6-2003

Predicting Sacroiliac Syndrome: The Association Between Noninvasive Sacroiliac Joint Tests and Sacroiliac Joint Injections

Lorraine D. Webb

LOMA LINDA UNIVERSITY

School of Allied Health Professions

Predicting Sacroiliac Syndrome: The Association Between Noninvasive Sacroiliac Joint Tests and Sacroiliac Joint Injections

by

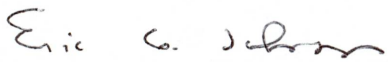
Lorraine D. Webb

A Publishable Paper in Lieu of a Thesis in Partial
Fulfillment of the Requirements for the Degree
Doctor of Physical Therapy Science

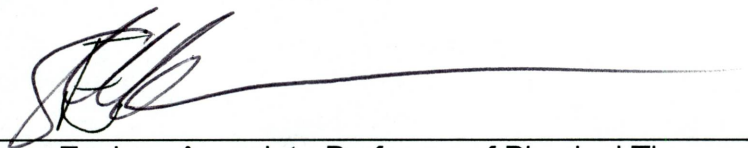
June 2003

Each person whose signature appears below certifies that this publishable paper in his opinion is adequate, in scope and quality, as a publishable paper in lieu of a thesis for the degree Doctor of Physical Therapy Science.

Everett Lohman III, Associate Professor of Physical Therapy, Chairperson



Eric Johnson, Assistant Professor of Physical Therapy



Steve Zecher, Associate Professor of Physical Therapy, Western University

ACKNOWLEDGMENTS

I wish to thank my research committee, Everett Lohman III, PT, DPTSc, OCS, Steve Zecher, PT, MPT, OCS and Eric Johnson, PT, DPTSc, for their innovative ideas, assistance with data collection sites and for their critical review of the final paper. I wish to acknowledge Grenith Zimmerman, PhD, for her incredible guidance and statistical support. Thank you to Jeanine Stewart-Mendes, PT, MPT for grammatically reviewing my final dissertation, and to James Syms, PT, MPT for help with my intra-rater reliability study. I must also acknowledge those who provided and helped coordinate subjects for my research: Lowell Reynolds, MD, Anne T. Cipta, MD and Laura Meadows, MA, CCRC of the Loma Linda University Center for Pain Management; Lillian Phang, RN, Jien Sup Kim, MD, Divakara Kedlaya, MD, Cathy Vega and Cynthia Acevedo of the Loma Linda University Outpatient Surgical Center; Vance Z. Johnson, MD, Terry Bonnabeesse, MD and Judy Smith of the Premier Outpatient Surgery Center and Inland Physiatry Medical Group, Inc. Lastly, Richard M. Finn, FACMPE, Larry Ding, MD from the Riverside Community Medical Group; Susan Jones, RN from the Riverside Community Surgery Center.

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ABSTRACT

Predicting Sacroiliac Syndrome: The Association between Noninvasive Sacroiliac Joint Tests and Sacroiliac Joint Injections

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Study Design. A prospective single sample observational design was performed. Sacroiliac tests that predicted ≥ 75% pain relief after sacroiliac joint (SIJ) injection were considered valid diagnostic tests for SIJ syndrome.

Objectives. To identify valid noninvasive sacroiliac tests that can be used to diagnose SIJ syndrome.

Summary of Background Data. The criterion standard for diagnosing SIJ syndrome is with SIJ intraarticular injections under fluoroscopy. This procedure is costly, invasive, and impractical for routine use. Clinicians need practical ways to diagnose SIJ syndrome; however, few studies have been performed to validate existing sacroiliac tests against SIJ Injections.

Methods. Nineteen subjects who were scheduled for a SIJ injection, and without lumbar discogenic symptoms were recruited for the study. Subjects were included who identified their pain below the 5th lumbar vertebra (L5), including the posterior superior iliac spine (PSIS). Pain presentation could also include the groin, hip, and/or entire lower limb. Prior to the injection, four sacroiliac tests were performed: the march test, PSIS symmetry, sacroiliac ligament tenderness, and the supine to long-sit test. Subjective pain intensity was recorded before and after the injection, on a 0 to 10 scale.

