SACROILIAC JOINT (SIJ) DYSFUNCTION

Idiopathic (nonspecific) Low Back Pain

The ubiquity and complexity of idiopathic low back pain (LBP) syndrome is probably unequaled by any other musculoskeletal lesion.[1] Non-specific back pain is the most common, with a prevalence of 80-85% in the general population.[2,3] It is an enormous clinical and public health problem that is associated with high health care burden and social costs.[3,4] Despite its benign nature, in many countries, LBP is the leading activity-limiting complaint, cause of disability and sick leave, and has the highest cost of workers' compensation.[3] Wong et al. cite a 30.8% one-month and 38.0% one-year prevalence of activity-limiting LBP.[5] A multiplicity of tissues have been implicated as etiological sources of musculoskeletal pain.[1] Sacroiliac joint dysfunction (SIJD) has been hypothesized to be a common, but often overlooked, cause of low back pain.[6-8]

Sacroiliac Joint

The sacroiliac joint (SIJ) is a curious and unique joint, involved in a wide variety of established pathological conditions, affecting individuals across the life span.[7] Its location, orientation, and morphology make the SIJ difficult to visualize clearly with radiographic procedures, increasing the problems in diagnosis of SIJ pathology. The sacroiliac joint is a diarthrodial joint with two bony surfaces, the sacrum and the ilium.[9] The sacroiliac joint joins the spine to the pelvis, helping to absorb vertical forces from the spine and transmit them to the pelvis and lower extremities, as well as transmitting them from the extremities to the spine.[10] The sacrum's rough, irregular surface and its wedge shape form an interlocking mechanism with the ilium.[10] The size, shape, roughness, and complexity of the articular surfaces vary greatly among individuals, contributing to the unique stability of the joint.[9] The SIJ changes as we age – in early childhood the joint surfaces are smooth and flat with gliding motions possible in all directions; after puberty, the joint surfaces change configuration and motion is restricted to antero-posterior movement of the sacrum on the ilium or the ilium on the sacrum; and in the elderly, the joint cavity is at least partially obliterated by fibrous adhesions and synovitis.[9] Surface irregularities of articular cartilage of both the sacral and ilial surfaces of the SIJ are age-related changes, reflecting the stresses and strains to which the joint is exposed, and are not pathological.[7,11] Sacroiliac joint stability is theorized to be enhanced in males versus females secondary to exposure to greater torques, leading to complementary intra-articular elevations and depressions in the SIJ architecture.[7] Torques may be greater in larger persons, not just in males, leading to the need to consider torque in relation to the joint surface area squared.[7]

Besides it's bony architecture, SIJ stability depends primarily on anterior and posterior ligaments, as well as adjacent muscles which have fibrous expansions that blend with the anterior and posterior ligaments and contribute to the strength of the joint capsule and ligaments, and thus to the joint's stability.[7,9] Ligaments function to control 6 degrees of motion and therefore, protect joint structures.[12] The muscles include the quadratus lumborum, erector spinae, gluteus maximus, gluteus minimus, piriformis, and iliacus muscles, as well as the even more distantly located latissimus dorsi.[7] This fascial reinforcement is greater posteriorly, as more muscles are adjacent to the joint on that aspect.[7] The posterior ligaments of the sacrum are loosened when the innominates move anteriorly on the sacrum and the thin sheath of anterior sacroiliac ligaments offer only minimal protection, making the SIJs vulnerable to injury and fixation anteriorly.[1] The presence of the strong posterior interosseous ligament attempts to prevent the creation of anterior capsule weakness.[7] Ligamentous structures are clearly important for proper joint function, but so is overall body structure and posture. The alignment of your body in gravity can profoundly affect how your pelvis is positioned and this in turn can determine how well your joints function.[13] Additionally, the tissues derived from muscle expansions may be placed in tension when the muscle bellies contract, making muscle activity likely to increase any symptoms arising from SIJ pathology.[7] The lumbar multifidi and internal oblique muscles activate before spinal motion and help stiffen the spine, reducing interspinal motion, and transverse abdominis significantly decreases the laxity of SIJ.[10] Lumbopelvic muscles in those with SIJ pain fire differently from those without pain, and subjects with SIJ pain show delayed onset of EMG activity of those muscles, as well as the gluteus maximus.[10]

The premise that the SIJ is a locus of low back pain rests on the assumption that the SIJ is capable of motion.[7] Motion must occur both to create SIJD and, more importantly, to substantiate manual procedures designed to relieve symptoms and restore function.[7] Motion studies confirm that some motion does occur in the SIJs.[7] Numerous anatomical studies suggest strongly that available motion may be greatest in women, especially late in pregnancy and the early postpartum period, and that motion decreases, possibly significantly, with natural aging.[7] During activities, the joint motion is small, not exceeding 2-3° in the transverse or longitudinal planes.[10] The joint is innervated, but the exact innervation is unclear. The predominant innervation appears to be from L4-S1 nerve roots, with some contribution from the superior gluteal nerve.[10] In addition, the presence of mechanoreceptors in the SIJ support the view that the central nervous system receives proprioceptive and probably pain inputs from the joint.[10]

Differential Diagnosis of Sacroiliac Joint Pathologies

Pain generated in the SIJ or surrounding structures can present as low back pain, sacral pain, pelvic pain, or gluteal pain.[10] Numbness, popping, clicking, or groin pain can occur. Unilateral pain is more common than bilateral pain by as much as a 4:1 ratio.[10] Athletes involved in sports that require unilateral loading such as kicking and throwing are at increased risk, and there is a history of trauma in 44-58% of individuals with SIJ pain.[10] SIJ pain is more common in pregnant women (possibly as a result of the release of the hormone relaxin, which allows pelvic expansion and increased motion).[7] Other factors, such as the trauma of childbirth, altered posture, increased lordosis, and weight gain, increase the risk of pain for pregnant women.[10]

As a physical therapist, it is important to prioritize appropriate differential diagnosis when it is related to LBP to understand the need for referral in patients who are not appropriate for PT services. This is increasingly important due to attainment of direct access of physical therapy services in most states. Knowledge of medical screening warning signs when evaluating a patient with LBP is important because serious spinal pathology can be the underlying cause.[14] Red flags include the following: constant, unrelenting pain, especially if occurring at night; age <20 or >55 years; persistent severe restriction of lumbar flexion; pain with breathing, coughing, or sneezing; previous history of cancer; recent history of trauma or infection; inability to find a position of relief or comfort; recent weight loss of >10 lbs.; lower limb weakness; altered bladder/bowel control; saddle anesthesia; and widespread neurological deficit.[14]

