I. Abstract

STUDY DESIGN: Retrospective Case Report.

BACKGROUND: Co-existence of sacroiliac joint dysfunction and limb length inequality is a common clinical presentation in patients who present with numerous lower quarter impairment complaints. Proper clinical examination highlighting regional interdependence is warranted in order to uncover any structural malalignments and lead to appropriate treatment interventions. Successful correction of any existing limb length inequality using orthotic prescription, combined with addressing any concomitant sacroiliac joint dysfunction can lead to successful treatment outcomes in this complex patient population.

CASE DESCRIPTION: A 30-year-old female dancer self-referred to physical therapy following a chronic, intermittent history of multiple lower extremity impairments and low back pain. Patient reported numerous episodes of foot, ankle, knee, hip, and lumbar spine pain throughout the years, first starting at age 12 with recurrent ankle sprains. Visits to orthopedic physicians and multiple attempts at chiropractic management had all lead to ineffective treatments, failing to this point. With worsening of her right hip and low back pain, the patient sought physical therapy treatment. Upon examination, the therapist noted limb length inequality with concomitant ilial rotation, leading to custom orthotic prescription, instruction in self-muscle energy techniques (self-MET), and prescription of a lumbar stabilization and stretching program for conservative management.

OUTCOMES: The patient has since returned to recreational hobbies, including running and Zumba, pain-free.

DISCUSSION: This case demonstrates the importance of a global assessment of structure in the case of chronic musculoskeletal pain, particularly in numerous lower extremity joints, including the low back and pelvis. Rotation of the innominates and torsion of the sacrum can result from forces being transmitted to these bones from the spine, pelvis, or lower extremities, with asymmetric loading occurring in the presence of a limb length inequality. It is essential to treat the patient using a “ground-up” approach in these cases for successful outcomes to be obtained. Otherwise, the faulty structural malalignments will continue to perpetuate the functional compensations, and lead to further biomechanical consequences for the patient.

LEVEL OF EVIDENCE: Therapy, level 4.

KEY WORDS: *custom orthotics, limb length inequality, muscle energy techniques, physical therapy, regional interdependence, sacroiliac joint dysfunction*

II. Introduction

Regional Interdependence is a concept within the musculoskeletal physical therapy evaluation that lacks emphasis. This term refers to the concept that seemingly unrelated impairments in a remote anatomical region may contribute to, or be associated with, a patient's primary complaint. [1] While there is no question that a patient's local area of primary complaint should be examined initially and treated as indicated with current best evidence, it is also pertinent and evidence-based to screen the regions above or below the area of primary dysfunction and then work to determine proper prioritization of intervening in these other regions during a patient's course of care. [1] Clinical observations of successful changes in a patient's signs and symptoms following interventions to address lower quarter malalignments add to the plausibility and evidence for the regional interdependence model of evaluation. [2] There have been numerous reports of hip involvement in patients with primary complaints of low back pain and knee osteoarthritis, in which a large proportion, if not all patients, with primary low back pain and knee complaints received treatment directed at the hip and experienced positive outcomes. [1] Conversely, intervention targeting the lumbar spine has been reported in the management of patients who have primary complaints of hip and knee pain. [1]

Low back pain (LBP) is one of the most frequent musculoskeletal complaints in today's societies, with epidemiologic studies having indicated a lifetime prevalence of 70-80% in the western population. [3] Limb length inequality has been associated with LBP, presumably due to sacroiliac joint dysfunction (SIJD). [4-6] The most common effect of an anatomic LLI is rotation of the pelvis and/or innominate bones – often referred to as pelvic torsion. [7] The innominate movement tends to be anterior on the side of the short leg and posterior on the side of the long leg. [7] Walsh et al. found that pelvic torsion was the most common compensation for LLI up to 22 millimeters. [8] With larger amounts of LLI, subjects begin to develop flexion of the knee in the long leg in addition to any compensated pelvic obliquity. [8] We must also consider, however, that while a LLI might cause low back pain, the pathomechanics that caused the low back pain (i.e. sacroiliac joint dysfunction for example), might also cause a discrepancy in limb length. Herein lies the conundrum, emphasizing the importance of a comprehensive evaluation that uncovers the interrelationship between each component of the whole clinical problem.