Results. The supine to long-sit test was a valid and fair predictor of sacroiliac joint syndrome (sensitivity = 100%, specificity 45%, PV+ = 50%, PV- = 100%, p=.026).

Conclusion. The supine to long-sit test is a fair predictor of sacroiliac joint syndrome when used in combination with sacroiliac tests that are highly specific for SIJ syndrome.

Key Words: Sacroiliac joint, injection, diagnosis, validity

Interest in the sacroiliac joint (SIJ) has increased in the last decade. Experts in the fields of physical therapy, medicine, osteopathy and chiropractic medicine identify the sacroiliac joint as a pain generator. [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16] Anatomically, the SIJ is both a diarthrosis with a corresponding joint capsule and synovial membrane, and a syndesmosis surrounded by ligaments. This unique structure enables it to distribute forces caudally to cranially during functional activities. Inherent stability is provided by a dense system of ligaments, fascia, and muscles. [5,7,17,18,19,20] While movement of the SIJ is thought to be small, [7] it is subject to shear and instability if forces are applied at the wrong angle or if the stabilization mechanism fails. [5,18,19,20] SIJ pain, known as SIJ syndrome, can then occur. Schwarzer et al [21] found 30% of low back pain (LBP) to originate from the SIJ, while Maigne et al [22] identified 18.5%.

Plain radiographs, computed tomography (CT), magnetic resonance imaging (MRI), and bone scans are currently unable to diagnose SIJ syndrome. [21,23,24] The criterion standard for diagnosing SIJ syndrome is with SIJ intraarticular injections under fluoroscopy. [2,5,23] This procedure is costly, invasive and impractical for routine use. For these reasons, injections are usually not performed until other means of conservative treatment have proved unsuccessful. However, without proper diagnosis, conservative treatment is left unguided. In some cases, SIJ injections are never performed, and proper diagnosis is missed. Proper diagnosis would enable healthcare professionals to provide treatment that is effective, promotes healing and restores health. Current

practice would be dramatically aided by noninvasive, cost effective tests that accurately diagnose SIJ pathology.

The purpose of this study was to identify noninvasive sacroiliac tests that diagnose SIJ syndrome. Ability to diagnose SIJ syndrome was determined by comparing SIJ test results with intraarticular SIJ injections. The four SIJ tests studied were: 1) march test (also known as the modified Gillet test), 2) PSIS symmetry, 3) sacroiliac ligament tenderness, and 4) supine to long-sit test. These tests have been found to be associated with low back pain by various authors. [4,10,11] They also have consensus-based validity, as experts and educators in the field of physical therapy identify these tests as indicators of SIJ syndrome. [3,4,5,10,25] If validated, these tests have the potential to be superior to other common SIJ tests. They are noninvasive, so eliminate the risk for infection or exacerbation of symptoms associated with SIJ injections. They do not rely on subjective information from the patient to yield a positive test, as do pain provocation tests. They also more specifically test the sacroiliac joint than pain provocation tests, which can also stress the hips, lumbar spine and related soft tissues. The four tests chosen for this study were simple to perform, time efficient, cost-effective and did not require special equipment. For these reasons, the author hypothesized the march test, PSIS symmetry, sacroiliac ligament tenderness and supine to long-sit test to be positive indicators of SIJ syndrome.

METHODS

Intra-rater Reliability Study

Intra-rater reliability of the primary examiner's (LW) performance of the four sacroiliac tests was determined prior to the implementation of the study. This was performed because reliability for most sacroiliac tests has been found to range from none to fair. [8,26,27,28,29,30,31] The examiner performed the four sacroiliac tests on a group of 10 physical therapy students, documented results, and reexamined the randomized subjects an hour later. The examiner's reliability was good to excellent (90-100%) for the sacroiliac tests studied. Agreement for the supine to long-sit test, and all ligamentous tests excluding the left sacrotuberous, was 100%. Kappa and agreement for the march, PSIS symmetry (k=.62) and left sacrotuberous ligament (k=.74) was 90%. The reliability study is described in detail in Appendix III.