Many structures of the trunk and pelvis can contribute to LBP through functional connections between the lower extremities and spine muscles and ligaments, thoracolumbar fascia, zygapophyseal joints, and intervertebral discs.[5] Other structures refer pain to the low back or generate signs and symptoms mimicking non-specific low back pain. These include the articular surfaces of the sacroiliac and hip joints and the soft-tissue structures overlying those joints.[5] Failure to recognize concurrent spine, sacroiliac, and hip pathology can lead to incomplete or inaccurate diagnosis and ineffective treatment.[5,15,16] Authors have noted the relationship between LBP, range of motion of the lumbar spine, hip range of motion and strength, and SIJ motion.[5] Multidisciplinary clinical practice guidelines (CPGs) developed by the American Pain Society recommend classifying people presenting with spinal conditions into one of three categories based on their medical history and examination: (1) non-specific LBP – the focus of which this paper lies; (2) back pain potentially associated with radiculopathy or spinal stenosis; and (3) back pain potentially associated with another specific spinal cause.[17]

Accurate diagnosis depends on using reliable, sensitive, and specific clinical examination techniques to screen the interdependent lumbar spine, sacroiliac, and hip joint functional complex.[5] Thorough medical history integrated with a review of systems is recommended in the diagnostic triage process to exclude specific spinal pathology and nerve root pain.[5] The physical examination requires functional testing (myotomes screening which could indicate radicular changes associated with nerve root function; gait abnormalities such as Trendelenburg sign resulting from hip abductor weakness; and balance assessments which can alert to hip abductor weakness, pelvic obliquity, or balance compromise), range-of-motion testing (hip external rotation and internal rotation; and spinal flexion, extension, and rotation assessment with attention paid to symptom reproduction as well as the quantity and quality of motion), and palpation.[5] In spinal range of motion tests, symptom peripheralization with spinal flexion can suggest nerve root compression that may be due to intervertebral disc herniation.[5] Revelation of anterior hip pain with combined hip flexion, adduction, and internal rotation (Appendix A: Figure 1) suggests femoral acetabular impingement.[5] This position also stretches the piriformis muscle, and in people with sciatic nerve irritation, this position identified piriformis syndrome with 85% sensitivity.[5] Differential testing that allows the clinician to discriminate between involved contractile and non-contractile tissues can be performed in supine individuals using contractile tissue assessment concepts which dictate that dysfunction within a specific muscular-tendinous unit typically elicits pain with both muscle stretch and contraction, unless a complete rupture is present.[5] Accurate identification of the involved muscular-tendinous unit can be enhanced with palpation of tender spinal areas.[5] Soft tissue evaluation is also a critical factor in the diagnosis of lumbar spine and sacroiliac dysfunction.[9] Use of flexibility testing of the hip flexor and hamstring muscles contributes to your clinical objective findings. Thomas testing (Appendix A: Figure 2) is a reliable assessment of hip flexor extensibility.[5] With the patient supine at the end of the table, one knee is held to the chest, while the other leg dangles towards the floor: hip flexion indicates iliopsoas tightness; knee extension indicates rectus femoris tightness; and hip abduction suggest tensor fascia latae tightness.[5] The straight leg raise test (SLR) (Appendix A: Figure 3 - passive knee extension with the patient supine and the hip flexed at 90°) can be used to identify hamstring tightness and/or herniated disc-related nerve root compression.[5] Comparison to the contralateral lower extremity is critical since normative hamstring length data is not available, but sources cite limitation of > 20° as abnormal.[18] If during the SLR test, plantar flexion of the ankle or cervical extension eliminate some of the tension felt, it is said to be even more indicative of neural tension symptomology.[5] Lastly, slump testing in sitting (Appendix A: Figure 4A) evaluates excursion of neural tissues within the vertebral canal and intervertebral foramen with excellent reliability.[5] The patient slumps completely, with slight overpressure maintained by the examiner while the person fully extends the knee with the ankle dorsiflexed; symptom reproduction is considered a (+) test, particularly if symptoms are diminished with the addition of cervical extension or ankle plantar flexion.[5] (Appendix A: Figure 4B)

Sacroiliac Joint Dysfunctions

The three ways the pelvis can create dysfunctions are torsion, flare, and shear.[13] Normal walking requires that each innominate rotate (or torsion) anteriorly and posteriorly in response to how each leg moves from heel strike to toe off.[13] Torsion of the innominate occurs around a transverse axis that runs through the inferior aspect of the sacroiliac joint.[13] Just as it is possible for the innominates to torsion normally, it is also possible for one of them to get stuck in either anterior or posterior torsion. With an anterior innominate rotation (torsion), the PSIS is higher and more anterior (and ASIS lower and more posterior) on the affected side compared with the contralateral side when standing.[9] Torsions of the innominates can result in a spinal scoliosis and an altered functional leg length (discussed later).[9] Flare of the innominate can occur as either out-flare or in-flare. When out-flared, the ilium rotates laterally on the involved side.[13] This opens the SIJ anteriorly while closing it posteriorly resulting in posterior landmarks (such as the PSIS) more medial and anterior landmarks (ASIS) more lateral.[9] In-flare behaves in the opposite fashion, with the ilium rotating medially.[13] This opens the SIJ posteriorly while closing it anteriorly, moving posterior landmarks more lateral and anterior landmarks more medial.[9] Shear is just a little bit more complicated, because it can occur in two distinct ways, either as anterior/posterior (A/P) shear or superior/inferior shear.[13] In superior/inferior shear, also known as up-slip and down-slip, one of the innominates either slips upward on the sacrum in relation to the other innominate or it slips downward.[13] With a unilateral up-slip of the innominate, the ASIS and PSIS are higher than the ASIS and PSIS on the opposite side.[9] Shear is most often the result of trauma and although down-slips do occur, they are very rare. When one does occur, it is usually corrected by walking. In A/P shear, one of the innominates either slips anteriorly in relation to the other innominate, or it slips posteriorly.[13] You could reasonably call A/P shear anterior and posterior slip.[13]