Limb length inequality (LLI) is a relatively common problem, found in as many as 40-70% of the population. [9,10] A difference in the length of the lower limbs has been identified as a predisposing factor for acute and chronic injuries to the sacroiliac joint and low back pain. [11] Limb length inequalities are usually classified into two groups: true and functional. True limb length inequalities (TLLI's) are those in which an actual bony asymmetry exists somewhere between the head of the femur and the mortise of the ankle. [12] Functional limb length inequalities (FLLI's) are those 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 leg when a bony asymmetry in the length of the bones might not actually exist. [12,13] Sources of FLLI's include foot mechanics, adaptive shortening of soft tissues, joint contractures, ligamentous laxity, and axial malalignments (including innominate subluxation and rotation). [13] 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. [14]

Controversy persists regarding the significance of leg length inequality, a diagnostic approach to the use of heel lifts, and the implementation of proper orthopedic support in treatment of limb length inequalities.[14] Minor LLI is described as being of such magnitude as to be unrecognized until looked for, and when found becomes obvious.[12] The significance of such minor LLI in pathology, is, however, controversial. Some authors believe that a LLI of 5 mm or less has definite significance in mechanically related dysfunctions around the hips, pelvis, and spine.[12] Others believe that LLI less than ½ inch (12.7 millimeters) is not significant and has no pathological implications.[12] The purpose of this single case report is to demonstrate one clinical case where a true LLI of 15 millimeters had definite significance in mechanically related dysfunction of a patient's hips, pelvis, and spine; and demonstrate how a custom-fitted orthotic to address the true LLI has resulted in decreased musculoskeletal pain, return to functional hobbies, and improved quality of life in a young, active, female.

III. CASE DESCRIPTION

History

A 30-year-old, Caucasian female and third-year physical therapy student self-referred for physical therapy consultation following a recent exacerbation of chronic lower quarter pain and impairments. Primary complaint leading to seeking physical therapy treatment included pain in the right posterior, lateral hip; lumbar spine pain; and big toe, ankle mortise, and fifth metatarsal pain. She was a dancer beginning in high school and in college, majoring in dance. She has extended this hobby into adulthood, dancing professionally and teaching dance for 3 years after college, but no longer participants in formal dance. She is also a Pilate's instructor for a local fitness center. Her activity level in the weeks prior to seeking physical therapy care had progressively decreased, ultimately to the point of no physical activity due to the pain and soreness she experienced both during and afterwards.

Patient reported significant past medical history related to her lower quarter musculoskeletal complaints.

Talocrural Joint Starting around the age of 12, she experienced recurrent ankle sprains bilaterally, estimating around 15 total sprains since they began. Last year, she began to experience medial calcaneal pain, occurring with all shoes and when walking barefoot. This occurs with pain in the ankle mortise and at the peroneal tendons, becoming more and more constant since initial onset.

Metatarsophalangeal Joints At the age of 16, following 8 ballet classes in point shoes, she developed bilateral hallux valgus / hallux rigidis, leading to pain and reduced hallux extension range of motion (ROM) for 1 year following cessation of the classes, with intermittent pain ever since. At the time, a podiatrist prescribed hard plastic sulcus length orthotics, but she discontinued use after about 6 months because she did not feel as though they were helping. Additionally, due to attempts to reduce weightbearing due to the pain in her first metatarsophalangeal joints, she began having pain in bilateral 5th metatarsophalangeal joints. In 2001, she fractured her left 5th proximal phalanx due to forceful abduction while dancing.

Patellofemoral Joint At 15, she was part of her track team, and she began to have knee pain bilaterally, eventually limiting her ability to participate. She majored in dance in college, dancing around 4 hours per day, all the while experiencing significant low back and patellofemoral knee pain. This was diagnosed as bursitis by her campus health doctors and she was treated with ice and non-steroidal anti-inflammatories. She attempted a 3-day hike, which worsened her knee pain bilaterally. She has not run since 2009, after having significant swelling in her knees after a 6-mile run.