Subjects

Subjects were recruited from three orthopaedic physician's offices in the counties of San Bernardino and Riverside, California. Subjects were included when pain presented below L5 [21] including the region of the PSIS. [32] Pain presentation could also include the groin, [21] hip, and/or entire lower limb. [33,34] Subjects were recruited who were between 18-50 years, to include those with skeletal maturity, while excluding those with probable SIJ degeneration. [35,36,37] Negative results from a lumbar MRI, CT scan, or lack of discogenic symptoms were required to rule out lumbar pathology that may present similarly to SIJ syndrome.

Subjects with any of the following known conditions were excluded from the study: lumbar disc pathology as indicated by MRI or CT scan, bowel and/or bladder symptoms, discogenic radiating pain and/or impaired sensation, abnormal deep tendon reflexes, profound lower extremity muscle weakness, asymmetrical sacral inferior lateral angles and/or asymmetrical sacral bases. Pregnancy, prostatitis, prostate cancer, gynecologic disorders, enteropathic disorders (ulcerative colitis, Crohn's disease, colon cancer, irritable bowel syndrome), endocarditis, spondyloarthropathies (ankylosing spondylitis, Reiter's syndrome, psoriatic arthritis associated with inflammatory bowel disease), Paget's disease, [38] psychosomatic pain and a history of lumbar surgery within the last year were also excluded.

Procedures

The examiner (LW) approached consecutive patients who were scheduled for a SIJ injection at the participating clinics, and who met the inclusion criteria. LW explained the study's procedures, risks and benefits, then asked the subjects to participate. The examiner obtained signed informed consents and followed ethical standards, approved by the Loma Linda University Institutional Review Board. Subjects were asked to point to the specific areas on their bodies where they felt pain. The examiner documented the reported pain patterns on a body diagram. Subjects who met the inclusion criteria for pain presentation were screened for sacroilial dysfunction. Sacroilial dysfunction is when the sacrum rotates in relation to the ilium. Dysfunction was determined by palpating the sacral bases and inferior lateral angles (ILA) for lack of symmetry in the

transverse plane. [6,25] If asymmetrical, subjects were excluded from the study, because the sacroiliac (SI) tests chosen for this study are believed to indicate iliosacral dysfunction not sacroilial dysfunction. [5,6]

PSIS symmetry

LW performed the sacroiliac tests in the following order to avoid variability from ordering effects: 1) PSIS symmetry, 2) sacroiliac ligament palpation, 3) supine to long-sit test, and the 4) march test. Both PSISs were assessed in prone, comparing their symmetry in the frontal and transverse planes. Asymmetry of the PSISs, noted either as superior, inferior, medial or lateral, suggests the innominate is malaligned. For example, when the PSIS is positioned inferiorly to the opposite PSIS, it is thought to indicate the innominate is posteriorly rotated in reference to the sacrum. [4,5,6,12,25] Asymmetry was operationally defined as more than one-centimeter difference between PSIS positions during the PSIS symmetry test. This was estimated visually, as performed clinically.

Sacroiliac ligamentous tenderness

The sacroiliac ligaments are integral stabilizers of the SIJ. [5,6,17] When a ligament is strained, palpation reveals tenderness. It is thought that identification of ligamentous tenderness can also aid the examiner in determining the type of SIJ asymmetry present (e.g. innominate rotation). [5,6,12,25] Three posterior ligaments were assessed on both sides of the pelvis; the long posterior SI, short posterior SI and sacrotuberous ligaments. The long posterior sacroiliac ligament was palpated inferiomedially to the PSIS, while the short posterior sacroiliac

ligament was palpated just medially to the PSIS. The sacrotuberous ligament was palpated superiolaterally to the coccyx. Tenderness upon palpation indicated a positive test for the palpated ligament.

