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Analysis of Pelvic Alignment Patterns Utilizing the Postural Restoration Institution Approach

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Abstract

Background: Low back pain is a common problem that can include injury to the sacroiliac joint (SIJ) with 15-30% of cases arising from LBP. Treatment for SIJ includes muscle energy. A newer approach from Postural Restoration Institution (PRI) centered around pelvic patterns alignment has also been used. There's limited research found describing the prevalence of pelvic patterns within populations with PRI method.

Purpose: To examine prevalence of pelvic patterns and investigate a relationship of low back pain. Furthermore, to explore the specific patterns closely and the ability to re-align pelvic patterns by utilizing PRI repositioning exercises.

Study Design: Cross sectional study

Methods: Individuals 18-26 years of age who met ACSM criteria of physically active. Participants filled out demographic survey on amount/type of physical activity they partake in as well as experience of LBP during physical activity accompanied with an Oswestry Disability questionnaire. Two special test, Adduction and Extension Drop Test were performed to determine pelvic pattern.

Results: High prevalence of PEC pattern (29/30) was noted with unsuccessful repositioning following intervention. Subjective data reported of less restriction in hip motion following the intervention with no change in ADT. No significance was found with LBP and pelvic patterns or physical activities participated in.

Conclusion: We found high prevalence of PEC patterns in the physically active college age population. No differences from report of LBP history to pelvic patterns were found. There were no true changes of any pelvic patterns but anecdotally reported less restriction in lower extremities following intervention.

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Chapter One:

Low Back Pain and Postural Restoration Institute Literature Review

EPIDEMIOLOGY AND INCIDENCE RATE OF LOW BACK PAIN

Low back pain is found to be a common problem within the general population specifically in western societies.[1-3], Research shows up to 80% of people will experience one episode of low back at some point in their life.[1,4-7] Researchers at the Mayo Clinic in Minnesota have found there to be lifetime incidence of low back pain to range 51%-84% worldwide.[8] Some international researchers have also concluded that it is the leading cause of disability among adults worldwide as well as the leading cause for activity limitation and work absence.[2,3,6,8,9] In a review article covering the epidemiology rate of low back pain (LBP) in Australia, the researchers stated that individuals with activity-limited LBP lasting greater than one day, will experience more recurring episodes that last longer in duration and may contribute to increased disability.[3] Researchers have also found that acute cases of LBP tend to resolve on their own within a 2-6 weeks[1,2,10], however, only 10-40% of those acute cases will become chronic in nature.[4] Another study covering general low back pain reports lifetime recurrences up to 85% in individuals who experienced frequent or long-lasting complaints of pain in the past.[2,11]

Multiple researchers have stated that there are many factors that go into the development of LBP and can influence the intensity and duration. The most common risk factor stated in research is age.[3] A review article out of Australia found that the prevalence of LBP increases from the 3rd decade up until the age of 60 or 65 years old.[3] However, Waddell's study that focuses on treatment of low back pain, refutes that age does not progressively increase with age

and in fact LBP peaks at about 40 years.[1] Gender also has shown to be linked with LBP but with mixed results within the literature. The study previously described, has stated from multiple international researchers that there is no significant difference in the prevalence rate between genders.[3,12] Some studies show that depending on confounding factors such as ergonomic and occupations, women are more likely to have a higher prevalence of LBP than males.[9] Similarly, the same study comparing genders and the prevalence rate of LBP according to age, showed males had higher incidence rate as they got older.[9] Another systematic review from the American Family Physician journal found that occupations that required individuals to lift or move heavy loads, bend or twist frequently or be involved in some whole body vibration work setting are risk factors for low back pain.[6,11]

Outside of the general confounding factors, some literature also states that psychosocial factors affect LBP.[2,6] Factors such as stress, anxiety, and depression have been shown in few studies to be associated with greater rates of LBP.[3,6,7] Throughout a review study in Australia, they found from multiple studies that the three psychosocial factors listed before were significantly related to the changing of acute pain into chronic LBP.[3] One study focusing on maladaptive movement and motor control impairments brings to light coping strategies and how they relate to increasing LBP.[4] Strategies such as negative thinking, pathological fear and abnormal anxiety, avoidant behavior, and catastrophizing have been linked to LBP by increasing the pain levels and associated disability followed by muscle guarding.[4] Another systematic review found that factors such as functional impairment, psychiatric illness and low general health were predictors for people to experience low back pain within a year.[11]

Sacroiliac Joint Incidence/Prevalence Rate

The sacroiliac joint is often overlooked or underrepresented as a source of low back pain.[13] A focused review article from 2006 reported that sacroiliac joint pain was a primary source of low back pain in the early 20th century.[14] It is estimated that 10%-38% of low back pain is caused directly or is a source of the sacroiliac joint.[15,16] One study that describes the biomechanics of the sacroiliac joint also confirms that the SIJ is the source of LBP in about 15%-30% of cases and the prevalence of LBP is higher because of it.[13] A comprehensive review study from 2005 reported that the dominant way to observe for prevalence was through diagnostic imaging including fluoroscopically guided injections or computed tomography.[17] The researchers from that study also stated that 16%-30% of subjects throughout three different trials fell into the sacroiliac dysfunction criteria.[17] Researchers from a clinical study out of Asia went further to state that 72.3% of individuals who presented with lumbar disc herniations also were positive findings for sacroiliac joint dysfunction.[18] There is little to no evidence to state the common findings of inward or outward flares or rotations of the iliac crests.

Cause of Non-specific Low Back Pain

The cause of back pain has been widely disputed in the literature. Generally, there are two routes to go when classifying LBP: 1) specific low back pain referred to as Patho-physiological or 2) non-specific low back pain.[2] Some researchers have described non-specific low back pain to be a diagnosis without concerning causes such as tumors, fracture, infection, inflammatory arthritis or cauda equina.[11] One focused review out of the Mayo Clinic of Minnesota refers to non-specific low back pain as axial LBP that results in pain caused from intervertebral discs, facet joints or paraspinal musculature.[8] Another study suggests that a large portion of disorders labeled as non-specific chronic low back pain represent a large group of

tissue strains and sprains that have not healed beyond normal time.[4] Multiple studies go on to say that these are also a few of the red flags signs, that if found in an individual's evaluation, should raise for concern for other life serious injuries.[6,8,11]

One study describes non-specific low back pain as symptoms without clear specific cause or an unknown origin.[2] Another study conducted by the Mayo Clinic of Minnesota states non-specific low back pain can stem from structure such as intervertebral discs, facet joints, sacroiliac joints and paraspinal musculature that they label axial LBP.[8] However another study focusing on the effects of visceral osteopathic manual therapy, discuss non-specific low back pain to be caused by tension or musculature stiffness that appears without any specific pathology.[7] For injuries disc related, patients tend to report localized pain to the midline of the spine with some referral patterns to the upper thigh.[8] Some researchers say that facet joint pain can also be localized to the midline in association with or without radiation to the groin thigh or past the knee.[8] Sacroiliac pain is often reported as gluteal or low lumbar/paraspinal pain that could mimic the radiation of facet pain.[8] In conjunction with SIJ pain, musculature pain can also have referral symptoms into the buttock.[8]

Other researchers have discussed that a big factor in non-specific low back pain is caused by instability.[19] They state that in some cases where there is no evidence of fractures, it can be deemed functional instability, which they coin as no defect in the architecture of the lumbar spine with no excessive translation or rotation.[19] The researchers from that same study report the clinical tests suggested for functional instability come from the 'Clinical Practice Guidelines linked to the International Classification of Function, Disability, and Health from the Orthopedic Section of the American Physical Therapy Association'.[19] The most commonly used clinical test include the prone instability test, passive lumbar extension, Aberrant Movements pattern,

posterior shear test, prone bridge test, the supine bridge test and the Active straight leg raise test.[19]

In one study focusing on the clinical diagnostic approach to chronic low back pain, they lump in the dominant clinical tests for sacroiliac joint dysfunction.[20] They state that the SIJ is often considered a major cause of low back pain, but like many other researchers, it's a difficult condition to confirm a diagnosis.[20]

Sacroiliac Joint Pain

Evaluation of the sacroiliac joint should always be included when there is suspicion of low back pain. With the connection and load transferring junction between the upper body to the lower body through the pelvis, this can lead to asymmetry, which as a result could be a reason for low back pain.[21,22] One review article discussing the diagnosis of SIJ pain states that motion along the SIJ is not liner, it occurs simultaneously in multiple planes.[15] The most discussed mechanisms of SIJ injury include a direct fall on the buttock, rear-end or broadside motor vehicle accident, or a step into an unexpected hole or miscalculating step off from a height.[8,13,14] Some researchers even state that a mechanism combining axial loading and abrupt rotation in conjunction with previously stated mechanisms can cause further SIJ injury.[13] In a study comparing test results in patients with and without back pain, they describe that a displacement of one innominate can cause a positional change within the SIJ.[21] As a result, this adds to the stress on the SIJ creating a torsion on the structures, causing a whole dynamic shift of the anatomy.[21] As a result, this can cause a limb length discrepancy that further leads to changes of stresses and force sustained by the affected leg.[13] However, the pain patterns described in a comprehensive anatomy review of the sacroiliac joint stated the most common patterns for referral of pain were radiation into the buttock, lower lumbar region, lower extremity and

ipsilateral groin pain.[15,17] Other researchers say that most common spot of SIJ pain is just inferior to the posterior superior iliac spine.[14] As a result, making it difficult for clinicians to differentiate between SIJ region or lumbar region injury.