Biomechanical Effects of Limb Length Inequalities

Limb length inequality (LLI) has been associated with LBP, presumably due to SIJD.[4,19,20] The pain is most frequently found on the side of the long limb, which has been found to be caused by a downward rotation of the innominate bone on the sacrum.[1] We must also consider that while a LLI might cause low back pain, the pathomechanics that caused the LBP might also cause a discrepancy in limb length. LLIs are usually classified into two groups: anatomical limb length inequalities (ALLIs), those in which an actual bony asymmetry exists somewhere between the head of the femur and the ankle mortise; and functional limb length inequalities (FLLIs), which occur as a physiological response to altered mechanics along the kinetic chain anywhere from the foot to the lumbar spine, giving the appearance of a short limb when a bony asymmetry in the length of the bones might not actually exist.[21-23] Sources of FLLIs include foot mechanics, adaptive shortening of soft tissues, joint contractures, ligamentous laxity, and axial malalignments (including innominate subluxation and rotation).[22] FLLI has been described as being descriptive of changes within the pelvis and its related musculature, and the semantic use of functional LLI to describe alterations of pelvic biomechanics is misleading in that it leads examination away from the primary pelvic problem.[21] Regardless of whether the LLI is anatomical or functional, the mechanical effects on the kinetic chain from the low back to the foot are potentially the same.[21] The sacrum supports the spine, and when the base of support for the spine is out of balance, there, in fact, lies the basis for increased mechanical stress at the lumbosacral region and the cause for pathomechanical compensatory dis-alignment of the vertebrae.[24] Lateral flexion deformity and related rotation of the vertebrae that is usually associated with unilateral limb length inequality are possibly the underlying factors that initiate the pathogenesis of low back problems.[24] The wear and tear of normal mechanical stress on the intervertebral joints can be increased in these joints which, due to being axially rotated out of alignment, become more susceptible to the effects of torsion than if it were not malaligned (Appendix A: Figure 5).[24]

Mechanically, lateral imbalance in the static erect posture caused by LLI and the associated pelvic tilt, is compensated by functional scoliosis, with lumbar convexity towards the short leg side.[21,25] Due to this pelvic tilt, adduction of the hip on the long leg side is produced, and that hip is more susceptible to muscular stress since it is further from the closed-pack position.[21,25] (Appendix A: Figure 6) This may be confirmed with the aid of Wiberg's angle (Appendix A: see Figure 7) which is considerably smaller on the long leg side, with the greater pressure per articular unit area being thought to promote the development of chondral damage and unilateral arthrosis in the hip of the long leg side.[25] Decreased contact area due to malalignments will lead to increased contract pressure and increased contact forces, which will want to do damage to articular cartilage.[11] In standing, a LLI is compensated for in different ways: pronation of the foot on the longer leg side or supination and/or plantar flexion of the foot on the shorter leg; knee and hip extension of the shorter limb and/or knee and hip flexion of the longer limb; and, if the leg is left uncompensated, ASISs and PSISs are lower on the side of the short leg, which in turn, may result in sacral base un-leveling and/or scoliosis.[21,23]

There is evidence that individuals with LLI develop compensatory strategies during gait, resulting in kinematic alterations in the lower limbs and pelvis.[19,20] LLI is the most common cause of pelvic obliquity, resulting in abnormal mechanical alignment of the SIJ of both sides, and high loads passing through the joint,.[4,26] The greatest source of stress on a joint is compression from muscle pull.[21] Torsional forces (axial rotation of the spine, coupled with lateral bending, and the pelvic rotation caused by anatomic relationships at the hip joints) exercise their strongest action at the lowest intervertebral joints, especially the lumbosacral junction, in which there is said to be more rotational stress than other lumbar joints.[21] Lateral bending and axial rotation is thought to be the most dangerous combination of motions to the disc, especially the lumbosacral segment which has the least rotational ability of the spine.[21,25] In cases of LLI, the physiological sway of the lumbar spine during gait subjects the lumbar motion segments to constantly repeated asymmetrical bending and torsional loads.[21,25] Effects of LLI on walking, in general, indicate that the individual with a LLI must step down onto the short limb and vault over the long limb resulting in an increase in vertical displacement of the center of mass, and hence an increase in energy consumption.[23] Gait characteristics with LLD include decreased stance time and step length on the shorter leg, decreased walking velocity, and increased walking cadence.[23] Decreasing the time at impact also increases joint loads due to decreased time for shock absorption.[27] Various compensatory mechanisms can occur to lengthen the shorter limb including increasing downward pelvic obliquity, increasing knee extension in midstance, vaulting, toe walking, or any combination of these.[23] In addition, an individual may shorten the longer leg by increasing pelvic obliquity, circumduction, increasing hip and/or knee flexion (steppage gait), increasing ankle dorsiflexion, or any combination of these.[23] Kiapour et al. recently published an article in which they concluded that LLI can significantly increase the load and stress at the SIJ, with the peak load increasing notably as discrepancy increased.[4] LLI increases the joint load on both the short and long leg sides, however, this increase was higher on the longer side.[4] Kakushima et al. simulated a LLI using a heel-raising orthotic device (designed to add height of 3 cm while preserving the normal grounding actions of the MTP joints) to examine the effects on spinal motion during gait.[28] Their results suggested that with the presence of LLI, the spine is likely to be exposed to a larger amount of lateral bending stress, which may lead to degenerative disorders.[28] If LLI does lead to LBP, then treatments aimed at equalizing the LLI should help with the symptoms.[23]

Assessment of Sacroiliac Joint Dysfunction

Although the sacroiliac joint is often considered as a source of LBP, its anatomic location makes examination difficult.[8] Other than ruling out other sources of pain, imaging is generally not helpful in the evaluation of SIJ pain.[5,10] In fact, American and European best-practice guidelines both strongly recommend against routine imaging or other diagnostic tests in people with non-specific LBP due to the poor reliability and accuracy of these tests in the diagnosis.[5] The International Association for the Study of Pain proposed criteria for diagnosing SI joint pain, including in these criteria the use of intraarticular injections.[29] There is no "gold standard" in diagnosing SIJ pain, so many practitioners and researchers consider intraarticular fluoroscopically guided injections to be the closest thing available.[8,10,29-31] A positive SIJ injection is when, using a slow injection of solutions, it provokes familiar pain, and instillation of a small volume of local anesthetic results in 80% or more relief of pain for duration of effect of the anesthetic agent.[10] Intraarticular injections are an invasive procedure, and the structural and biomechanical aspects of the SIJ and spine are key determinants in the problem of low back pain, so SIJ pain provocation tests are a good alternative. More than 15 specific tests for SIJD have been described and are basically of two types: (1) palpation of bony landmarks with or without measurement and (2) pain provocation tests.[7]

Accurate detection and subsequent treatment depend ultimately on the reliability and validity of the tests used to identify SIJD.[6] Individual tests that are commonly used to identify SIJD have been shown to have questionable reliability, which is necessary for dependability in a measure, especially in regards to clinical usefulness.[6,8] Two methods proposed by Cibulka et al. have improved reliability of tests used to identify SIJD. These include discussing sources of disagreements that occur between therapists (i.e. training) and combining the results of four different tests used to confirm or deny the presence of SIJD.[6] When a combination of tests, finding at least 3 out of five positive tests, was used to determine the presence of SIJD, excellent inter-rater reliability was found.[5,8,29] European guidelines suggest that pain arising from the SIJ is best diagnosed from a cluster of pain provocation tests and pain palpation testing of the long dorsal SI ligament and pubic symphysis.[32] The most common reasons for poor test reliability include anatomic variation in bony prominence, excessive adipose tissue, and the examiner's skill where the examiner must accurately located bony prominence and clinically judge anatomic variations between sides.[8] The five SIJ pain provocation tests utilized which have substantial inter-rater reliability and consist of the following: distraction test, compression test, thigh thrust test, FABER, and Gaenslen test (Appendix B).[5] Clinical use of these five SIJ provocation tests can help to rule in or out SIJ pathology for the purposes of physical therapy practices, with the thigh thrust test being the most sensitive test, and the distraction test being the most specific.[29]