Supine to long-sit test

The supine to long-sit test compares apparent leg lengths in the supine and long-sit positions. LW first assessed apparent leg length with the subject supine and their legs straight. The examiner palpated the most inferior aspects of both medial malleoli, and viewed their position relative to each other in the frontal plane. Next, the subject was asked to assume long-sitting while maintaining their legs extended on the examination table. To change positions, the subject pushed or pulled with their arms on the examination table, or was helped by an assistant. Positions of the medial malleoli were then reassessed. An observable change in apparent leg length, a difference greater than one-centimeter between medial malleoli, between supine and long-sit was deemed a positive test, believed to indicate SIJ syndrome [4,6,12] and iliosacral dysfunction. This test has been found highly sensitive and specific for identifying patients with LBP. [4]

If the right innominate is rotated posteriorly, the right leg will appear shorter in supine as compared with the left. A posterior movement of the innominate causes the acetabulum to move superioposteriorly, resulting in a femur that is translated superiorly. This movement makes the leg appear shorter. In long-sitting, the hips flex and the innominate rotates anteriorly, moving the acetabulum inferioanteriorly. In this position the leg appears lengthened. Thus, a change in relative leg length between supine and long-sit was documented as a positive

test. Results for the supine to long-sit test would not be altered by an actual leg length discrepancy, so no measurements were taken.

March test

The march test is believed to analyze the movement of the SIJ during flexion of the ipsilateral hip. The examiner, positioned behind the subject, palpated the PSIS of the SIJ to be tested with her thumb while palpating the adjacent 2nd sacral (S2) spinous process with the other thumb. The subject, standing with his or her feet approximately 12 inches apart, was asked to flex the knee above the hip on the same side as the SIJ to be examined. In normal motion, the PSIS moves inferiorly, due to posterior rotation of the innominate relative to the sacrum. Lack of or diminished inferior movement, as compared bilaterally, is thought to indicate limited posterior innominate rotation, a positive test. [4,5,12,25]

To examine anterior rotation of the innominate, the examiner performed the following. Without changing manual contacts, the patient was asked to flex the contralateral limb in the same manner as before. This produces anterior rotation of the innominate on the ipsilateral side. In normal biomechanics, as the hip flexes, the innominate on the same side posteriorly rotates. Once end range is achieved, the lumbar spine is recruited into flexion. As it flexes, the sacral base extends, which is also known as counternutation. When the sacrum extends, the examiner will feel the S2 spinous process move inferiorly. Diminished inferior movement of S2 as compared bilaterally indicates a positive test, specifically, limited innominate anterior rotation. [5,6]

Sacroiliac Joint Injection

SIJ injections were performed following the sacroiliac tests to determine the presence or absence of SIJ syndrome. Injections were not a direct part of this study, rather normal care as recommended by the subjects physicians. Injections were performed utilizing fluoroscopy, the criterion standard for diagnosing SIJ syndrome. [21-24,32] Injections consisted of a local anesthetic and corticosteroid. The local anesthetic was expected to relieve SIJ pain within a few minutes post injection. After the injection, subjects rested supine for 15-30 minutes.

Prior to and 15-30 minutes following the injection, subjects were asked to record their pain intensity. They were instructed to circle the number on a 0 to 10 pain scale that best represented their pain. Zero represented no pain, 10 the most excruciating pain possible. They were also asked to state what percentage of pain relief they experienced after the injection (e.g. 80%). At both time intervals, subjects were asked to document relief of familiar pain.

Subjects who reported pain relief ≥75% after SIJ injection, calculated by pain scale changes, were considered positive for SIJ syndrome. These subjects comprised experimental group 1. Those who experienced pain relief less than 75% made up the second group, those without SIJ syndrome.

Data Analysis

Analysis of data included sensitivity, specificity, positive predictive value and negative predictive value for the SIJ tests. [39] Discriminant analysis was also used to determine the best predictor. Intra-rater reliability of the examiner (LW)

to administer the SIJ tests was determined by percentage agreement and kappa. The level of significance was set at alpha = 0.05.

Results

Nineteen subjects met the inclusion criteria, and participated in the study. Group 1 had one male and seven females, while group 2 had one male and 10 females. The higher incidence of SIJ syndrome in females is postulated in the literature. [17] The two groups were not significantly different in age, height, weight, body mass index or pain level before the injection. The amount of pain reduction was the only significant difference between the groups. Ten subjects had a negative lumbar MRI, while the other nine subjects did not have a MRI. All subjects were free of disc symptoms, as diagnosed by a physician. Characteristics of the subjects are summarized in Table 1.