To help clinicians differentiate between LBP and SIJ injury, the use of diagnostic testing is key. A review article discussing the diagnosis for sacroiliac joint pain reports a possible gold standard for diagnosing SIJ is through the use of image guided injection of a local anesthetic.[15,16] However, other researchers disagree with this aspect stating that there is no gold standard set, and for local anesthetic injections is too costly for some to use diagnostically.[23] Other researchers have stated that without image guided technologically, for a true diagnosis of sacroiliac joint dysfunction, a clinician needs to have three positive special tests that determine the injury as SIJ dysfunction.[15,17,21-23] In a review article demonstrating four clinical tests on innominate torsion, stated that the common tests utilized for SIJ torsion are the posterior superior iliac spine (PSIS) level assessment in sitting and standing, Gillet test, standing flexion test and sitting flexion tests.[21] These tests are all used dynamically to access the motion of the sacroiliac joints either sacrum moving on innominate or innominate on sacrum.[21] However, some researchers have discussed that some of these special test yield rather low sensitivity or specificity for true SIJ pathology.[14,17] Outside of the torsional tests and injuries, other diagnostic special tests should be used in conjunction. Some common provocation tests of the SIJ include Patrick's (FABER) and Gaenslen's test as well as compression and distraction of the innominate bones.[14,17] All of these test provide some compression stress on the SIJ, indicating joint irritation or sprain of the surrounding soft tissue.[24] One review article from 2020 states that the previously discussed provocation tests along with the thigh thrust have a high degree of sensitivity and specificity.[15] They conclude that with the three or more tests needed to be positive, on must be

the thigh thrust or compression test.[15] They further stated this yields a sensitivity of 85% and specificity of 76%.[15]

Anatomy of the Lumbar Spine and Sacroiliac Joint

The low back is a complex section of the body due to the orientation of the anatomy involved. The lumbar vertebrae are the strongest and thickest portion of the spine.[24] The lumbar section consists of five vertebrae. Bony anatomy of the vertebrae consists of the spinous process, transverse process and the facet joints located in the posterior aspect and the intervertebral disc primarily located in the anterior section. The intervertebral disc is located to the adjacent vertebrae above and below and is an avascular structure that allows movement of the vertebral bodies, as well as act as a shock absorber.[24] The intervertebral disc consist of two parts. The outer layer called annulus fibrosis is a dense ring of layered collagen fibers that helps to resist tensile forces.[8] The inner portion called nucleus pulposus, contains collagen and elastin fibers in a gel-like state.[8] Both sections of the intervertebral disc play a huge role in pathological injuries such as disc degeneration, compression injuries, and rotational stresses.

The muscles of the low back along with the abdominal musculature help to provide stabilization and movement of the whole trunk. The abdominal muscle primarily responsible for flexion is the rectus abdominis, with the external oblique and internal oblique providing lateral bending and torsional movement.[8] The prime extensors of the whole spine include erector spinae, serratus posterior inferior, and the latissimus dorsi superficially and the multifidus and quadratus lumborum deep to the spine.[8] The superficial muscles span a wide number of vertebrae, whereas the deeper muscles only connect to a few of the lower vertebrae. Other important muscles of the lower spine area include the psoas and iliacus muscles which join

together at the lesser trochanter of the femur, commonly referred to as the iliopsoas. The iliopsoas helps maintain upright and erect posture as well as helps to flex the hip joint.[8]

With close proximity of the pelvic girdle to the lumbar spine, anatomy of the lesser half has to be reviewed in conjunction with low back pain. The pelvic girdle consists of three portions such as the hip joint, sacroiliac joint and the pubic symphysis.[24] The sacroiliac joint (SIJ) lies directly inferior to the lumbar spine and helps to connect the spine to the pelvis. The sacrum is positioned along the midline in between the ilium of the left and right hemipelvis. Together, these two bones are held together by a fibrous capsule at each adjoining point followed by numerous ligaments.[13] The interosseous ligament also helps to connect the sacrum and ilium together around S1 and S2 levels. Ligaments notably found posteriorly of the pelvis are the sacrotuberous and sacrospinous ligaments as well as the long posterior sacroiliac ligaments that consist of multiple bundles. Anterior structures include the iliolumbar ligaments that originate off the 5th lumbar vertebrae, as well as the anterior sacroiliac ligament.

Muscle involvement within the sacroiliac joint is unique in the sense that no muscle acts on the SIJ itself, but rather surround the joint and pelvis. Some researchers say that the pelvis and SIJ are surrounded by the largest and most powerful muscles within the human body.[13] Muscles that stem from the lumbar or spinal aspect are the erector spinae, multifidus, quadratus lumborum, and psoas as well as the abdominals (transverse and obliques.) Muscles that originate around the pelvis and sacrum and attach inferiorly include glutei, piriformis, and hamstrings (bicep femoris, semitendinosus.) The pelvic floor muscles (levator ani and coccygeus) lining the bottom of the pelvis also help to provide stability of the whole pelvic region.[13] Other important muscles that act on the pelvis and hip joint include the quadriceps, adductors (longus, brevis, gracilis), Iliacus, sartorius and tensor fascia latae.

Anatomical Difference Males Versus Females

Depending on the gender, the makeup of human anatomy varies within the pelvic region. In a study describing the biomechanics of the sacroiliac joint, males are commonly known to have a long and narrow pelvis as compared to females.[13] They also found that male SIJ have a relatively greater surface area then females, allowing them to withstand greater loads.[13] Another article describing the anatomy and physiology of the SJI, stated that male sacroiliac development is a functional adaptation to the changing forces over a lifetime.[14] Which agrees with the previous study, explaining that males tend to have on average 40% less motion than females.[13] As a result, less motion leads to thickening of the ligaments and decreased mobility.[13,14] Females however, are more likely to have higher mobility due to a greater pubic angle and a less pronounced curve in the SIJ.[13] This is an effect of the hormone influence, relaxin which is stated to allow greater pelvic ligamentous laxity, allowing that greater motion.[13,14,17] As a result, the increase of relaxin hormone provides females the ability of natural childbirths.[13] However, the researchers have found that from hormone influences, predisposes women to a greater risk of pelvic pain and hypermobility.[13,14]

CLINICAL SPECIAL TESTS

Non-Specific Low Back Pain

Clinical tests geared specifically towards a back evaluation can have a wide range of diagnoses. For non-specific low back pain, there is not one standard test to perform, given that it does not have a specific diagnosis. Researchers say that the most widely back clinical test used is the straight leg raise test[8,19,20] with the literature of one review study stating the sensitivity is 64% with a specificity of 57%.[8] Another review article found the straight leg raise to have a sensitivity of 91% and a specificity rating of only 26%.[6] One study looking at the inter and intra

tester reliability of lumbar clinical test stated that the straight leg raise has an inter-rater reliability of 0.78 and intra-rater reliability of 0.78 as well.[25]

The straight leg raise test is used to identify sciatic nerve root irritation that can result from a possible disc herniation, muscle spasm, facet pathology or inflammation.[24] The straight leg raise test is performed in the supine position, and is completed passively by the clinician. The involved leg's hip is placed into internal rotation and adduction with knee in full extension.[24] Clinician will slowly lift the leg upwards until the patient reports pain in the back of the leg and is then repositioned just before pain is elicited and applies dorsiflexion of the foot.[24] A positive test will result in the patient reporting pain during the leg lift.[24] Shultz [24] also states that depending on where the patient feels the pain during the lifting, can be an indicator of the pathology that could be causing the symptoms. Such as 30% of range of motion leads to disc involvement, and pain felt from 50%-70% can be an indicator of nerve irritation without disc involvement.[24]

Another test or modification to the straight leg raise is the bowstring test. It is described as once a discomfort is met with a leg raise, the knee is slightly flexed, resulting in decreasing the symptoms.[20,24] However once the clinician applies pressure to the popliteal fossa, symptoms can reoccur and counts as a positive test.[20,24]

