Look for any rotational change from the sacral base to L5, and from one vertebral level to the next.</td>
<td>The entire spine should be aligned with the sacral base. <em>Small right or left rotational changes (approximately 10 degrees) in the orientation of the transverse processes.</em></td>
</tr>
</tbody>
</table>
**Session 110 Low Back Pain: Thinking Outside the Disc**

<table>
<thead>
<tr>
<th>Examination</th>
<th>How to Perform</th>
<th>Normal/Abnormal</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gluteus Medius Inhibition</strong></td>
<td>Use both hands to simultaneously monitor three muscles: the gluteus medius (just above the hip pocket), quadratus lumborum (between ribs and pelvis), and tensor fascia lata (between anterior iliac crest and greater trochanter) while instructing the patient to slowly lift the top leg.</td>
<td><em>Hip abduction is performed primarily by the gluteus medius; a firm contraction should be felt in the gluteus medius. The gluteus medius contracts only minimally, with stronger contractions felt in the tensor fascia lata and quadratus lumborum.</em></td>
<td><em>Patients will usually complain of hip pain in the presence of gluteus medius inhibition. The gluteus medius and the substituting muscles (gluteus minimus, TFL, QL, vastus lateralis) will often develop trigger points. Gluteus medius (abductor) inhibition is usually due to reciprocal inhibition from tightness in the adductors which in turn is often secondary to a symphysis pubis dysfunction.</em></td>
</tr>
<tr>
<td><strong>Muscle Trigger Point Examination</strong></td>
<td>Using firm pressure (enough to blanch the tip of the nail bed on your thumb), palpate for trigger points in the following muscles: gluteus medius, piriformis, gluteus minimus, TFL, vastus lateralis, quadratus lumborum, lat dorsi, infraspinatus.</td>
<td><em>Sensation of pressure, but no pain. May be exquisitely tender. Presence of a trigger point often signaled by a “jump sign”, causing the patient to jump when you press on a trigger point. Patient may experience local and referred pain from a trigger point.</em></td>
<td><em>Consider trigger points as a marker of muscle overload. Ask yourself, why would this particular muscle be working so hard? (Is it compensating for a structural abnormality such as unequal leg length, stabilizing an unstable structure, substituting for an inhibited muscle, over working due to tightness in the muscle’s antagonist, or is the muscle over-stimulated by an irritated nerve?)</em></td>
</tr>
</tbody>
</table>
Common Trigger Points in Low Back Pain

**Psoas**

Usually found on the same side as an SI joint dysfunction.

Tightness of the psoas has a strong influence on lumbar spine.

**Piriformis**

Often found in presence of inhibition affecting the gluteus maximus, or on the same side as an innominate upslip.

A tight piriformis muscle may entrap the sciatic nerve.

**Gluteus Medius**

Usually found on same side as a sacroiliac joint dysfunction, and occurs in presence of gluteus medius or gluteus maximus muscle inhibition.

A gluteus medius trigger point refers pain over the sacrum, iliac crest, or gluteal region.
Gluteus Minimus

Usually found in presence of gluteus medius inhibition, or on the side opposite from an innominate upsip.

Often refers pain down the side of the leg to the thigh, calf, and ankle and can easily mimic a radiculopathy.

Quadratus Lumborum

Usually found in the presence of inhibition of the gluteus medius.

Trigger points and tightness in the quadratus lumborum may further inhibit the gluteus medius.

Vastus Lateralis

Often found in the presence of gluteus medius inhibition and a tight IT band.

Patient may be unable to lie on affected side at night.
Tensor Fascia Lata

May be found in the presence of gluteus medius muscle inhibition.

The pain from the tensor fascia lata may prevent the patient from lying comfortably on their side.

Latissimus Dorsi

Located in the posterior axial fold, this trigger point often occurs in the presence of gluteus maximus inhibition on the opposite side.

Trigger point may refer down the arm to the ulnar aspect of the hand.

Infraspinatus

Commonly found on the side opposite from gluteus maximus inhibition, due to tightness of the latissimus dorsi causing internal rotation of the shoulder. Also common in computer users working with their mouse on a desktop.

May cause shoulder pain, or mimic CTS or a cervical radiculopathy.