Table 1. Characteristics of Subjects

Variable	Pain Relief ≥ 75% (n = 7) Mean (SD)	Pain Relief < 75% (n = 12) Mean (SD)	p-value*
Age	41.9 (7.3)	41.7 (6.6)	0.96
Height (inches)	65.0 (3.6)	63.6 (4.3)	0.47
Weight (pounds)	182.3 (33.8)	158.6 (46.3)	0.24
Body Mass Index+	30.3 (4.4)	27.5 (7.5)	0.37
Subjective Pain Relief (%)	93.1 (11.3)	36.5 (34.0)	<.001
Pain Before Injection	6.2 (1.9)	5.8 (2.5)	0.72
Pain After Injection	0.3 (0.5)	3.9 (2.3)	<.001
Change in Pain Scale (%)	93.5 (9.6)	28.7 (32.1)	<.001

* Independent t-test

+ wt (kg) /ht^2(meters)

Group 1, subjects who reported ≥75% pain relief after SIJ injection, reported a mean pain decrease of 93.5%, while group 2, those with <75% pain relief, reported 28.7% decrease (p<.001). Pain change (%) reported by the subjects was significantly associated with pain change (%) calculated from the 0 to 10 pain scale (p=.001). See Table 2 for details.

Table 2. Association of Subjective Pain Change (%) and Change in Pain Scale (%)*

	Subjective Pain Relief ≥ 75%	Subjective Pain Relief < 75%	Total
Pain Scale Change ≥ 75%	8	0	8
Pain Scale Change < 75%	2	8	10
Total	10	8	18

* $\chi^2 = 3.56$ df=1; p=.001

Sensitivity, specificity, positive predictive value (PV+) and negative predictive value (PV-) were calculated for each sacroiliac test studied. The findings are given in Tables 3, 4, and 5.

Table 3. Supine to Long-Sit Test: Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value

	Positive Change	Negative	Total
Pain Relief ≥ 75%	8	0	8
Pain Relief < 75%	6	5	11
Total	14	5	19

Sensitivity = 8/8 = 100% PV+ = 8/14 = 57%

Specificity = 5/11 = 45% PV- = 5/5 = 100%

Table 4. March Test: Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value

	Positive Change	Negative	Total
Pain Relief ≥ 75%	5	3	8
Pain Relief < 75%	3	8	11
Total	8	11	19

Sensitivity = 5/8 = 63% PPV+ = 5/8 = 63%

Specificity = 8/11 = 73% PPV- = 8/11 = 73%

Table 5. PSIS Symmetry: Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value

	Positive (Not level)	Negative (Level)	Total
Pain Relief ≥ 75%	6	2	8
Pain Relief < 75%	6	5	11
Total	12	7	19

Sensitivity = 6/8 = 75% PV+ = 6/12 = 50%

Specificity = 5/11 = 45% PV- = 5/7 = 71%

The supine to long-sit test was found most sensitive (100%), but demonstrated low specificity (45%). The march test had 63% sensitivity and fair specificity (73%), while the PSIS symmetry test had fair sensitivity (75%) and poor specificity (45%). Neither the march or PSIS symmetry tests were associated with SIJ syndrome. Palpation of the SIJ ligaments was also not found to predict SIJ syndrome. A tender left posterior short SI was the only ligament found associated with SIJ syndrome (p=.048), although it was not a predictor. Results for all tested ligaments ranged as follows: sensitivity 38-75%, specificity 18-55%, PV+ 22-46%, PV- 29-67%. See Appendix II for details.

Canonical discriminant analysis was also used to determine the best predictor. It identified the supine to long-sit test (PV+ = 50%, PV- = 100%,

p=.026) as the best predictor studied. The test correctly classified 68.4% of cases for this study. No combination of tests was found significant.

The direction of the innominate's positional fault (e.g. anterior or posterior) is thought to influence which sacroiliac ligaments are tender to palpation.[5] It is believed that when the innominate is rotated posteriorly, for example, the ipsilateral sacrotuberous and posterior short SI ligament would be tender to palpation. When the innominate is positioned in an anterior rotation, the posterior short SI and posterior long SI ligaments would be tender. For analysis of this theory, the position of the innominate was first determined by the PSIS symmetry findings. The specific ligaments that were found tender were analyzed for correlation with an anterior or posterior rotated innominate.