Sacroiliac Joint In 2006, she began having recurrent pain in her right sacroiliac joint (SIJ), which she sought both physical therapy (PT) and chiropractic treatment for, from 2006-2007, but had no relief following treatment.

Lumbar Spine Patient has had low back pain since 2004 that “comes and goes” but seems to worsen with any prolonged standing or sitting. Patients states she feels this pain is related to muscle tension and alignment issues, as she “feels unveven.”

At initial evaluation, current complaints were of right hip and lumbar spine pain (around L3/L4 area), as well as foot pain, worse with most activity, not relieved with foot wear, and limited all fitness activities. Patient stated her pain on a verbal analog scale (VAS) from 0 to 10 (0 being no pain and 10 being the worst pain imaginable) as the following: SIJ – current 2/10, best 0/10, worst 5/10; Lumbar spine – current 3/10, best 1/10, worst – 6/10; Hip – current 3/10, best 2/10, and worst 6/10; and Foot – current 6/10, best 2/10, and worst 6/10. Reported no mechanism of exacerbation aside from normal daily activities as a physical therapy student, which included sitting for long periods of time studying. No neurological signs or symptoms of note, except occasional number and tingling in her foot when doing the elliptical at the gym, but since pain began, she had not been able to participate in her normal gym activities, so she had not experienced this recently. She had not seen a physician for her pain, nor had any other consultations or interventions. Specifically, the patient stated she was fully aware that her primary complaints were of a chronic problem that she needed to have addressed appropriately once and for all. The clinician administered the Patient Specific Functional Scale (PSFS), which has been reported to be valid, reliable, and responsive in populations with knee dysfunction, cervical radiculopathy, acute and mechanical low back pain, and chronic conditions.[15] The ICF activity component is most commonly represented by patient-nominated PSFS items.[16] The patient was asked to identify up to five important activities that she was having difficulty with or was unable to perform, and then rate the current level of difficulty associated with each activity on an 11-point scale, 0 (“unable to perform activity) to 10 (“able to perform activity at same level as before injury of problem”). The patient reported difficulty with walking (5/10), running (0/10), dancing/Zumba without shoes (2/10), and dancing/Zumba with tennis shoes on (3/10) for a total PSFS score of 2.5 for the initial assessment.

Examination and Evaluation

Informed consent for treatment was obtained and the case report had approval through the Human Subjects Research Review Committee at The University of North Carolina at Chapel Hill. The subject signed a photo release for publishing rights of pictures to accompany the case report. Results of the objective examination are summarized in **TABLE 1**.

TABLE 1 OBJECTIVE MEASURES FROM INITIAL EXAMINATION

Test	Result
PROM (right, left)	
Hip flexion	WNL Bilaterally
Hip extension	WNL Bilaterally
Hip external rotation (90/90 position)	65°, 65°
Hip internal rotation (90/90 position)	25°, 35°
Ankle DF (in knee flexion)	-10° to neutral bilaterally
Ankle DF (in knee extension)	-30°, -25°
Forefoot Measurements (right, left)	
Forefoot varus	17°, 15°
Rearfoot varus	3°, 2°
Hallux extension	40°, 45°
Active Lumber Movement	
Flexion	Hyper-flexible – can touch palms to floor; exhibits slight deviation to the L
Extension	Full; apex of the curve in thoracic spine
L Side-bend	Fingertip to inferior pole of patella, apex of curve at L2
R Side-bend	Fingertip to top of patella, apex of curve at thoracolumbar junction; produces back pain on the L
L rotation	25%; produces stretch but not pain
R rotation	25%; produces pain on L
L rotation (from below)	75%
R rotation (from below)	75%
Muscle Length Tests (right, left)	
90-90 Hamstring Test	Normal bilaterally
Ober's Test	Positive (3 inches from medial condyle to floor), Positive (4 inches from medial condyle to floor)
Thomas Test	Positive (-22°), positive (-15°)
Ely's Test	Positive (10 inches from heel to buttock), Positive (15 inches from heel to buttock)
Strength Testing (right, left)	
Hip adduction (with IR)	4-/5; 4/5
Hip abduction (with ER)	4-/5; 4/5
Hip extension	4+/5; 4+/5
Palpation	
Lumbar paraspinals	No tenderness noted
Greater Trochanter	TTP, L>R
Iliotibial band	TTP, L>R
ASIS	TTP, R>L
PSIS	TTP, R>L
Iliac Crest	TTP, R>L