Conservative Treatment

Treatment techniques range from use of sacral belts to localized oscillatory motions, larger range mobilization or manipulative procedures (i.e. in which the leg may be used as a lever), and teaching patients to manage their back problems.[7] The main purpose in the design of rehabilitation exercises for the locomotor system is to lower joint load and increase muscular activity.[33]

Detection and Correction for Limb Length Inequality The accepted standard for assessing LLI in patients has been radiographic evidence, determined as accurate to within 3 mm for both ALLI and FLLI.[22] Clinical assessment consists of direct and indirect methods. Direct methods involve measuring limb lengths with a tape measure between 2 defined points. This method presents the following sources of measurement error: difficulty in palpating bony landmarks, iliac asymmetries that may mask or accentuate a limb length inequality, unilateral deviations in the long axis of the lower limb (i.e. genu valgum), asymmetrical position of umbilicus, and joint contractures.[22] In addition, this method involves 6 procedures for which error may be introduced into the determination of limb length inequality.[22] If a tape measure method is used, measurement from the ASIS to the lateral malleolus is the most reliable technique, and using the mean of 2 measurements increases reliability.[22] Indirect methods involve palpating bony landmarks while the examiner assesses for levelness of the palpated landmarks.[22] Simple visual estimates have been used, as well as the use of blocks or book pages of known thickness under the shorter limb until iliac crests or ASISs appear level.[22,34] A rigid pelvic leveling device used in conjunction with iliac crest palpation and the block correction method appear more accurate and precise than other clinical assessment methods described in the literature, either direct or indirect, though no uniform agreement exists and further investigation is warranted.[20,22] Clinicians should recognize that asymmetrical pelvic rotations in planes other than the frontal plane may be associated with limb length inequality, so the greater trochanters and as many pelvic landmarks as possible (i.e. iliac crests, anterior superior iliac spines, posterior iliac spines, and ischial tuberosities) should be palpated.[22] In addition, caution should be exercised when undertaking intervention strategies for LLI less than 5 mm when the identified LLI has been determined using clinical techniques.[22] Kiapour et al. showed that increased LLI will result in significantly higher loads and peak stresses at contact surfaces of the SIJ, potentially causing LBP.[4] Trying to offset the LLI surgically by lengthening the short side, shortening the long side, or by using shoe lifts should decrease the load at the SIJ, and consequently reduce the pain at the joint.[4]

Controversy persists regarding the significance of LLI, a diagnostic approach to the use of heel lifts, and implementation of proper orthopedic support in treatment of LLI.[21] The effects of appropriate lift therapy have been demonstrated to alter the kinematic motion of the lower extremity by improving the biomechanical efficiency of ambulation and has been shown to have a positive effect in acute and chronic or recurrent low back pain.[21] This said, it should be remembered that just as LLIs affect the biomechanics of the ankle, knee, hip/pelvis, and spine, heel lifts also change the mechanics of these joints.[21] Lifting should be gradual, in 3 to 5-mm increments over 2-3 weeks to allow for spinal decompensation without adverse symptoms.[21,22] Heel lifts greater than 10 mm disturb foot biomechanics, so a LLI of 10 mm or more requires some combination of heel lift and sole lift.[21] Deviations of over 3.5 cm may need a prosthetic device or shoe modification, and major discrepancies may require surgery.[21] Shoe lift therapy should be recommended for clinical use as an inexpensive, safe, and noninvasive alternative to methods of treatment that have already proven unsatisfactory.[25]

Spinal Manipulation Therapy (SMT) Thrust and nonthrust mobilization/manipulation is a common intervention utilized for non-specific acute, subacute, and chronic low back pain. Recent research has demonstrated that SMT is effective for subgroups of patients and as a component of a comprehensive treatment plan, rather than in isolation.[35] Flynn et al conducted a study resulting in the development of a clinical prediction rule (CPR) which identifies patients most likely to benefit from a general lumbopelvic thrust manipulation (Figure 8).[36] The five criteria in the spinal manipulation CPR are: duration of symptoms less than 16 days; no symptoms distal to the knee; lumbar hypomobility; at least 1 hip with >35° of internal rotation, and fear avoidance beliefs questionnaire work subscale score of < 19.[35,36] The CPR was validated by Childs et al, who demonstrated similar results in treatment success defined as a 50% or greater reduction in Oswestry Disability Index scores.[35] Studies have also demonstrated the effectiveness of an SMT performed in side-lying and purported to also affect generalized lumbopelvic dysfunction (Figure 9).[37,38] The presence of 4 predictors increased the probability of success with thrust SMT from 45% to 95%.[35] Clinicians should consider utilizing thrust SMT procedures to reduce pain and disability in patients with mobility deficits and acute, subacute, or chronic low back pain and back-related buttock, thigh, or pelvic pain.[35]

Muscle Energy Techniques The pelvis is often believed to be an area of dysfunction in patients and treatment is aimed at restoring symmetry of skeletal structures using a variety of techniques such as myofascial release, soft tissue mobilization, stretching, muscle energy techniques (METs), mobilization, and exercise.[39] Myofascial release treatment is commonly stated by clinicians to be very effective in correcting pelvic asymmetries and in reducing low back and/or sacroiliac region pain.[39] METs have been shown to relax muscular spasm, stretch shortened muscles, mobilize restricted joint, and increase fluid mechanics.[40] These techniques use active contraction of deep muscles that attach near the joint and whose line of pull can cause the desired accessory motion.[41] When performed with the assistance of the treating therapist, the technique requires the therapist to stabilize the segment on which the distal aspect of the muscle attaches.[41] A command for an isometric contraction of the muscle is given, which causes accessory movement of the joint.[41] The most important part of treatment deals with active mobility and patient self-treatment in order to perform these stabilization techniques themselves outside the clinical setting on an ongoing basis.[9] Descriptions of the *many* METs that have been described for the pelvic girdle complex are beyond the scope of this paper, but many of the maneuvers used for evaluation of the sacroiliac joint dysfunctions can also be used to correct the asymmetries. (See Appendix A: Figures 10 & 11 for two examples of this type of self-treatment)