Tenderness to palpation of the ipsilateral posterior short SI ligament was present in 80% of posterior innominate rotations (four of five subjects). Ipsilateral sacrotuberous ligament tenderness was found in only one of five cases. Posterior long SI ligament tenderness was found in all three cases of anterior innominate rotation, while tenderness of the posterior short SI ligament was present in two of three cases. Contrary to the above theories, all but one of the rotated innominates also had contralateral tenderness of the posterior short and long SI ligament(s), and/or the sacrotuberous ligament(s). The position of innominate rotation was also compared with the results of the supine to long-sit test. Five of 15 subjects (33%) of supine to long-sit test results accurately predicted the direction of innominate rotation. None of the above findings were statistically significant.

The direction of innominate rotation was also determined by the supine to long-sit test results. This innominate position was again analyzed for correlation with the postulated ligament tenderness. Tenderness of the ipsilateral posterior short and long SI ligaments were present in 100% of anterior innominate rotations (seven of seven cases). In posteriorly rotated innominates, three of seven subjects exhibited tenderness of the ipsilateral posterior short SI ligament, and three of seven subjects had ipsilateral sacrotuberous ligament tenderness. Tenderness of contralateral SI ligament(s) tenderness was found in six of seven anterior innominate rotations and seven of seven posterior, inconsistent with the tested theory. Of the five subjects who had a negative supine to long-sit tests, only one had no sacroiliac ligament tenderness. The march test was not studied in the above manner because data was not collected to identify the direction of rotational limitation. None of the above analyses were statistically significant.

DISCUSSION

Physicians, physical therapists, chiropractors and osteopaths can use the supine to long-sit test to indicate SIJ syndrome during the differential diagnosis process. This test can also be performed to determine if a patient is an appropriate candidate for a SIJ injection. In order to identify possible false positives that the supine to long-sit test will miss, the author suggests also using the FABER test (also known as the Patrick's test), resisted hip abduction, and/or the posterior sheer test. [40] These tests were found to be 100% specific, and 77-87% sensitive for identifying SIJ syndrome.

The supine to long-sit test was not found to predict the direction of innominate positional fault, as determined by the PSIS asymmetry test. The author thinks changes in PSIS symmetry may be too small to identify by palpation. Research has found very small movement at the SIJ, about 2 degrees or 0.4 to 2.5mm.[41,42,43] However, movement of the SIJ has been found to be 25% greater when measured between supine and the long-sitting positions.[43] This means that a positional fault of the SIJ would be more easily detected between the supine and long-sitting positions. This may explain why results of this study found the supine to long-sit test to be a better predictor of SIJ syndrome than PSIS asymmetry test.

The 0 to 10 pain scale is commonly used in clinical settings to quantify pain intensity. It is also used to document pain changes. In this study, the degree of pain change after injection was determined two ways. Subjects were asked to rate their pain on a 0 to 10 scale both before and after the injection, then the

difference was calculated (%). The second technique for determining pain change was asking the subjects what percentage the pain had changed. This study discovered that these two ways for determining pain change produced similar results. Because of this correlation, physicians may rely on patient feedback to determine effectiveness of SIJ injections.

In this study, 42% of subjects experienced significant pain relief (≥75%) after intraarticular injections of the SIJ. This confirms previous assertions of the sacroiliac joint as a LBP generator.

Tenderness of the sacroiliac ligaments did not correlate with ≥75% pain relief after SIJ injection. This contradicts current practice of diagnosing SIJ syndrome and identifying candidates for SIJ injections by those with palpable tenderness of the area surrounding the SIJ. Ligaments neighboring the SIJ are potential pain generators, but tenderness may indicate a ligament sprain that is independent of SIJ syndrome. Prior research [33,44] also did not find an association between ligament tenderness in the area of the sacral sulcus and SIJ syndrome.