Standing Static Postural Observations (see photo)	
Shoulder height	R shoulder height higher when compared to L
Scapula	R scapula more protracted when compared to L
Iliac crest	R lower than L
Popliteal crease	R lower than L
Special Tests (right, left)	
Neurologic screen	
Slump Test	Negative bilaterally
LE myotomes (L2-S1)	Normal bilaterally
LE reflexes (L4/L5)	Normal bilaterally
Dermatomes (L2-S1)	Normal bilaterally
Clonus (L3)	Negative bilaterally
Babinski sign (S1)	Negative bilaterally
FABER	(-) but with pelvic compensation; (+) with pain localized to R SIJ
FADIR	
Scour	(+) bilaterally
SIJ Provocation (right, left)	
Compression	(+), (-)
Gapping/Distraction	(+), (-)
Thigh Thrust	(+), (-)
Gaenslen's Test	(+), (-)
Standing Flexion Test	(+), (-)
Gillet Test	normal on the R; L side displays L posterior rotation
Prone Instability Test	(-)
Sign of the Buttock	(-)
Joint Play Assessment (spinal level) [P/A mobs]	
L1-L2	Normal mobility
L2-L3	Normal mobility
L3-L4	Normal mobility
L4-L5	Normal mobility
Beighton scale	
Genu recurvatum greater than 10°	Positive
Elbow extension greater than 10°	Negative
Wrist flexion with thumb touching forearm	Positive
5^{th} MCP extension to 90°	Positive
Palms to Floor	Positive

Of note specifically, the patient had within normal limit (WNL) hip motion bilaterally, with the exception of hip external rotation (which was 65° bilaterally, 20° more than the normative range) and hip internal rotation (which was 25° on the right and 35° on the left, 20° and 10° less than the normative range, respectively). Dorsiflexion range of motion, tested with the knee in extension, was decreased bilaterally. Lumbar range of motion testing revealed 100% range of motion of all movements with the exception of left and right rotation, which were both 25% limited. Additionally, lumbar flexion revealed a deviation to the left when performing this motion, consistent with an observed left lateral flexion in static stance.

Hamstring flexibility tested in the 90-90 position was normal bilaterally. She had a positive Ober's test bilaterally, the left side demonstrating less flexibility than the right. Her Thomas Test was positive bilaterally, the right side demonstrating less hip flexor flexibility than the left. Lastly, she had a positive Ely's test for rectus femoris flexibility bilaterally, left greater than right.

Manual muscle testing revealed decreased strength in bilateral hip adductors and abductors, right side weaker than the left (4-/5 on the right vs. 4/5 on the left for both hip adduction and hip abduction), as well has for hip extension which tested at 4+/5 bilaterally.

Palpation revealed that the patient was tender to palpation over the greater trochanter and iliotibial band, increased on the left when compared to the right for both. Iliotibial band palpation tenderness coincided with the decreased flexibility on that side when compared to the right. Palpation of the anterior superior iliac spines (ASIS), posterior superior iliac spines (PSIS), and iliac crests revealed the opposite, in that they were all more tender to palpation on the right when compared to the left. Decreased flexibility of the right hip flexors in comparison to the left coincided with increased tenderness to palpation of the right ASIS compared to the left ASIS. Lumbar paraspinals revealed increased tonicity but were not tender to palpation.

Her static standing postural observation (see **FIGURE** 1) revealed the following: her left shoulder appeared lower while the right shoulder appeared higher, her right scapula was more protracted than the left, her right iliac crest was lower than her left iliac crest, and the right popliteal crease was lower than the left.

The standard neurological screen was negative for any neurological signs and symptoms. Special testing revealed positive FABER on the right, positive Scour test bilaterally, positive standing flexion on the left, and positive Gillet test on the left (and revealing a posterior rotation on that side). Sacroiliac joint provocation tests revealed three out of four positive tests, indicating a reliable assertion of sacroiliac joint dysfunction according to the literature.[17] Joint play assessment of the lumbar spine did not reveal any restriction or provoke any pain.