Adduction Drop Test vs Ober's Tests

Most clinicians know an orthopedic test called Ober's and have probably used it periodically in their own practice. The researchers from a study focusing on hamstring and abdominal muscle activation with a positive Ober's test, describes the history of the test and how it came about from an Orthopedic spine surgeon by the name of Frank R. Ober in 1937.[26] At that time, the test was determined to be used to assess the passive hip adduction range of motion in

all patients.[26] Throughout that same study with hamstring and abdominal activation on a positive Ober's test, found that Ober himself discovered that a tight iliotibial band (ITB) wouldn't allow a patient to have full passive adduction of the femur and increased the lordotic curvature in the spine.[26] Those researchers later discusses that Ober found that if he surgically excised a tight ITB, it would ultimately enhance the passive range of motion (ROM) seen in passively adducted hip.[26] Many researchers in present day explain that the Ober's test determines if the ITB or tensor fasciae latae (TFL) muscle is in contracture or in a shorten position and determines if those structures should be stretched.[26-28]

The Ober's test is described as the following: patient is lying on their side with hips and knees in 90° of flexion. The examiner performing the test for the patient will then passively flex, abduct and then extend the top hip to neutral all while maintaining the knee flexion. Some literature refutes that the knee has to stay in an extended position during the Ober's test, as it puts the ITB in a greater stretch as compared to a flexed knee; putting more stretch on the femoral nerve instead.[27] A great deal of the literature says to maintain the top innominate aligned over the bottom, allowing the pelvis to say stacked on top of one another throughout the motion.[24,29] According to some researchers they describe that a positive test would be indictive with the limb unable to fully adduct beyond the midline of the body.[30] Consequently, a negative finding would show that the limb is able to lower until the knee rest on the table, crossing over the midline. Jackson et al.[30] also states that a positive test traditionally indicates the limited extensibility of the ITB.[30]

However, Jackson et al.[30] also states that the knowledge obtained from the Postural Restoration Institute utilizes this test to identify different properties. Some studies describe that instead of a soft tissue outlook, the PRI belief is that a positive Ober's test actually indicates an

impingement of the posterior inferior femoral neck on the rim of the acetabulum, leading a negative test to indicate a neutrally positioned innominate and acetabulum.[26,30,31] One study looking at hamstring and abdominal activation confirmed through their study that the Ober's test may indicate a lumbopelvic complex that is not in a neutral position.[26] Some of the literature has mentioned that the clinical findings after performing an Ober's test should be reconsidered with some saying that the test should only be used for finding a bony block, rather a soft tissue extensibility issue within the ITB.[30,32]

Extension Drop Test

The extension drop test or commonly known to clinicians as the Thomas test are thought to be interchangeable. However, reputable researchers describe the Thomas test as an orthopedic special test indicated more for flexibility of the hip flexors.[27] They also describe the execution of the Thomas test differently than others stated in some of the literature.[27] For a Thomas test described by Schultz, they instruct the patient to lie supine on a table and to bring one knee up to their chest.[27] They are then instructed to flatten their back to the table with the knee fully flexed into the chest. A positive finding during this test is described to be if the extended leg (opposite than one pulled into chest) becomes flexed so the thigh is no longer resting on the table.[27] They also go into detail saying if there is overpressure applied to the extended leg now in a flexed position, you would see the pelvis rotate anterior, increasing the lumbar lordotic curve.[27] Other researches who have looked at the Ober's test in a speed and power assessment also agrees with Schultz on the conducting the Thomas test as stated above.[30]

Researchers from a particular article utilizing the Postural Restoration Institute techniques on a rotator cuff case study reports different procedures. Waldron[29] reports the extension drop test similar to the Thomas test. However, they start with the patient supine on the

table with both knees tucked into the chest to start. The tested leg is then lowered passively downward by the clinician while they maintain the untested leg in full hip flexion.[29] Waldron [29] also reports to not let the tested leg abduct which would then lead you to a false negative position. Waldron[29] however, does agree with Schultz[27] that a positive finding during the test is the tested leg unable to rest on the table, allowing for slight hip flexion and a lordotic curvature.[24,29]

However, the researchers conducting a study with speed and power analysis report the findings from this test could be interpreted differently given the background of the Postural Restoration.[30] They express that a positive finding would imply a non-neutral pelvis, limiting the hip extension allowed. The reasoning Jackson and the authors gave is stated that the positioning is determining femoroacetabular femoral head orientation in the acetabulum with ligamentous and capsular integrity and stability of the joint.[30] They further express that a negative finding could be either two options: 1) A neutral pelvis that allows full FA joint motion or 2) a non-neutral pelvis with compromised ligamentous stability that compensates for the neutral pelvis and allows for full range of motion.[30] Masek[32], a Physical Therapist who is certified in the Postural Restoration from PRI, agrees with Waldron's positioning of the extension drop test, coincidentally agrees with Jackson et al. reasonings behind a positive finding to be non-neutral pelvis and the femoral head orientation being off from normal.

Hruska Lift Test

The Hruska lift tests were designed by a physical therapist by the name Ron Hruska.[33] The lift tests are specialized to the Postural Restoration Institute certified clinicians, therefore the literature regarding the direction and execution of the two tests is very limited and not widely discussed. There are two different lift tests, one involving abduction and another involving

adduction which is the more recently discussed in the literature. These lift tests were designed to test the myokinematic functional assessment of a patient's ability to recruit specific muscles while inhibiting others, specifically working in the kinetic chain patterns described later.[34] The name of the tests includes the leg that is being tested, such as the Right Hruska adduction lift test (HAdLT) with the right leg being placed on top of the clinician's shoulder.[29,35] Both lift tests involve a grading scale from 0-5 and are scored on the patient's ability to achieve each movement pattern in each stage per the discretion of the clinician's evaluation of the movements.[29,35] The positioning starts side lying on the table with the testing leg on the shoulder of the clinician, the lower leg flexed on the table, and maintaining pelvic neutral.[29,35] The grading starts at 0, with the patient unable to raise lower ankle off the table or mat. Grade one is awarded with the ability to raise the lower ankle up to the knee of the top leg.[29,35] Grade two is achieved with the ability to raise the lower knee up to top leg while maintaining the ankle positioning.[29,35] Grade three is the ability to maintain all previous positions while lifting the lower hip off the table just slightly.[29,35] Grade four is the ability to completely lift lower hip off the table in line with the patient's shoulder.[29,35] Grade five is the accomplishment of raising the hip level above the patient's shoulder, to be in line with the clinicians shoulder.[29,35] In a case report study done in 2020 centered around treatment for a rotator cuff pathology utilizing PRI, the researchers describe each grading level with the movement to be accomplished. They further indulge the results of each stage as the inability to achieve the motions is a result in either weakness in the earlier stages or instability of certain joint positions in the later stages.[29]

Traditional Treatment Interventions

Due to the complexity of non-specific low back pain, finding an effective treatment plan is still an ongoing process throughout the literature.[10] Many studies describe various treatment

dimensions to tackle low back pain that include core stabilization exercises, group exercise such as Pilates or yoga, aerobic specific exercises, and flexibility programs to combat the affects felt from low back pain. In a systematic review produced by the American Family Physician journal in 2019 found that exercise therapy that focused on stabilization and strengthen of the abdominals and back showed some improvements with pain and functioning.[36] Another study noted between physical therapy usage compared to home exercises also found that through isotonic and isometric strengthen of the frontal and deep abdominals as well as the back muscles lead to an increase in functional levels and improved pain.[37] In a systematic review completed in 2016, they also describe that exercises geared towards activating and strengthen the abdominal muscle groups, are important in supporting the lumbar spine and can help reduce pain.[10] However, in all of these studies, they do not specify the exercises that were utilized that target the specific muscle groups of the abdominals or back muscles.