Results for specific ligamentous tenderness did not significantly predict the direction of innominate rotation. For anterior rotation, ipsilateral posterior short SI and posterior long SI ligaments are believed to be tender to palpation, while a posteriorly rotated innominate would have ipsilateral tenderness of the sacrotuberous and posterior short SI ligament. In this study, ligament tenderness did not present entirely in this manner. Subjects also reported other ligaments in the sacroiliac region, posterior short SI, posterior long SI, or sacrotuberous ligaments were also tender to palpation. Therefore, ligament tenderness did not

discriminate which innominate rotation was present. Unfortunately, the small sample size in this study did not allow for adequate analysis of a possible relationship.

The high incidence of ipsilateral posterior short SI ligament tenderness in posterior innominate rotations (80%), and ipsilateral posterior short and long SI ligament tenderness in anterior rotations (100%), warrants further study with larger sample sizes. Researchers could also utilize anterior superior iliac spine (ASIS) positional findings to more accurately define innominate rotations and combined rotations with innominate upslips.

Sample sizes also did not render sufficient power to study the association of innominate rotation, determined the supine to long-sit test, and sacroiliac ligament tenderness. In this study, all seven cases of anterior innominate rotation, determined by the supine to long-sit test, had tender ipsilateral posterior short and long SI ligaments. This finding warrants further study of these variables with larger sample sizes. Prior research of the supine to long-sit test, however, found that it was unable to identify the presence of innominate rotation.[10]

SIJ injections are the criterion standard for diagnosing SIJ syndrome. SIJ syndrome is diagnosed when a considerable amount of pain is relieved after injection. The degree of pain relief required for diagnosis has not been standardized, and it varies in the literature from 50% to 90%. [22,33,34,40,44,45] In this study the two groups of subjects reported significantly different degrees of pain relief after SIJ injection ($p<.001$). Group 1, subjects who reported ≥75% pain

relief after SIJ injection, had a mean pain decrease of 93.5%, while group 2, those who reported <75% relief, reported 28.7% decrease. Subjects who felt pain relief after the injection experienced a substantial amount of relief, over 90%. On the other hand, subjects who did not feel a substantial amount of pain relief reported a much smaller degree of relief, less than 30%. Clinicians and researchers who diagnose SIJ syndrome can use this information as part of their diagnostic criteria. When a patient reports greater than 90% pain relief after SIJ injection, diagnosis of SIJ syndrome may be made.

Future research on SIJ syndrome should include subjects whose pain is characteristic of those with SIJ syndrome. Previous research studies have analyzed the association between possible sacroiliac tests and LBP. [4,9,10,11] Analysis of LBP is nonspecific, and represents the pain patterns of a number of pathologies, both of the lumbar spine and the sacroiliac joint. These studies, therefore, cannot conclude correlation of SIJ tests with SIJ syndrome, only with LBP. Researchers who wish to identify patients with SIJ syndrome should require pain referral patterns specific of the SIJ. These patterns have been outlined in clinical research. [21,32]

Future research should avoid dividing subjects into groups. Previous researchers divided subjects based on the percentage of pain relief reported after SIJ injection, but were not consistent regarding the degree of relief necessary to diagnose SIJ syndrome, ranging from 50% to 90%. [21,22,33,40,44,45] The percentage of pain relief needed to diagnose SIJ syndrome has not been established. Future research should analyze the association of SIJ blocks and

sacroiliac tests without dividing subjects into groups. They can record the amount of pain change (%) after injection, and compare it to the studied tests. Data can then be analyzed utilizing parametric tests such as the ANOVA, which are more powerful statistical tools than their nonparametric counterparts.

This study also had the following limitations. The author believes it was necessary to include strict inclusion and exclusion criteria to best isolate SIJ syndrome, and exclude lumbar pathologies. As a result, the sample size was small, decreasing the generalizability of the results. Sample sizes were also insufficient to determine if a combination of tests could predict an innominate positional fault. Because SIJ injections were not a direct part of the study, no control group was included. This left the placebo effect uncontrolled. Further analysis of the march test was not performed because the researcher did not record the direction of motion limitation. In order to study the correlation of motion restrictions with innominate rotation or other findings, the direction of motion limitation must be documented. Data collection for innominate inflares and outflares was not performed, which may have influenced findings.