Upon patient asserting that she had been told she was hypermobile, and noting her hypermobility of lumbar flexion range of motion, the Beighton variables were assessed, with the patient scoring 7/9.

Lastly, upon observing asymmetrical bony landmarks, clinical assessment for a limb length inequality was initiated. The result of this exam are outlined in **TABLE 2** and **TABLE 3.** This direct method of tape measurements of bony landmarks was used because it is the clinician preference of the physical therapist administering these measurements, who has been using this method in her clinical practice daily, and who has been a practicing clinician for over 20 years, increasing the intrarater reliability of these measurements. Each measurement was taken 3 times, and the average of the three measurements was reported. Measurements were taken using a new, standard woven tape measure.

Table 2 BONY LANDMARK MEASUREMENTS IN SUPINE	**Right Lower Extremity**		**Left Lower Extremity**	
	Average of 3 (in centimeters)		**Average of 3 measurements (in centimeters)**	
Landmarks	**Pre-orthotic Intervention**	**Post-Orthotic Intervention (Worn for 21 days)**	**Pre-Orthotic Intervention**	**Post-Orthotic Intervention (Worn for 21 days)**
ASIS to medial malleolus	79.5 cm	79.8 cm	81.8 cm	80.2 cm
ASIS to lateral malleolus	80.7 cm	81 cm	82.7 cm	81.4 cm
Greater Trochanter to medial malleolus	73 cm	Not measured*	74.5 cm	Not measured*
Greater Trochanter to lateral malleolus	71 cm	Not measured*	72.5 cm	Not measured*
*A second measurement was not taken because this measurement should not change secondary to orthotic wear				

Table 3 BONY LANDMARK MEASUREMENTS IN STANDING	**Right Lower Extremity Measurements (centimeters)**		**Left Lower Extremity Measurements (centimeters)**	
	Average of (3) Measurements		**Average of (3) Measurements**	
Landmarks	**Pre-Orthotic Intervention**	**Post-Orthotic Intervention (Worn for 21 Days)**	**Pre-Orthotic Intervention**	**Post-Orthotic Intervention (Worn for 21 Days)**
ASIS to Floor (natural stance)	84.5 cm	83.5 cm	85.3 cm	84 cm
PSIS to Floor (natural stance)	88 cm (anterior rotation noted)	86.5 cm	87 cm (posterior rotation noted)	86.4 cm
Iliac Crest to Floor (natural stance*)	90.5 cm	91 cm	91 cm	91 cm
Greater Trochanter to Floor (natural stance*)	71.1 cm	71.3 cm	74.3 cm	74.5 cm
*Natural Stance is defined as “Standing naturally, as one would normally stand.”				

Diagnosis

Patient presented with chronic history of right hip, lumbar spine, and bilateral foot pain, with recent exacerbation limiting functional and recreational mobility tasks. Upon physical therapy evaluation, patient displayed decreased muscle strength in bilateral hip abductors, adductors, and extensors. The patient demonstrated aberrant lumbar flexion range of motion to the left. The patient also demonstrated a 1.5 centimeter difference in limb length, left longer than right, as indicated by the measurements of greater trochanter to medial malleolus and greater trochanter to lateral malleolus. Measurement from ASIS to lateral malleolus indicated a 2 centimeter difference between the left and right lower extremities, the left again the longer of the two.