One study targeted the hip with strengthening exercises and looked at the effectiveness of reducing LBP.[38] This study found that individuals with limited hip range of motion were more likely to experience back pain.[38] Between the two comparison groups in that study, the group with multi-directional hip stretching exercises showed to be more effective in improving LBP and function.[38] This group included strengthening exercises focused on the glutes and hip external rotators, while also providing stretching exercises to the hip rotators, flexors in lunge form, adductors and abductors.[38]

In a systematic review focusing on the effects of exercise compared to physical activity found that just staying active in any way can help affect the recovery from LBP.[10] The review also states that aerobic interventions at 40-60% (unspecified exercises) could significantly reduce the presence of nonspecific LBP by 47%.[10,39] Researchers also found that core stabilization

programs can reduce chronic LBP 39%-76.8%, however not being specific with which exercises can achieve that.[10] However, within the systematic review, researchers found in a 3-month intervention comparing core stabilization to conventional exercises (slow curl ups, bird dogs, planks, and sit ups) found that both programs to be successful in reducing LBP but with core stabilization resulting in great significance.[10,40]

Modality Treatment

Outside of the traditional exercise programs to help relieve LBP, other techniques that utilize modalities or manual work are also seen to have an influence. In a pilot study focusing on the use of ultrasound in conjunction with strengthening exercises found that with a combination of ultrasound and exercises performed after can be an effective treatment to reduce LBP and function.[41] Researchers from a study looking at the efficacy of transcutaneous electrical nerve stimulation (TENS) and percutaneous neuromodulation therapy (PNT) found that both methods were successful at providing early relief of pain caused by activity in patients with low back pain.[42] Researchers from another report covering the direct and indirect benefits of TENS found that some participants found pain relief while others found only a cover up of their pain symptoms.[43] They further found that the participants also noted a reduced sensation of muscle tension or muscle spasm from the TENS therapy.[43]

Aside from modality usage, manual therapy techniques used by clinician's hands directly are also form of treatment therapy for low back pain patients. A study looking at the combination of utilizing spinal manipulations and myofascial release on the lumbar spine and the sacroiliac joint to see if there was a reduction in disability and pain.[44] The result of the study was that between the two treatment groups, the group who received both manipulation and myofascial

release showed improvements in pain, disability, and quality of life post intervention but stated the effects did not sustain for long term.[44]

Another therapy used to help relieve back pain is traction. There are various kinds of traction that include motorized lumbar traction, auto traction, manual traction, or gravitational traction utilizing inversion tables.[45] Some researchers state that traction is useful to providing intervertebral separation throughout the lumbar spine, reducing the pressure on the spinal column with the lumbar apophyseal joints and the sacroiliac joints.[45,46] One study focusing on the effects of inversion traction on pain, flexibility and trunk muscle strength found that gravitational traction at -30° and -60° helped increase trunk flexibility and muscle strength.[45] In another study, the researches hypothesized that traction can cause an activation of the muscle spindles to stimulate a stretching response to the paravertebral muscles.[46]

Muscle Energy

Due to the complexity of the sacroiliac joint, treatment for SIJ dysfunctions can involve a different form of manual therapy called muscle energy. Muscle energy is described as a soft tissue manipulation method involving isometric or isotonic contractions applied by the patient that are met by the clinician's force.[18,47] Houglum[47] describes the objective of muscle energy is to relieve the barriers caused by the restriction of movement from malalignment. Study done by Sarkar applied the muscle energy techniques for anterior and posterior innominate rotations.[18] For the anterior iliac rotation, the researchers report the technique as the patient lying prone with the involved leg off the table while the clinicians hand supports the leg in flexion until a barrier is sensed.[18,47] The patient than applies 20% of a contraction against the force form the clinician for 10 seconds, completing anywhere form 5-12 repetitions.[18] A similar technique is used for a posterior iliac rotation except the patient is fully on the table with the involved leg extended until

a barrier is felt. For this position, the clinician is advised to stand on the opposite side of the affected leg.[18,47] With the same parameters as described before, patient exerts 20% force contraction against the clinician's force for 10 seconds over 5-12 repetitions.[18] Both of these techniques are also referenced by common athletic training textbooks, described the same way.[47]

POSTURAL RESTORATION INSTITUTE

The Postural Restoration Institute™ (PRI) started from various clinicians in the physical therapy setting, centered around holistic properties as an intervention to treat individuals and their specific body demands.[48-50] The technique of Postural Restoration has been around for many years, but was not widely used or researched until Ron Hruska developed what became known as the Postural Restoration Institute™ (PRI) in 1999. As it becomes more widely known on a broader spectrum, the techniques and interventions are being utilized or recognized by more clinicians like athletic trainers. However, there are few studies that have been conducted within the athletic training community with most of the literature resulting in studies being completed in the physical therapy setting, showing little knowledge or confidence of the knowledge to other professions.[33]

A few studies have described the holistic approach as it takes in to account the dysfunctions of the body as it relates to posture and the limitations of movement in multiple systems.[29,30] The PRI outlook according to Boyle, is to utilize the science behind postural adaptations and asymmetrical patterns and how they are perceived in the human body given all the polyarticular muscle chains.[50] A case report study completed on postural restoration for the use of rotator cuff pathology agreed with Boyle's perspective on Ron Hruska's outlook as integrating posture-based intervention programs for the management of injuries and asymmetries caused by postural adaptations.[29] Throughout the exploration of PRI research, researchers have

found that multiple systems in the body such as musculoskeletal, nervous (autonomic, central and peripheral branches) and respiratory systems are the main drivers of their principles.[26,29,30,48,50] Other systems that also factor into adaptations, but are not in the main focus, are circulatory, reproductive, digestive and immune systems.[26,49] These systems aren't widely explored in the literature, however are still a key aspect according to Boyle.[49] Depending on the pattern or asymmetrical limitations that an individual is focusing on, will depend on the body systems that take precedence. Some studies theorize that multiple systems can cause moderate dysfunctions and movement limitations and by correcting these adaptions, the examiner or clinician can restore balance or variability to the body systems as well as the individual themselves.[29,30] Many other clinicians, have used the Postural Restoration interventions for various pathological conditions such as sciatica, sacroiliac joint pain[51] or lumbopelvic pain[26,49], thoracic outlet syndrome[48], rotator cuff pathology[29,31], trochanteric bursitis[52] along with iliotibial band syndrome and other single muscle activation interventions.

PRI Asymmetry of the Body

Multiple studies have stated that asymmetry of the body is caused by the positioning of bodily organs.[33,35] Hruska explains that the body is designed to be asymmetrical and due to the different demands, functions, and responsibilities of the various systems involved, the human body is uniquely balanced from the asymmetrical organs.[33] Many authors have noted that the bodily organs are what helps to maintain the overall balance, mainly with the liver positioning on the right side and the location of the heart on the left side of the thorax.[50] Hruska's description of this aspect is the liver helps to provide a structural support and positioning to the right side of the diaphragm, making it the dominant portion of the diaphragm used during respiration.[35] Secondarily, the unequal lobes of the lungs bilaterally also being a factor in controlling the

imbalances.[30,35] Jackson, Purvis, and Brown[30] also do a great job expanding on Hruska's asymmetry concept that the functions of the cerebral hemispheres and their control over the extremities also helps guide our unique imbalances. It is also known by many clinicians that the two hemispheres of the brain are responsible for different functions, Hruska expands on this concept stating the left brain controls the right upper extremity, making it the dominant extremity in the general population for communication, growth and development.[35] In addition, the extremity dominance stated by Hruska is balanced by reciprocal function, meaning the left arm moves with the right leg and right arm with the left leg during walking/running.[30,33] Hruska and other researchers have expanded on that topic together saying that because of the right side dominance, it becomes more of a habit to shift and stand solely on the right leg, decreasing the activity of the left side of the body creating structural instabilities.

Ron Hruska, from the PRI, complements Boyles approach and adds that due to the attachment of the diaphragm on the frontal lower portion of the lumbar spine, the attraction of pull on the right side from the liver, and the overall right side dominance of extremity use positions or allows our spine to rotate to the right more often.[31,35] From the loss of the directional pull and the strength of the diaphragm without structural support, this distorts the left ribcage to be pulled up and outward due to the pericardium unable to hold in neutral position.[35] In return this forces the upper thoracic area to rotate opposite of the lumber to the left. As a result, the left diaphragm becomes weak and decreases the efficiency of respiration.[35]

PRI Kinetic Chain Patterns

PRI thrives on finding the asymmetrical pattern within every individual patient as the beginning of their evaluation. The most widely discussed pattern within the literature was the left anterior Interior chain (AIC).[31] Other patterns that were discussed more superficially are the

brachial chain found mostly oriented on the right side of the body and the Posterior exterior chain (PEC) that incorporates a bilateral influence noting the most extreme pattern to be positioned in. Depending on the asymmetries found within, will depend on the specific pattern present in the patient.