Specific balanced muscle groups are fundamental to balancing the pelvis and lumbar spine.[9] There are 35 muscles that attach directly to sacrum or innominate bones and function with the ligaments and fascia to produce synchronous motion of the trunk and lower extremities.[9] Decreases in the length or strength of these muscles caused by adaptive shortening, for example, due to compensatory posturing or repetitive activities can alter normal pelvic mechanics.[9] The clinical significance is that it is essential to stretch out or lengthen the tight, short tonic muscle groups before you try to re-educate the weak, dysfunctional phasic muscle groups.[9] The main muscles and muscle groups of the pelvic-hip complex that are prone to tightness include the erector spinae, quadratus lumborum (producing lateral tilting of the pelvic girdle due to attachments on the sacral base and ala), rectus femoris, iliopsoas, tensor fascia latae, piriformis (decreasing the stability of the sacrum between the innominates), short hip adductors, and hamstrings.[9] The main muscles and muscle groups of the pelvic-hip complex that are prone to weakness include the gluteus maximus (can produce posterior rotation of the ilium), gluteus medius (resulting in limited hip abduction and loss of lateral stabilization of the ilium), gluteus minimus (decreasing the dynamic stability of the pelvic girdle and predisposing it to recurrent articular strains), rectus abdominis (weak abdominals promotes a forward pelvic tilt and anterior migration of the center of gravity), vastus medialis, and vastus lateralis.[9]

Spinal stabilization Exercise is used widely as a treatment approach, and a number of specific exercise approaches have been advocated over the last few decades, including general aerobic exercise, flexion or extension-based exercises, and stretching programs (mentioned above).[42] Exercises intending to address inter-segmental stability in the lumbar spine have emerged, and are referred to as "lumbar stabilization," "segmental stabilization," or "core stabilization."[42] These programs are directed towards enhancing the function of musculature thought to have an important role in the dynamic control of the lumbar vertebral segments.[42] A study by Cleland et al. (2009) included 2 treatments of spinal stabilization exercise in both of their spinal manipulation treatment groups. All patients were instructed in spinal stabilization exercises targeting the transverse abdominis, multifidus, erector spinae, and obliques. Performance of spinal stabilization exercise in adjunct to SMT produced reduced pain and disability scores up to 6 months of follow-up.[37] A structured, activating exercise program may assist in recovery for patients, but it needs to be provided in the context of each individual patients specific needs, evaluated on a case by case basis.[42] Clinicians should consider utilizing trunk coordination, strengthening, and endurance exercises to reduce low back pain and disability in patients with subacute and chronic low back pain with movement coordination impairments.[35]

Patient educational interventions Functional movement training/re-education has been ranked as a "very important strategy" for therapists to implement in their plan of care for patients.[35] This often involves identifying movements that are associated with their symptoms and then providing cuing and education on movement options that enable the activity to continue to be performed with fewer, to no, symptoms.[35] Physical therapy CPGs outlined by Delitto (2012) emphasize that education and counseling strategies should not directly or indirectly increase the perceived threat or fear associated with back pain, rather they should emphasize: (1) the promotion of the understanding of the anatomical/structural strength inherent in the human spine; (2) the neuroscience that explains pain perception; (3) the overall favorable prognosis of LBP; (4) the use of active coping strategies that decrease fear and catastrophizing; (5) the early resumption of normal or vocational activities, even when still experiencing pain; and (6) the importance of improvement in activity levels, not just pain relief.[35]

Conclusion

In conclusion, presentation of sacroiliac joint dysfunction that presents as non-specific low back pain can have multiple etiologies, including effects from anatomical or functional limb length discrepancies. Physical therapy management using conservative treatment methods have proven successful in relieving pain and dysfunction for this patient population. A comprehensive static postural and functional movement assessment are critical elements of our management of these patients, due to the effects from abnormal alignment, muscular strength and length imbalances, and dysfunctional movement patterns. Use of inductive reasoning with these patients is of the utmost importance in order to identify these abnormalities and provide the most effective treatments in order to manage and reduce their pain, decrease impairments, and increase participation.

APPENDIX A: FIGURES


Figure 1


Figure 2


Figure 3

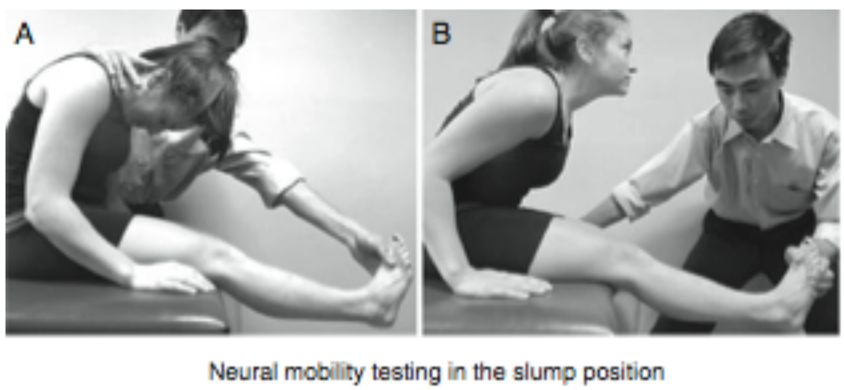


Figure 4A Figure4B

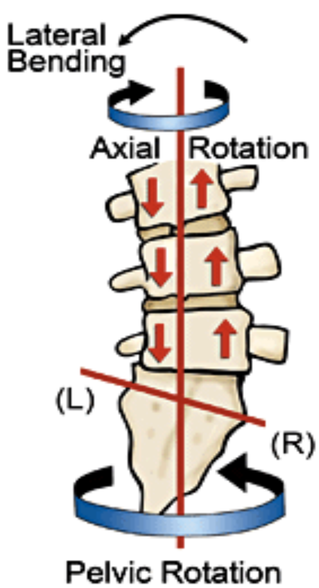


Figure 5 – Short right leg causing contralateral pelvic rotation and increased spinal pressures