Intervention

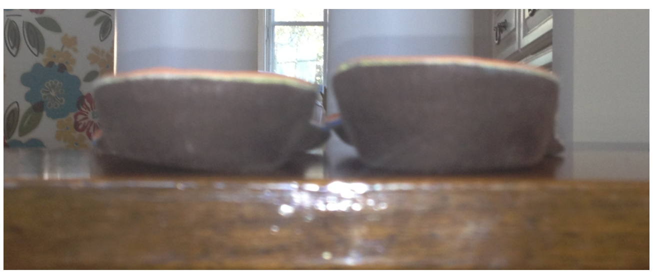
The successful management of many sport-related injuries by the use of orthoses, reported in some clinical studies, have shown them to be very effective in providing symptomatic relief of lower extremity complaints arising from biomechanical abnormalities, such as excessive pronation or limb length inequality. [18] Lift therapy helps correct a limb length inequality and results in symptom resolution for patients complaining of low back, sacroiliac joint, and hip pain. [13] Implementation of lift therapy for limb length inequality is currently based on clinical judgment and experience. A uniform protocol for intervention has not been established, but guidelines regarding the implementation of lift therapy have been recommended. [13] The patient in this case report was given a full length insert that was matched for arch length for the sole. On the right, there was an addition of 1/8th of an inch of heel lift made of polypropylene shell with corax rearfoot post, with a deep heel cup. She was given an insert for the left as well, which included only a 6° forefoot wedge to correct for forefoot varus. The right insert also had a 4° rearfoot wedge and a 4° forefoot wedge. (See **FIGURES 2 & 3**)

Following 21 days of wear and successful outcomes, the specifics were sent off to have a custom-orthotic made by a lab. (**FIGURE 4)**

FIGURE 2

FIGURE 3

FIGURE 4



In addition to the orthotic management, the patient was given a home exercise program that included stretching of her gastrocnemius in subtalar neutral, with her knee extended, allowing no bend as to compensate for her lack of dorsiflexion range of motion; bilateral hip abduction in side-lying; heel raises to strengthen her plantar flexors; stretching of the right hip flexors and left iliotibial band; and a self muscle energy technique (self-MET) which consists of a single-leg bridge with the right lower extremity (using the hamstrings to posteriorly rotate the right innominate) and flexion of the left hip, resisting with her hand against a slight to moderate contraction (to use the iliopsoas to anteriorly rotate the left innominate). This self-MET has since been modified in order to take the hamstrings and iliopsoas out of a shortened position in order to avoid any possible reinforcement of the innominate rotation. She now performs this self-MET with the right hip flexed and resisting hip extension with the hamstrings, while extending the left leg and performing a miniature straight leg raise to activate the iliopsoas. Inclusion of hip abductor strengthening bilaterally and left iliotibial band stretching was important to this case report because hip muscle imbalance has been implicated in many lower quarter impairments. [19] Fredericson et al. found that knee internal rotation was greater in those with ITBS, but due to increased femoral external rotation, not due to tibial internal rotation, likely due to muscle imbalances at the hip. [20] Insufficient activity of the gluteus minimus, anterior fibers of the gluteus medius, and tensor fascia latae which serve to abduct and internally rotate the femur can lead to increased femoral external rotation. [20] Neuromuscular function (strength and activation) of the hip musculature is essential to providing proximal stability for lower extremity motion. Neuromuscular deficits may compromise the stability of the hip when it is loaded during weight bearing, resulting in faulty dynamic alignment of the lower extremity and potentially increasing the risk of injury. [19] Decreased strength and activation of the hip abductors has been reported in those with low back pain and lower extremity injuries. Injured athletes have been reported to have decreased strength in the hip abductors and hip extensor musculature as compared to uninjured athletes, resulting in adduction and internal rotation of the hip and knee valgus, commonly termed “functional valgus collapse.” [19] The relationship between lower extremity alignment, neuromuscular function of the hip, and dynamic hip and knee motion is important because one skeletal malalignment may cause compensatory alignment changes at other bony segments, resulting in abnormal stress patterns or compensatory motions along the kinetic chain. [19]