Researchers have discussed the left AIC pattern to be the predominant pattern among the general literature. Many studies have concluded that the prominent positioning of the body that constitutes a left AIC pattern is observing a specific orientation of the pelvis that includes the left pelvis in a forward or anterior rotation with the right pelvis in a backward or posterior rotation; left hip and innominate externally rotated and abducted with right hip in the opposite of internal rotation and adduction.[29-31,49] This pattern is characterized by the following musculature being asymmetrical and in a hypertonic phase on the left side of body as compared to the right side: the left AIC involves the left hemisphere of the diaphragm, psoas, vastus lateralis, and the medial hamstrings and their respective ligaments and tendons.[30] A greater range of motion of Internal rotation on the right side and greater abduction motion on the left is due to the positioning and musculature involved and the functional positioning of the pelvis.[30,49] Boyle also notes that the clinician may observe a more inferior position of right shoulder[49], lumbar vertebrae rotation to the right, with the upper thoracic region rotated to the left.[30,31,49]

Another pelvic pattern discussed is the posterior exterior chain (PEC). There is limited research to discuss the dynamic properties of the PEC pattern. One researcher describes the positioning of the pattern in a simplistic way as both left and right hips are positioned in external rotation, abduction, and flexion also resulting in a bilateral ribcage flare, instead of the single side as described in the previous pattern.[29] Multiple researchers have described that the PEC pattern is commonly found to have bilateral anterior tilt of the pelvis that is also in combination

with hypertonic back extensors increasing the lordotic curve and hip flexor musculature found in a shorter position.[26,29] Some conclude that the pattern only exist as a bilateral compensation with both hemipelvis involved within the PEC pattern.[29] More research is needed to understand the patterns and how common they present themselves within the active general population.

Chapter Two: Analysis of Pelvic Alignment Patterns Utilizing the Postural Restoration Institution Approach

INTRODUCTION

Low back pain (LBP) is found to be a common problem within the general population specifically in western societies, with up to 80% of people experiencing one episode of low back at some point in their life.[1,3-7] LBP is the leading cause of disability as well as activity limitation and work absence among adults.[2,3,6,8,9] Individuals with activity-limited LBP lasting greater than one day, will experience more recurring episodes that last longer in duration.[3] LBP cases can resolve on their own within 2-6 weeks, however 10-40% can develop into chronic LBP.[1,2,4,10] The most common risk factor to developing LBP is age, specifically from the 3rd decade of life up until 60 or 65 years old.[3] Other factors that should be considered are occupational,[9] gender discrepancies, as well as psychosocial issues such as stress, anxiety, and depression.[3,6,7]

Non-specific low back pain (NSLBP) is described as a diagnosis without concerning causes such as tumors, fractures, infections, inflammatory arthritis or cauda equina or without a clear or unknown origin.[2,11] NSLBP usually stems from the intervertebral discs, facet joints, or the paraspinal musculature resulting from a tissue strain or sprain that has not healed beyond the normal time.[4,8] Another cause of LBP is injury to the sacroiliac joint (SIJ) which is often overlooked at by clinicians.[13] Due to the biomechanical properties of the SIJ itself, it is said to be the source of LBP in about 15-30% of cases making the prevalence rate of LBP higher.[13]

The SIJ is a load-transferring mechanical junction between the spine and lower extremities.[13,22] Injury to the SIJ is more common than people think with mechanisms including a direct fall on the buttock, rear-end or broadside motor vehicle accident, or a step into an

unexpected hole or miscalculated step off from a height.[8,13,14] Often this leads to a displacement of one of the innominate bones, causing a positional change within the SIJ.[21] Pain referral patterns for SIJ can often be confused with facet or intervertebral disc injuries, making the diagnosis for SIJ injury difficult.[8] Over lapping pain patterns include radiation into the buttock, lower lumbar region, lower extremity regions and the ipsilateral groin pain.[15,17] In order to distinguish SIJ injury from LBP, clinicians are to have three or more positive special tests that determine SIJ dysfunction.[15,17,21-23] Most utilized clinical tests include the Gillet test, sitting and standing flexion tests, Patrick's, Gaenslen's, and compression/distraction tests.[14,17,21]

Traditional treatments utilized for LBP include core stabilization exercises, group exercise such as Pilates or yoga, aerobic specific exercises, and flexibility programs geared towards activating and strengthening the abdominal muscle group. Core strength is important for supporting the lumbar spine and can increase the functional levels as well as improve pain.[10,37] Other forms of treatment include modalities such as ultrasound or electrical nerve stimulation with transcutaneous (TENS) or percutaneous neuromodulation therapy (PNT) have also been shown to have pain relief factors when combined with therapeutic exercises.[41-43] Manual therapy techniques such as spinal manipulations and myofascial release for both the lumbar spine and SIJ when combined together improve pain, disability and quality of life for short term relief.[44] Treatment directly for the SIJ involves muscle energy techniques utilizing isometric or isotonic contractions to relieve the barriers that cause restriction of movement or malalignment.[18,47]

A relatively newer specialized treatment intervention was developed by Ron Hruska of the Postural Restoration Institute (PRI). PRI utilizes the dysfunctions of the body as it relates to posture and limitations of movement found within multiple systems.[29,30] Boyle describes the PRI intervention as utilizing the science behind the postural adaptations and asymmetrical patterns to

integrate a postural based intervention for management of injuries and musculoskeletal asymmetries.[29,50] Theory behind the PRI techniques is to restore balance and variability to the body systems by correcting the dysfunctions and limitations found within the musculoskeletal, nervous, and respiratory systems.[29,30] The anatomy approach discussed by Hruska was the body was designed to be asymmetrical for the demands, functions and responsibilities of all systems.[33] The asymmetrical make up is provided by bodily organs such as the liver and the three lobes of the lungs located on the right side with the heart opposite on the left, as well as the cerebral hemispheres controlling the opposite sides of the body.[30,35,50] With the bodily organ positions and crossover from the cerebral hemispheres, this sets up the right portion of the diaphragm to act stronger than the left side during respiration due to the lack of structural support on the left side.[35]

Musculoskeletal asymmetries of the body have been described as specific pelvic patterns according to Hruska. The most predominant pattern discussed is the left anterior interior chain (AIC) that is said to have a specific orientation of the pelvis that includes the left pelvis in a forward/anterior rotation, left femur externally rotated and abducted.[29-31,49] The left AIC patterns includes the left hemisphere of the diaphragm, psoas, vastus lateralis, and the medial hamstrings and their respective ligaments and tendons appearing in a hypertonic phase as compared to the right side of the body.[30] Due to the musculature involved, a greater range of internal rotation will be noted on the right side, with greater abduction motion noted on the left due to the positioning of the pelvis.[30,49] Hruska also describes a more extreme pattern, the Posterior exterior chain (PEC), that involves both left and right innominate positioned in external rotation, abduction, and flexion.[29] This pelvic pattern will include hypertonic erector spinae and iliopsoas bilaterally found to be in a shortened position.[26,29] This pattern has been discussed to only exist as bilateral

compensation pattern with both hemipelvis involved, creating a bilateral ribcage flare and exacerbated lordotic curvature as a result.[26,29]

Recent evidence has shown the use of the Postural Restoration Institute treatment interventions more widely for various pathological conditions such as thoracic outlet syndrome[48], rotator cuff pathology[29,31], and trochanteric bursitis.[52] However, the PRI specialized approach has also been utilized for sciatica, sacroiliac joint pain[51] and lumbopelvic pain,[26,49] showing limited research on the efficacy of the PRI approach in a group of subjects presenting with non-specific low back pain. There is also limited research found describing the prevalence of the pelvic patterns within either the general or athletic populations given all the pathologies that PRI has been used to treat. Prevalence rates are helpful to determine for clinicians so we can see how much of the population is coping with such pathologies, injuries, and illnesses, or specific pelvic patterns.

The gap in the literature that was evident for us, was there are no previous studies conducted to help address the prevalence rate of each pelvic pattern in the general population. This would be important for us to find out how much of the population lives with each pattern and what drives the pattern to help figure out a common prevention and treatment paradigm for individuals. Therefore, the purpose of this study was to examine the abundance of pelvic patterns within the general young adult population. We also wanted to investigate whether there was a relationship of low back pain to the rate of pelvic patterns found during the study. Furthermore, we would also like to explore the specific left AIC pattern and investigate the ability to re-align the left AIC pattern as well as the PEC pattern to more neutral positions by utilizing some of the specific PRI repositioning exercises.

Specific Aims and Hypothesis:

1. To assess the pelvic pattern prevalence within the physically active young adult population.

Hypothesis 1: There will be a higher frequency of patterns in those who participate in various activities as opposed to a single activity.

2. To compare the pattern prevalence between those with and without a history of low back pain.

Hypothesis 2: There will be a higher frequency of pelvic patterns found in those with a history of low back pain compared to without a history.

3. To examine the common trends of pelvic patterns between the genders.

Hypothesis 3: There will be a higher frequency of pelvic patterns in females as compared to males.

Secondary Aims and Hypothesis:

1. To investigate how effective the PRI approach is to realigning the left AIC/PEC pelvic pattern.

Hypothesis 4: There will be a decrease of pelvic patterns found after repositioning.

2. To examine the relationship between pre and post assessment by utilizing a patient reported outcome measure.

Hypothesis 5: There will be better outcomes on the post assessment for those who completed the re-positioning alignment portion.