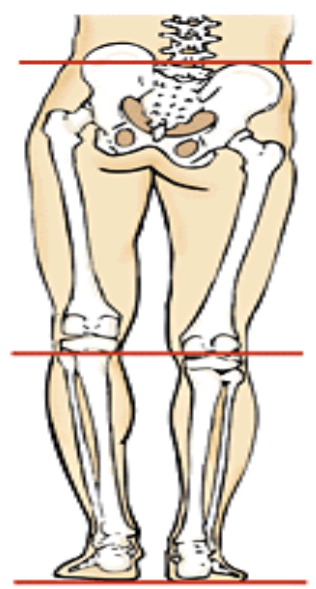


Figure 6 – Anatomic short right leg

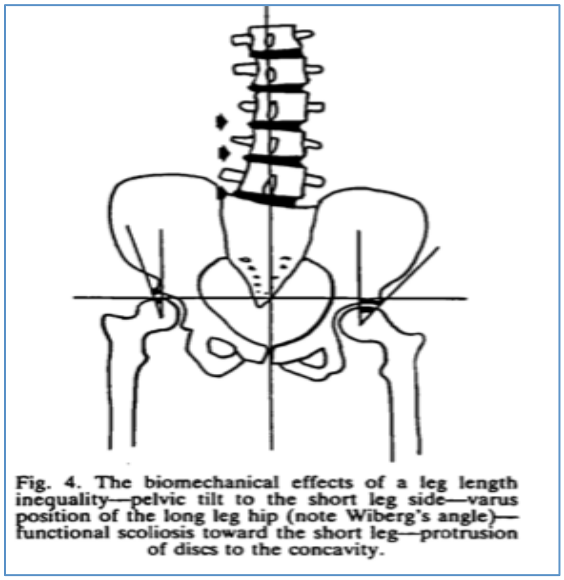


Figure 7

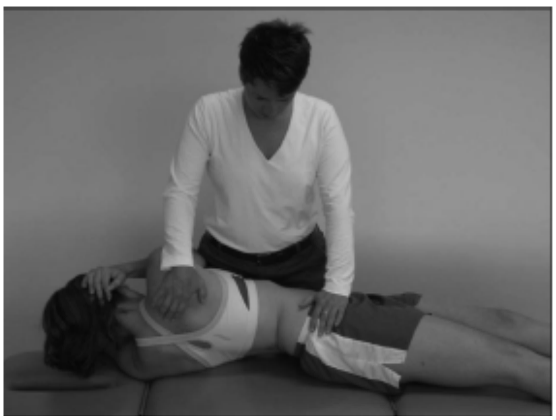


Figure 8

Figure 9

Figure 10 – Self Treatment of Innominate Inflare

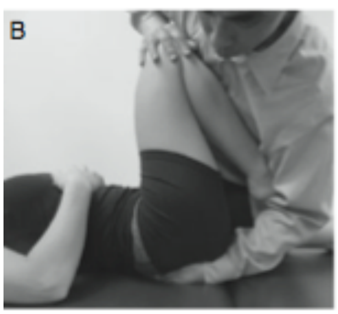
Figure 11 – Self Treatment of Innominate Outflare

APPENDIX B:
Special Testing Involved with
Differential Diagnosis of Sacroiliac Joint Dysfunction

Sacroiliac Provocation Tests

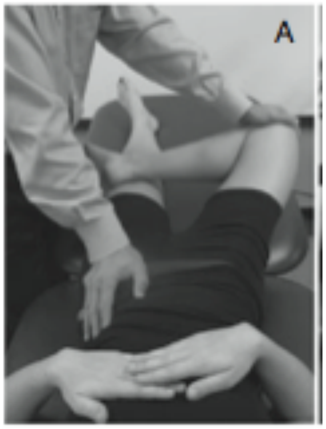
SIJ Distraction: With the patient supine, pressure is applied downward and laterally to the bilateral anterior superior iliac spines.[18] This maneuver stretches the ventral sacroiliac ligaments and joint capsule while placing pressure on the dorsal sacroiliac ligaments.[18]

SIJ Compression: With the patient side-lying, the therapist places both hands on the ilium of the affected side and exerts a downward pressure on the pelvis.[18] Occurrence of a pain, or increase in a pain, in the sacroiliac joint suggests a SJD, indicating a (+) compression test.[18]



Thigh Thrust Test: Patient supine with symptomatic-side hip flexed 90° in the sagittal plane and the sacrum stabilized by the examiner's hand, examiner imparts an axial thrust through the femur, causing shear on the ipsilateral sacroiliac joint. This test has the highest reported sensitivity (88%) of any sacroiliac joint test, with a 69% specificity that results in positive likelihood ratio (+ LR) of 2.8.[5,29]

Gaenslen's Test: With the patient supine, lying close to the edge of the table, and the buttock of tested side over the edge of the table, the patient's leg is dropped off the table. The contralateral knee is then maximally flexed and held to the chest. The clinician places their hand over the patient's thigh and ASIS of the test side to introduce hip extension and anterior pelvic tilt. Pain or discomfort is a (+) test for sacroiliac joint dysfunction. (Example is picture of a RIGHT Gaenslen's Test)



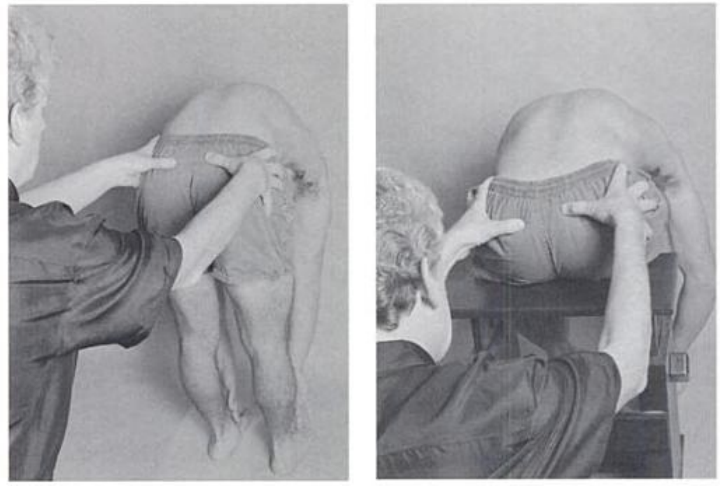
FABER: Combined hip flexion, abduction, and external rotation comprise the FABER test. The lower extremity is placed in a 'figure-four' position with the ipsilateral foot resting on the contralateral thigh just above the knee.[5] Reproduction of hip pain when downward force is applied to the ipsilateral medial thigh indicates hip joint pathology and/or restrictions of the anterior or lateral hip capsule.[5] Pain referred to the contralateral buttock during FABER testing suggests SIJ pathology with high sensitivity and (+) LR.[5]

Other Special Tests for the Sacroiliac Joint

Forten Finger Test: The patient is asked to point to the region of pain with one finger. Positive sign was if the patient can localize the pain with one finger, the area pointed to was immediately inferomedial to the PSIS within 1 cm, and the patient consistently pointed to the same area over two trials.[18]

Stork Test: Have patient standing and facing a wall so that they can stabilize themselves while performing the test. Put the pad of your right thumb on the posterior aspect of the right PSIS and your left thumb at the same level on the median sacral crest, which is basically the mid-line of the sacrum. Ask the patient to raise his left knee to at least 90° and watch what your right thumb does: if there is no iliosacral fixation, your right thumb will ride inferiorly as the patient raises their leg and your left thumb will remain where it is. If there is a fixation, then your right thumb will remain where it is and not move inferiorly. Test the other side in the same way.[13]

Sacral Apex Test: The patient is positioned prone on the exam table and the clinician applies a vertical downward pressure to the sacrum with the heel of the caudal hand. Rock the sacrum by repetitive pressure to its apex. The 3-point contact of the pubis and the anterior ends of the ilium with the surface of the treatment table will stabilize the pelvis, so repetitive pressures at the apex will induce a small degree of movement of the sacrum on the ilium. Symptom reproduction indicates a (+) test.