Outcomes

The structural response to the orthotic intervention used in this case report are detailed in **TABLES 2 & 3.** After 21 days of orthotic wear, the patient demonstrated a leveling effect upon re-measurement of the same bony landmarks, with attainment of measurements that demonstrated symmetry between left and right lower extremities. This coincided with a complete resolution of her musculoskeletal complaints, and return to her functional mobility tasks and recreational hobbies without pain. When asked to re-rate her pain on the verbal analog scale, her rating were as follows: SIJ – current 0/10, best 0/10, worst 0/10; Lumbar spine – current 0/10, best 0/10, worst – 0/10; Hip – current 0/10, best 0/10, and worst 2/10; and Foot – current 0/10, best 0/10, and worst 1/10 (unless she attempts to go barefoot, while not wearing her prescribed orthotic). Currently she is able to participate in Zumba fitness class and a boot-camp on a regular basis with no complaints. Additionally, post-assessment scores on the Patient Specific Functional Scale were: difficulty with walking (10/10), running (5/10), dancing/Zumba without shoes (5/10), and dancing/Zumba with tennis shoes on (10/10) for a total PSFS score of 7.5. This indicated a statistically significant change in the patient's impairment level according to the International Classification of Functioning, Disability, & Health (ICF). [15,16]

Discussion

Radiologic methods are generally accurate and reliable, but their widespread clinical and scientific use has been limited, partly at least, by the objectionably large exposure to radiation, rendering these methods unethical for major screening studies, especially for young and fertile subjects. [6,10] While radiologic methods are the most accurate method for proving limb length inequality, the methods used in this case report were those used in the clinic with tape measure due to clinician preference and experience with performing those measures.

At this time, there is no real reliable method to asses for pelvic torsion, but many studies have cited the occurrence of a posteriorly-rotated innominate on the side of the long limb in the presence of a limb length inequality [11], which is consistent with observations made in the case of this patient. The effects of a limb length inequality on pelvic torsion, as well as on the lumbar spine itself are thought to contribute to the presence of low back pain in patients who demonstrate a LLI. The normally symmetrical sinus curve formed by the center of gravity when walking or running is distorted in the case of LLI, and the lumbar curve swaying from one side to another is asymmetrically inclined, thus subjecting the lumbar spine to continuous asymmetric bending and rotating torques. [10]

Additionally, due to the pelvic torsion, the hip joint of the longer lower extremity is in varus position (this may be confirmed with the aid of Wiberg's angle), which decreases the load-bearing articular surface of the hip joint, resulting in greater pressure per articular unit area and promoting chondral damage and/or unilateral arthrosis of the hip on the long leg side. [10] Pauwels has demonstrated that LLI of onehalf inch (12.7 millimeters) can change the angle of Wiberg of the hip on the side of LLI by as much as 2.3°, and this change is enough to upset the normal joint mechanics and eventually lead to degenerative osteoarthritis of that hip. [12] Due to our patient's age and amount of time and physical activity performed with the asymmetry, there is the potential for some damage to the cartilage in the R hip, which could explain why our patient still experiences some degree of pain in her hip, despite physical therapy and orthotic management of her limb length inequality. The patient's right iliac crest was observed to be higher in comparison to the left iliac crest, coinciding with research that demonstrates that the iliac crest on the side of the longer lower extremity is higher than the iliac crest on the side of the shorter lower extremity. [6]

Treatment of pelvic torsion 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. [21] 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. [21] METs have been shown to relax muscular spasm, stretch shortened muscles, mobilize restricted joint, and increase fluid mechanics. [22] These techniques use active contraction of deep muscles that attach near the joint and whose line of pull can cause the desired accessory motion. [22] 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. [23] Descriptions of the *many* METs that have been described for the pelvic girdle complex are beyond the scope of this case report, but many of the maneuvers used for evaluation of the sacroiliac joint dysfunctions can also be used to correct the asymmetries.

Specific balanced muscle groups are fundamental to balancing the pelvis and lumbar spine.[23] 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.[23] 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.[23] 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.[23] The main muscles and muscle groups of the pelvic-hip complex that are prone to tightness include the erector spinae, quadratus lumborum, rectus femoris, iliopsoas, tensor fascia latae, piriformis (decreasing the stability of the sacrum between the innominates), short hip adductors, and hamstrings.[23] 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.[23]

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.”[24] 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.[24] 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.[24] 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.[25]

Conclusion

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. [25] A case report cannot draw definitive cause and effect relationships, hence the level of evidence that is assigned to them. This case, does however, highlight the importance that limb length inequality, even minor, can have on alignment characteristics of the entire lower quarter, and how treatment aimed at correcting a limb length inequality has led to resolution of all lower quarter impairments in a young, active female.

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