METHODS

Experimental Design

The design of this study was an observational cross-sectional study, which included a pilot test retest for the second phase of the study. Data collection was completed in the fall semester of the 2021-2022 academic year. The independent variables were gender (male vs female) and the history of low back pain that the subjects indicated on their demographic questionnaire. The dependent variables were the pelvic alignment patterns established during the assessment as well as the Oswestry disability questionnaire. The pelvic patterns discussed by the PRI were distinguished by the outcome of the two special tests performed: adduction drop test and extension drop test. We also took observational palpations of the iliac crest height, anterior superior iliac spine (ASIS), and the posterior superior iliac spine (PSIS) levels to determine traditional pelvic pattern after each assessment of the subjects. Each participant filled the Oswestry questionnaire out before the initial assessment took place.

During phase two, we first constructed that only those participants who presented in a Left AIC pattern would partake in the repositioning aspect of phase two if they consented to participate. However, after assessing the first few participants, we changed the protocol to allow all participants, PEC pattern included, to participate in the repositioning phase due to the findings that the PEC pattern was very prominent. Phase two of the study consisted of participants who presented in either a Left AIC or a PEC pattern and then participated in one exercise, 90/90 hemi bridge with hip shift and adduction squeeze, for a series of sets and reps.

Participants

All participants included in this study were current students at West Chester University (West Chester, PA) during the 2021-2022 school year. Subjects were recruited from around the

south campus of West Chester University Sturzebecker building. The process was completed by flyers that were handed out around south campus as well as posters that were hung up around the health science building of Sturzebecker. Another form of recruitment that was done was visiting classes throughout the Sturzebecker building that currently houses all the Health Science departments such as Kinesiology, Exercise Science, Sports Medicine and Nutrition. All subjects were required to be between the ages of 18 and 25 years old to participate. Determination of subjects to be included in the study depended upon meeting the criteria of being physically active as defined by the American College of Sports Medicine: "All healthy adults aged 18-65 yr. should participate in moderate intensity aerobic physical activity for a minimum of 30 minutes, five days a week or vigorous intensity aerobic activity for a minimum of 20 minutes three days per week."[53] Participants who had any recent injuries or surgical procedures performed to the spine, hips or pelvis within the past year were asked not to participant. All participants were educated on the procedures of the study before obtaining a written informed consent by each individual. After initial study was completed, those who agreed and consented to participate in the reposition aspect were asked to stay to complete phase two.

Instrumentation

Oswestry low back pain disability questionnaire. The Oswestry disability questionnaire is used as a patient reported outcome measure by researchers and clinicians to measure a patient's functional disability. The Oswestry questionnaire is seen as the gold standard of low back pain functional outcome tools used most widely. The questionnaire consists of ten different sections that are based on different daily life activities (pain intensity, lifting, walking, personal care, sitting, standing, social life, travel, sleeping) and determine if a patient's disability is affecting a portion of completing or managing said daily activities. Each section consists of six statements

that range from the first statement being zero difficultly/pain in completing activity to the last statement of most severe I cannot complete activity or pain prevents extreme difficulty to complete activity. The patient was to pick the best statement that best describes their disability. Once completed the clinician scored the questionnaire as follows. Each section has a possible score of 5 and depending on which statement was selected, depended on the score for that section: the first statement scores a 0, second statement a 1, third statement a 2, etc. to the last statement equaling a 5. Once all 10 sections have been scored, the final score is calculated as follows: # of total scored divided by # of total possible score (total sections that were answered * 5), then multiplied by 100 to equal your final percent score. If there was a section that was not answered, then the total possible score drops by five points, and is replaced in the equation. Once the final percent score is calculated, the clinician can then interpret the amount of disability the patient is experiencing from 0-20% being minimally disabled, 21-40% moderate, 41-60% severe, 61-80% crippled, and 81-100% either bed-bound or exaggerating on symptoms.

Adduction drop test. The adduction drop test was used to determine if there is an impingement of the posterior inferior femoral neck on the rim of the acetabulum, indicating a non-neutral positioned innominate.[30] To perform this test, the subject lies on their side opposite the leg that will be tested. The examiner stands behind the subject and makes sure the subject has 90 degrees of hip flexion and knee flexion. The examiner will cradle the subject's knee as they bring it up into flexion and abduction and then bring it back into extension. Once extension has been achieved, the examiner will lower the leg towards the table to assess if the leg can drop below midline towards the table or not. While moving the patient's limb, the clinician should note to keep the hips stacked on top of one another and not to let the top hip roll backwards. A positive test would exhibit the subject's leg unable to reach past midline, indicating impingement of the femoral

neck in the acetabulum. A negative test would present with the subject's leg dropping below midline down to the table, indicating a neutral aligned pelvis and acetabulum.

Extension drop test. The extension drop test was used to assess the positioning of the head of the femur in FA positioning compared to the orientation in the acetabulum and the integrity and stability of the ligamentous structures in the joint.[30,33,51] This test has similar properties to the Thomas test, just with a different outcome. To perform this test, the subject starts by sitting on the end of a table and grabbing both knees as they slowly lower their body down onto the table. The examiner stood in the front of the subject and grabbed one knee to fully extend, as they apply overpressure to the opposite knee to the chest. A negative test would indicate that the subject's leg is able to fully extend at the hip from start position to rest on the table, indicating full hip extension or compromised ligamentous stability allowing the hip to achieve full motion. A positive test would be indicative of the thigh unable to rest on the table, unable to achieve full hip extension. This finding would imply a non-neutral pelvis, resulting in limited hip extension and an anteriorly tipped innominate or the presence of intact ligamentous stability.

90/90 Hemi-bridge with Hip Shift and Adductor Squeeze. This exercise was developed by the PRI as a re-positioning exercise to help individuals achieve more of a neutral pelvic alignment. To perform this exercise, the participant would lie on their back on the table with their feet flat on the wall with knees bent to create a 90 degree angle at the hip joint and knee joint. The clinician will then place a ball that is roughly 4-6 inches between the knees of the participant to gently squeeze during the execution of the exercise. The clinician instructs the participant to perform a posterior pelvic tilt, possibly feeling their tailbone raise off the table but should make sure that their back is still fully flat on the table. The participant will next press their feet into the wall in a downward motion with their heels to isometrically engage the hamstrings, without letting their

feet physically slide down the wall. To prevent the sliding of the feet, placing a box or stool of appropriate height under their heels can help counteract the movement or que the individual to contract more. As the patient is then instructed to maintain the posterior pelvic tilt off the table, they should perform a shift within the hips, bringing the left femur down towards the table and lifting the right femur up towards the ceiling, so the right knee will sit just above the left knee. Last movement would be an adduction squeeze of only the left knee on the small ball that was placed in between the knees at the start. The right knee should not be squeezing, only allowing the left adductors to be contracting. Simultaneously during all motions, the participant will inhale through their nose and exhale all the air through their mouth, until there is no more air to be released, feeling the deep abdominal muscles contract. The participants were instructed to perform five sets of six breathes of this exercise with a small rest time in between each set.

Procedure

Recruitment of subjects to participate in this study was the first order of business. This was conducted through flyers, posters and word of mouth delivered during in-person class visits, given permission by the professor first. Once subjects shown interest to participate in the study, each subject was asked to fill out a basic demographic questionnaire upon assessment. The questionnaire consisted of basic identification questions such as age and gender. The questionnaire also asked about any history of low back pain in a yes or no format experienced within the past five years. If the subject selects yes to having a history of LBP, they were asked to elaborate further by answering questions as to how recently they have experienced an episode, how long does it usually last, and rate the intensity of pain or discomfort felt. Questions regarding any complications to performing specific tasks, were covered by the Oswestry low back pain disability questionnaire also handed out pre assessment. If answered no to never having an episode of LBP, they were

asked to skip the extra questions. The last question on the form asked about activity participation and how frequently they participated in said activities that were selected.

Subjects who had a clear history without current injury or surgical procedures were asked to participate in the initial assessment session. The sessions took place within the West Chester University Athletic Training room located in Sturzebecker on south campus. The sessions were also made by appointments only, to help accommodate the schedules of the examiner and subjects, as well as the WCU athletic training room compliance terms with student-athletes. Before the assessment portion of the study, the subjects completed an informed consent form describing specifically what the examiner will look for. During the assessment portion, palpations of the iliac crest, anterior superior iliac spine (ASIS) and the posterior superior iliac spine (PSIS) were all assessed in the standing position. Following palpations, two special tests were performed, first the adduction drop test and second the extension drop test, both performed bilaterally. All information per subject was kept in a secure excel document form on a password protected thumb drive.