Standing Flexion Test: The standing version of this test adds the influence of the pelvis and legs.[13] Palpate the PSISs and place your thumbs on the inferior slopes of the PSISs.[8,13] With the patient standing and your thumbs in position, ask them to bend forward as far as they comfortably can, and watch what happens to your thumbs.[13] A superior movement of 1 PSIS compared to the other indicates a positive (+) standing flexion test.[8,18] A (+) test indicates that SIJ dysfunction exists on the side of the superior PSIS.[8,13] This test works quite well, unless the hamstrings or the quadratus lumborum are asymmetrically tight. If the hamstrings are tight on the side opposite to where your thumb rides up, or if the quadratus lumborum is tight on the same side as where your thumb rides up, the superior movement of your thumb will not be a true indicator and will create a false positive for this test.[13] The sitting version of this test can be used to determine unilateral sacroiliac fixations because it effectively removes the influence of the patient's legs (i.e leg length discrepancy or tight hamstrings) and pelvis on the sacrum.[13] With the patient sitting and your thumbs in position on the inferior slope of the PSIS, ask them to forward bend as far as they comfortably can. Again, if one of your thumbs rides up superiorly, you have discovered SIJD on that side.[13]

Long Sit Test: Disparity in limb lengths, functional or anatomical, and pelvic muscle length asymmetry are considered prime factors in detection of SIJD.[7] This test compares apparent limb lengths in the supine and long-sitting positions. With the patient in supine, ask them to perform 3 repetitions of the bridge exercise.[9] Instruct the patient to relax completely and allow you to position their legs out straight on the table for them. This process helps to ensure a completely neutral alignment of the pelvis on the table.[9] The clinician pulls distally on both lower extremities at the ankles to position the medial-lateral orientation of the pelvis perpendicularly to the lower extremities.[43] With the thumbs positioned on the inferior aspect of bilateral medial malleoli, the lengths between lower extremities is compared. In supine, the finding of a shorter limb when compared to the opposite side, suggests (but does not confirm) a posteriorly rotated innominate.[8] While the therapist holds the medial border of the malleoli with the thumbs, the patients is asked to come to a long-sitting position. Any apparent lengthening of the short limb implies the presence of sacroiliac joint dysfunction and a posteriorly rotated innominate of that side.[8]

In the supine position following the same bridge exercise and passive extension/pulling distally on both lower extremities, the clinician can also then passively position both of the patient's feet flat on the examining table so that both the patient's knees are flexed to 90° and both hips are flexed to 45°, with medical malleoli touching.[43] If one knee projects more anteriorly than the other from a lateral view, asymmetrical length between the two femurs is suggested.[43] If one knee projects more superiorly off of the examination table than the other from an anterior view, asymmetrical length between the two tibias is suggested.[43] Tape measure can also be used to compare symmetry of measurements from the anterior superior iliac spine to the greater trochanter to the lateral tibiofemoral joint line, the lateral tibiofemoral joint line to the distal aspect of the fibula, the medial tibiofemoral joint line to the distal aspect of the medial malleolus, and the anterior superior iliac spine to either medial or lateral malleolar landmarks.[43]

REFERENCES

1. DonTigny RL. Anterior dysfunction of the sacroiliac joint as a major factor in the etiology of idiopathic low back pain syndrome. *Phys Ther*. 1990;70(4):250-65; discussion 262-5.

2. Trigueiro MJ, Massada L, Garganta R. Back pain in portuguese schoolchildren: Prevalence and risk factors. *Eur J Public Health*. 2012. doi: 10.1093/eurpub/cks105.

3. Chanplakorn P, Sa-Ngasoongsong P, Wongsak S, Woratanarat P, Wajanavisit W, Laohacharoensombat W. The correlation between the sagittal lumbopelvic alignments in standing position and the risk factors influencing low back pain. *Orthop Rev (Pavia)*. 2012;4(1):e11. doi: 10.4081/or.2012.e11.

4. Kiapour A, Abdelgawad AA, Goel VK, Souccar A, Terai T, Ebraheim NA. Relationship between limb length discrepancy and load distribution across the sacroiliac joint--a finite element study. *J Orthop Res*. 2012;30(10):1577-1580. doi: 10.1002/jor.22119; 10.1002/jor.22119.

5. Wong CK, Johnson EK. A narrative review of evidence-based recommendations for the physical examination of the lumbar spine, sacroiliac and hip joint complex. *Musculoskeletal Care*. 2012;10(3):149-161. doi: 10.1002/msc.1012; 10.1002/msc.1012.

6. Cibulka MT, Delitto A, Koldehoff RM. Changes in innominate tilt after manipulation of the sacroiliac joint in patients with low back pain. an experimental study. *Phys Ther*. 1988;68(9):1359-1363.

7. Walker JM. The sacroiliac joint: A critical review. *Phys Ther*. 1992;72(12):903-916.

8. Cibulka MT, Koldehoff R. Clinical usefulness of a cluster of sacroiliac joint tests in patients with and without low back pain. *J Orthop Sports Phys Ther*. 1999;29(2):83-9; discussion 90-2.

9. Hertling D, Kessler R. Chapter 23: Sacroiliac joint and lumbar-pelvic-hip complex. In: Lippincott Williams & Wilkins, ed. *Management of common musculoskeletal disorders: Physical therapy principles and methods*. 5th ed. ; 2006:935--989.

10. Foley BS, Buschbacher RM. Sacroiliac joint pain: Anatomy, biomechanics, diagnosis, and treatment. *Am J Phys Med Rehabil*. 2006;85(12):997-1006. doi: 10.1097/01.phm.0000247633.68694.c1.

11. Gross MT. Effects of aging on the musculoskeletal system. *Voicethread*. 2012;University of North Carolina at Chapel Hill: Division of Physical Therapy(Unit 9).

12. Gross M. *Ligament: Composition, structure, function, mechanical properties, and healing. University of North Carolina at Chapel Hill: Division of Physical Therapy*. 2012;Voicethread.

13. Maitland J. *Spinal manipulation made simple: A manual of soft tissue techniques*. North Atlantic Books; 2001:184. Accessed November 29th, 2012.

14. Ferguson F, Holdsworth L, Rafferty D. Low back pain and physiotherapy use of red flags: The evidence from scotland. *Physiotherapy*. 2010;96(4):282-288. doi: 10.1016/j.physio.2010.01.001.

15. Mellin G. Correlations of hip mobility with degree of back pain and lumbar spinal mobility in chronic low-back pain patients. *Spine (Phila Pa 1976)*. 1988;13(6):668-670.

16. Cibulka MT. The treatment of the sacroiliac joint component to low back pain: A case report. *Phys Ther*. 1992;72(12):917-922. https://auth.lib.unc.edu/ezproxy_auth.php?url=http://search.ebscohost.com/login.aspx?direct=true&db=c8h&AN=1993154124&site=ehost-live&scope=site.

17. Chou R, Qaseem A, Snow V, et al. Diagnosis and treatment of low back pain: A joint clinical practice guideline from the american college of physicians and the american pain society. *Ann Intern Med*. 2007;147(7):478-491.

18. Magee DJ. Chapter 10: Pelvis. In: *Orthopedic physical assessment*. 5th ed. Saunders Elsevier; 2008:617-658. Accessed December 2nd, 2012.

19. Needham R, Chockalingam N, Dunning D, Healy A, Ahmed EB, Ward A. The effect of leg length discrepancy on pelvis and spine kinematics during gait. *Stud Health Technol Inform*. 2012;176:104-107.

20. Young RS, Andrew PD, Cummings GS. Effect of simulating leg length inequality on pelvic torsion and trunk mobility. *Gait Posture*. 2000;11(3):217-223.

21. Danbert RJ. Clinical assessment and treatment of leg length inequalities. *J Manipulative Physiol Ther*. 1988;11(4):290-295.

22. Brady RJ, Dean JB, Skinner TM, Gross MT. Limb length inequality: Clinical implications for assessment and intervention. *J Orthop Sports Phys Ther*. 2003;33(5):221-234.

23. Gurney B. Leg length discrepancy. *Gait Posture*. 2002;15(2):195-206. doi: 10.1016/S0966-6362(01)00148-5.

24. Jones CL. The damaging effects of a disaligned musculoskeletal system. *J Am Podiatry Assoc*. 1971;61(10):369-381.

25. Friberg O. Clinical symptoms and biomechanics of lumbar spine and hip joint in leg length inequality. *Spine (Phila Pa 1976)*. 1983;8(6):643-651.

26. Schuit D, McPoil TG, Mulesa P. Incidence of sacroiliac joint malalignment in leg length discrepancies. *J Am Podiatr Med Assoc*. 1989;79(8):380-383.

27. Gross MT. Articular cartilage: Composition, structure, function, mechanical properties, and healing. *[VoiceThread]*. 2012;University of North Carolina at Chapel Hill: Division of Physical Therapy.

28. Kakushima M, Miyamoto K, Shimizu K. The effect of leg length discrepancy on spinal motion during gait: Three-dimensional analysis in healthy volunteers. *Spine (Phila Pa 1976)*. 2003;28(21):2472-2476. doi: 10.1097/01.BRS.0000090829.82231.4A.

29. Laslett M, Aprill CN, McDonald B, Young SB. Diagnosis of sacroiliac joint pain: Validity of individual provocation tests and composites of tests. *Man Ther*. 2005;10(3):207-218. doi: 10.1016/j.math.2005.01.003.

30. Forst SL, Wheeler MT, Fortin JD, Vilensky JA. The sacroiliac joint: Anatomy, physiology and clinical significance. *Pain Physician*. 2006;9(1):61-67.

31. Manchikanti L, Datta S, Derby R, et al. A critical review of the american pain society clinical practice guidelines for interventional techniques: Part 1. diagnostic interventions. *Pain Physician*. 2010;13(3):E141-74.

32. Vleeming A, Albert HB, Ostgaard HC, Sturesson B, Stuge B. European guidelines for the diagnosis and treatment of pelvic girdle pain. *Eur Spine J*. 2008;17(6):794-819. doi: 10.1007/s00586-008-0602-4.

33. Nemeth G. On hip and lumbar biomechanics. A study of joint load and muscular activity. *Scand J Rehabil Med Suppl*. 1984;10:1-35.

34. Hanada E, Kirby RL, Mitchell M, Swuste JM. Measuring leg-length discrepancy by the [ldquo]iliac crest palpation and book correction[rdquo] method: Reliability and validity. *Arch Phys Med Rehabil*. 2001;82(7):938-942. doi: 10.1053/apmr.2001.22622.

35. Delitto A, George SZ, Van Dillen LR, et al. Low back pain. *J Orthop Sports Phys Ther*. 2012;42(4):A1-57. doi: 10.2519/jospt.2012.0301.

36. Childs, J.D., Fritz, J.M., Flynn, T.W., et al. A clinical prediction rule to identify patients with low back pain most likely to benefit from spinal manipulation: A validation study. *Ann Intern Med*. 2004(141):920-928.

37. Cleland JA, Fritz JM, Kulig K, et al. Comparison of the effectiveness of three manual physical therapy techniques in a subgroup of patients with low back pain who satisfy a clinical prediction rule: A randomized clinical trial. *Spine (Phila Pa 1976)*. 2009;34(25):2720-2729. doi: 10.1097/BRS.0b013e3181b48809.

38. Cleland JA, Fritz JM, Whitman JM, Childs JD, Palmer JA. The use of a lumbar spine manipulation technique by physical therapists in patients who satisfy a clinical prediction rule: A case series. *J Orthop Sports Phys Ther*. 2006;36(4):209-214. https://auth.lib.unc.edu/ezproxy_auth.php?url=http://search.ebscohost.com/login.aspx?direct=true&db=c8h&AN=2009160841&site=ehost-live&scope=site.

39. Barnes MF, Gronlund RT, Little MF, Personius WJ. Efficacy study of the effect of a myofascial release treatment technique on obtaining pelvic symmetry. . 1997;1(5).

40. Halpin S. Case report: The effects of massage therapy on lumbar spondylolisthesis. *J Bodyw Mov Ther*. 2012;16(1):115-123. doi: 10.1016/j.jbmt.2011.04.003.

41. Kisner, C. & Colby, L. Chapter 5: Peripheral joint mobilization. In: *Therapeutic exercise: Foundations and techniques*. 5th ed. F.A. Davis & Company; 2007:109-146.

42. Standaert CJ. Core stabilization for low back pain and performance. *Sport-Orthopädie - Sport-Traumatologie - Sports Orthopaedics and Traumatology*. 2011;27(2):92-98. doi: 10.1016/j.orthtr.2011.03.001.

43. Gross MT. Lower quarter screening for skeletal malalignment--suggestions for orthotics and shoewear. *J Orthop Sports Phys Ther*. 1995;21(6):389-405.