Once all qualified subjects completed the assessment portion, all subjects who were classified as either a Left AIC or PEC pattern, were asked to complete phase two immediately following the initial assessment. Phase two included the use of one PRI exercise targeting the repositioning of the Left AIC pelvic pattern. Subjects were instructed properly on how to execute the exercise and had a chance to demonstrate each step and ask questions before they were asked to complete five sets of six breaths. The exercise instructed was the 90/90 hemi-bridge with hip shift and adduction squeeze. At the conclusion of all five sets, another assessment portion was completed utilizing the same steps as the first assessment portion. All palpations were compared to pre intervention, and the special tests used were also noted if they changed. Following the ending of the realignment assessment, the Oswestry questionnaire was not distributed to participants as

previously discussed, as we did not instruct participants to come back at a later date to follow up. We also did not see a change in baseline LBP immediately following the intervention in the first few participants and we deemed the second Oswestry handout to be an inaccurate assessment. Thus, the Oswestry questionnaire was only distributed once upon the initial assessment before repositioning.

Statistical Analysis

For the purpose of this study, IBM Statistical Package for the Social Sciences version 27 (SPSS), was utilized as the data analysis software. Descriptive statistics utilizing crosstabulation analysis, was performed to assess if the frequencies between physical activities, history of low back pain, and gender differences with the pelvic patterns. To compare the frequency between the history of low back pain to the pelvic patterns found, a Fisher's exact test was performed. Due to the small sample size of the population and unequal distribution between groups that were analyzed, we chose to run a Mann Whitney U test to evaluate the comparison between the Oswestry Low Back pain questionnaire scores and genders of male and female. A significance level of p-value will be set at $p<0.05$ for all tests.

RESULTS

Demographic Information

Descriptive outcomes are presented in table 1. During data collection that took place from October through November of 2021, 11 participants were included in the initial recruitment with original procedures and an extra 22 additional participants were further included following a modification of the procedures to have a total N of 30.

Table 1: Demographic and Clinical Charateristics

Groups	Mean Age ± SD	Male	Female	BMI	Oswestry Score	+L ADT	+R ADT	+L EDT	+R EDT	L AIC	PEC
No LBP	20.5 ± 1.00	1	3	27.42 ± 4.77	3.00 ± 6.00	4	3	2	1	1	3
LBP	20.88 ± 1.72	7	19	24.35 ± 4.07	6.64 ± 6.54	26	26	5	7	0	26
Totals	20.83 ± 1.62	8	22	24.76 ± 4.21	6.15 ± 6.49	30	29	7	8	1	29

LBP=Low back pain, BMI=Body mass index, L=Left, R=Right, ADT=Adduction Drop test, EDT=Extension drop test, AIC=Anterior interior chain, PEC=Posterior exterior chain

Back Pain and Oswestry Score Assessment

Of the 30 participants, 86.7% had stated that they have experienced at least one episode of low back pain within the past five years and only 13.3% reported having a mild form of scoliosis. Following the calculation of the Oswestry scores, the mean score was 6.6 (SD 6.5) with the highest score seen of 28% moderately disabled (3.3%). Most Oswestry scores were observed in the minimally disabled category with 33.3% reporting a zero disability score after completion of the questionnaire.

Pelvic Alignment Assessment

Table 2 presents the traditional pelvic alignment patterns as well as the PRI pelvic patterns as assessed before and after intervention. There was no changed noted in pelvic patterns following the re-positioning exercise intervention. Of those participants presenting in a PEC pattern, 21

Table 2: Pelvic Alignment Assessment

	Pre (%)	Post (%)
Traditional		
Neutral	6 (20.7)	15 (51.7)
L Upslip/ R Downslip	4 (13.8)	3 (10.3)
R Upslip/ L Downslip	5 (17.2)	1 (3.4)
L Anterior Rotation/ R Posterior Rotation	6 (20.7)	4 (13.8)
R Anterior Rotation/ L Posterior Rotation	8 (27.6)	6 (27.6)
Postural Resturation Instititue		
Neutral	0	0
Left AIC	1 (3.3)	1 (3.3)
PEC	29 (96.7)	29 (96.7)

L=Left, R=Right, AIC= Anterior inferior chain, PEC=Posterior Exterior chain

(95.5%) were female, 8 (100%) were male and those presenting in a Left AIC pattern, only 1 (4.5%) were female.

Oswestry Questionnaire Scores Between Genders

Independent sample t-test was used to evaluate the mean average in Oswestry scores. Mean score for females was 6.1±6.8 and the mean score for males was 6.25±5.9. Comparison of Oswestry disability scores in males (Mdn = 6.0) were higher than those Oswestry scores of females (Mdn = 5.0). A Mann Whitney test revealed no statistically significance in scores, $U(N_{males}= 8, N_{females} = 22) = 84.5$, $z = -0.168$, $p =0.872$.

DISCUSSION

This was the first study known to look at the prevalence of the pelvic patterns as defined by the PRI in a general physically active population. We anticipated getting more participants presenting in the left AIC pattern, however, due to the small sample size and high rate of PEC patterns, we chose to keep all the participants in the study with only one subject presenting in the Left AIC pattern overall.

We found a higher rate of PEC pelvic patterns (29/30) then what was expected and only examined one left AIC pelvic pattern. These findings are in contrast to the findings from Nourbakhsh et al. who looked at contralateral shoulder range of motion and torque production utilizing neuromuscular training exercises in a similar population of college aged individuals. Our findings differed because we accepted those who experienced LBP as well as a positive bilateral adduction drop test rather than just one side. What was different about the Nourbakhsh study was the inclusion of 42 out of 95 participants screened that presented with a positive Ober's test on one leg and a decrease in range of motion on the contralateral shoulder in internal rotation, deeming a left AIC pattern according to Hruska.[31,33] We are unaware of what pelvic pattern the remaining

population of the Nourbakhsh study fell into, as they did not report why they were excluded from the study.[31] If we expanded the inclusion criteria of our study to the whole University, then we may have seen more of a diversification in participant size as well as pelvic patterns found. To our knowledge, we do not know if the study by Nourbakhsh et al. may have excluded those participants who experienced LBP, as they only state participants with bilateral positive Ober's, structural leg length discrepancies or any other musculoskeletal impairments were excluded.

With the small sample size, we chose to include participants (n=26) who specifically had experienced low back pain and found that 86.7% the participants gathered, fell into the LBP category and were all classified a PEC pattern. Due to the high frequency of finding mostly PEC patterns in a generally active population, this could be hypothesized that the positioning and orientation of the PEC pattern, could be inhibiting the functional ability of the hip flexors and causing hypertrophy of the erector spinae muscles, causing some of the back pain noted in some participants.[33] Our findings don't correlate with Jackson et al. which examined PRI exercises against traditional postural interventions on the anatomical alignment, range of motion and symmetry, and speed and power. Jackson et al. choose to study Division III collegiate hockey and football athletes, and further excluded participants with a history to the sacroiliac, lumbosacral, or lumbar region injuries within three months of testing. A case study conducted by Robey and Boyle which examined a baseball athlete with sacroiliac dysfunction, described the athlete experiencing bilateral SI pain with a severe rating (48%) on the Oswestry disability questionnaire with a clinical finding of a left AIC. However, this is the only study known to us, to make note of LBP or SI dysfunction within the inclusion criteria for the participant.[51] An interesting point from the differences, is that some studies outside of the Robey and Boyle case study, chose to exclude individuals who presented with dysfunction or injury within the low back region as hypothesized

they may not have wanted to worsen the condition or injury by including them in the studies. The athletic population utilized in the Jackson et al study, was also in the middle of their collegiate season, so the athletes could have been performing other exercises or drills that would help the athletes to achieve a negative on the ADT following the four week program. Our findings cannot be compared to Nourbakhsh or Waldron et al. studies because LBP was not reported in either the inclusion or exclusion criteria of both studies.

Repositioning exercises done in this study were unsuccessful in our participants as we saw a higher amount of PEC patterns than expected. We chose the 90-90 hemi-bridge with a hip shift and adductor squeeze after determining the 90/90 hemi-bridge exercise to be prevalent exercise in the literature.[31,48,54] The PRI Myokinematic manual indicated this exercise as a good starting point when applying PRI interventions to patient populations who appear in a Left AIC pattern.[33] However, with the unsuccessful re-positioning, anecdotal evidence reported participants' lower extremities could move with less restriction with some improvements in passive ROM following the intervention, but the improved findings were not enough to deem a true negative by the clinician. These subjective findings supports the study of the Jackson et al., as they reported the symmetry to increase after the four week program of PRI exercises but the ROM measurements in that study was reported as not significantly different from the treatment to control groups.[30] Our findings differ between the Jackson et al study, because they included the use of three different PRI exercises and utilized real measurement of ROM with a goniometer to provide objective data and saw an increase in absolute asymmetry in femoroacetabular internal rotation and hip abduction, improving the ADT scores to elicit a change in pelvic patterns.[30] We choose not to do goniometer measurements and just utilize the ADT test to determine the outcome of the exercise to understand if you can see a change in pelvic patterns from performing a single special test or

not. Our findings also differed to Nourbakhsh et al. that with a larger sample size, they saw greater amount of improvement in pelvic alignment that was significantly higher in the neuromuscular group with subjects improving from a left positive to negative Ober's test with 14% still in malalignment compared to the treatment group (93%) and control group (79%) still malaligned.[31] However, we are unaware of the pelvic patterning in the remaining population from Nourbakhsh study and why they were not included in the final study. We cannot confirm our findings to Waldron et al. as they did not disclose of their efforts in ROM within their case study.

The parameters for the PRI exercise we chose were three sets of five breaths but later increased to five sets of six breaths after witnessing some participants were improving their ROM to realignment but still showed a positive test with bilateral adduction drop tests. We also increased our parameters following the first few participants because as with observed with majority of all participants, it took the first and half the second set for individuals to get used to the proper movements, execution of proper form, and activating the appropriate muscles simultaneously while concentrating on the deep breathing. We theorized that by adding 2-3 more sets to our exercise, we would elicit a more sustainable change than just with the three sets. In conjunction with many other studies, Nourbakhsh et al. used almost identical exercise parameters but added blowing up a balloon for diaphragmatic breathing. They chose to do the exercise every day for one week under supervision for four times while holding the breath for three seconds and found great success with overall repositioning within their neuromuscular group with 86% appearing with a negative Ober's test post-test.[31] A case study conducted by Waldron et al. also utilized a similar exercise with a single volleyball athlete that conducted the exercise in three sets of ten repetitions of breathing for three times a week for two weeks under direct supervision again.[29] Both studies were successful at performing and sustaining realignment of the left AIC pattern, however, this

could stem from performing the exercise for a more prolonged period of time. With Jackson et al. and Waldron et al., they included parameters that extended over one week at least with the exercise being performed daily. This would most likely lead to a more sustained change with frequent training and activation of the muscles in charge for re-positioning over a single execution. With an increase in sets and repetitions of the exercise, may explain the success that these studies reported and may lead to an increase in neutrality within pelvic patterns.

Although we did not set out to solely explore the relationship between traditional pelvic alignment techniques with the PRI techniques, we did take note of the different pelvic patterns regarding upslips and rotations within each participant upon their initial assessment with iliac palpations. To our knowledge, this concept has not yet been widely explored in multiple studies if there is any relationship between PRI and traditional AT pelvic pattern findings. We saw a small margin of each traditional pattern throughout the participants that we had (left upslip/right down slip, right upslip/left down slip, left anterior rotation/right posterior rotation, right anterior rotation/left posterior rotation). The only changes we observed in the pelvic alignments following the intervention, were the iliac palpations during post assessment. We observed a total of six participants in neutral position before the intervention and had 15 participants present in neutral positioning following the intervention. Regarding the specific traditional alignment patterns as the right upslip/left down slip, we saw the biggest change from five participants to only a single participant after intervention. However, there is only one study known conducted by Robey and Boyle for a case study in a baseball athlete with SI dysfunction that did reference a traditional pelvic alignment described as a left anterior rotation, right posterior rotation with a left inflare and right-on-right sacral rotation, but that was solely a case study and not well known.[51] We theorize that according to PRI and Hruska, we observe a right sided dominance as our stance leg, and that

possibly these two could be related with individuals favoring to stand on their right leg, and could that be the driving factor for our pelvis to shift into a right upslip as well as into a PRI left AIC pattern at the same time.[33]

LIMITATIONS

A limitation in this study was we did not include a follow up period to determine if there were any increase or decrease in back pain following the intervention period. This would have allowed for us to examine our second secondary aim of analyzing pre and post Oswestry scores more readily instead of a single score. Another limitation seen was the absence of range of motion measurements taken during the initial assessment to compare to after execution of the repositioning exercise. This would have been an area to look at to determine if we had made any quantitative changes to increase/decrease ROM within the hip internal and external motions, even if there were no pattern changes. With this information it may be more helpful to successfully classify a left AIC, PEC or neutral pattern. Overall, the small sample size is also a limitation to this study, as the sample population did come from one aspect of the University campus, and if we did extend it to the whole student population, we may have seen a more diverse population of pelvic patterns.

Intra and interrater reliability were not consistent throughout this study. At the onset of data collection, the primary investigator was the main clinician who administered all palpation measures with assistance by the faculty sponsor for a few participants when administering the ADT and EDT test. In collaboration with the faculty sponsor who was trained in the PRI methodology, together we assessed four participants at the beginning to ensure the proper technique was accurate by the primary investigator. This study does show a high intra rater reliability rate as the outcome was 29/30 PEC patterns, however the inter rater reliability is low,

since we only collaborated on four participants out of the whole population; could we have continued it for the rest of the population, measures may have provided a different outcome.

DECISIONS AND HYPOTHESES

Decision on hypothesis 1: There was no statistically significant difference in the number of different physical activities individuals participated in comparison to pelvic patterns. Failed to accept the hypothesis.

Decision on hypothesis 2: There was no statistically significant difference in frequency of pelvic patterns between history of back pain and pelvic patterns. Failed to accept hypothesis.

Decision on hypothesis 3: There were no statistically significant differences in the frequency of pelvic patterns in females compared to males. Failed to accept hypothesis.

Decision on hypothesis 4: There were no statistically significant differences in the changes of pelvic patterns after the repositioning. Failed to accept hypothesis.

Decision on hypothesis 5: We did not assess post intervention Oswestry scores; therefore, we cannot accept or fail the hypothesis.

DIRECTION OF FUTURE RESEARCH

Future studies should look at including a form of range of motion measurement technique during a repeat prevalence study to establish if there are any true quantitative changes seen in pelvic alignment following repositioning exercises. Given the information about achieving a more neutral pelvic alignment, you would see more symmetrical ROM values bilateral within the hip motions of internal and external rotation; possibly giving more information on true repositioning of the pelvic patterns. Since this was the first known study to look at the prevalence rates in a general population, another area of focus for future studies is to examine the prevalence of patterns in the athletic populations either in a diverse range of sports or sport specific. There has been

limited evidence produced with small portions of team sports such as hockey and baseball athletes in the literature with PRI and only a few case studies highlighting individual athletes in football and volleyball with repositioning exercise experience. Future studies should incorporate team and individual sports such as swimming for example, for prevalence rates to get a more assorted perspective of prevalence rates.

There are studies currently out in the literature that do present with utilizing multiple exercises during that intervention phase, however, these studies use traditional exercises compared to PRI exercises. It appears there is limited evidence of studies using one PRI exercise against multiple PRI exercises for one study in relation to realigning pelvic patterns for the individual with LBP. Future research that focuses on PRI exercises could explore the idea of using multiple PRI exercises during a re-alignment phase to see if performing multiple exercises would be more powerful and elicit a stronger change in pelvic alignment then just the one exercise conducted in this study. Another topic along those parameters, studies could also examine a common set of parameters for multiple PRI exercises and construct a set of guidelines for individuals to help elicit a more sustainable neutral pattern over longer periods of time. This was a common trend in this study, as we did experience a change with our parameters after a few participants because we did see and subjectively hear those pelvic patterns were shifting, but objectively could not deem it a true change with the special tests.

After noting that PRI exercises may have an effect on traditional alignment patterns, future research is warranted to explore the relationship further for the use of PRI exercise methods on the effectiveness of realigning traditional pelvic abnormalities. There was one case study, conducted by Robey and Boyle with a baseball athlete that briefly touched on the traditional aspect of pelvic abnormities but did not explore if utilizing the PRI theory would cause any changes until after the

third intervention. More research is warranted to see if there is any correlation with the use of PRI exercises on traditional pelvic patterns and realignment processes.

CONCLUSION

The purpose of this study was to examine the abundance of pelvic patterns within the general young adult physically active population as according to PRI techniques in relation to the history of low back pain. We found a high prevalence of PEC patterns in the general physically active college age population. We found no statistically significant differences in the number of activities participated in or whether the individuals had a history of LBP or not in relation to pelvic patterns. We did not see any true changes in any of the pelvic patterns observed during the intervention. However, we did note that some subjective findings reported by the participants themselves noted they felt different following the intervention but could not be followed up with true measures by the clinician to deem successful. The exercise chosen warrants more evidence to be conducted to be utilized by clinicians as a re-alignment exercise. The intervention provided by the PRI that was utilized in this study is shown to be a safe exercise to utilize in clinical practices; adjustments to sets, repetitions and frequency of exercise may need to be modified in order for it to be utilized as a re-alignment technique.

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