CONCLUSION

The purpose of this study was to identify valid noninvasive sacroiliac tests that could be used to diagnose SIJ syndrome. The supine to long-sit test was identified as a fair predictor of SIJ syndrome; however it needs to be used in combination with other tests that have high specificity for SIJ syndrome. Three tests found to be 100% specific were the FABER test (also known as the Patrick's test), resisted hip abduction and the posterior sheer test. [40] Neither the supine to long-sit test nor SI ligament tenderness predicted the positional fault of the innominate; however, an insufficient sample size did not allow for complete study of these possible relationships. Results of this study confirm the SIJ as a generator of LBP, as 42% of subjects experienced significant pain relief after intraarticular SIJ injections. Results also advocate that physicians may rely on patient feedback to determine effectiveness of SIJ injections. Medical professionals can better aid patients with SIJ syndrome when they search for its diagnosis with valid sacroiliac tests: supine to long-sit test, Patrick's test (also known as FABER), posterior shear test and resisted hip abduction.

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APPENDIX I.

LITERATURE REVIEW

Clinicians search for practical ways to diagnose SIJ syndrome, however, few studies have attempted to validate sacroiliac tests against the criterion standard, SIJ injections. The four studies [1,2,3,4] that follow attempted to validate specific sacroiliac tests. Broadhurst and Bond [1] found three pain provocation tests, the Patrick's test (also known as FABER), posterior shear test and resisted hip abduction to predict ≥ 70% pain relief from SIJ injection. Pain levels were gathered after each test, both prior to and following injection. The three tests had a specificity of 100%, and a sensitivity range of 77-87%.

Dreyfuss et al [2] analyzed 12 SIJ tests and subjective criteria for their ability to diagnose SIJ syndrome. Each was considered diagnostic if it correlated with ≥90% pain relief post SIJ injection. The authors chose 90%, a high criterion, in hopes of identifying true SIJ pathology. None of the following tests were found likely to diagnose SIJ syndrome: SI pain, buttock pain, groin pain, PSIS pain, asymmetrical sitting position, Gillet test, thigh thrust, Patrick's test, Gaenslen's test, midline sacral thrust, joint play, and sacral sulcus tenderness. Poor inter-rater reliability for administering three of the twelve tests and high requirements for pain relief after injection may have skewed results.

Maigne et al [3] compared the results of seven SIJ pain provocation tests with SIJ syndrome, operationally defined as >75% pain relief after two consecutive SIJ injections. The SIJ tests examined were: SIJ distraction, compression, sacral pressure, Gaenslen's test, Patrick's test, pubic symphysis pressure and

resisted hip external rotation. The authors utilized a double block procedure, in which pain relief was first required from a local anesthetic, then from a longer lasting "confirmatory" block to be considered positive for SIJ pathology. This procedure was advocated to eliminate the need for a placebo. None of the SIJ provocation tests studied predicted SIJ syndrome. Maigne and colleagues did not report the reliability of their examiner(s) in performing pain provocation tests. If reliability was poor, conclusions between the pain provocation tests and SIJ syndrome would not be correct. This study was the only one found that utilized the double block procedure.

Slipman et al [4] studied three SIJ tests for their ability to predict ≥80% pain relief after SIJ blocks. Sixty percent of subjects with positive test results had SIJ syndrome. These findings were not sufficient to validate the tests studied: Patrick's test, sacral sulcus pressure, shear test, standing extension, Gaenslen's maneuver and Yeoman's maneuver.

Other researchers found associations between SIJ test results and low back pain. Cibulka and Koldenhoff [5] found that a positive test for three of four sacroiliac joint tests indicated LBP. The tests utilized were the standing flexion test, sitting PSIS palpation for asymmetry, supine to long-sitting test and the prone knee flexion test. This group of tests had a sensitivity of 0.82, specificity 0.88, positive predictive value of 0.86 and negative predictive value of 0.84 for LBP. Another combination of tests, palpation of the PSIS for tenderness, the femoral compression test and iliac gapping had good sensitivity and specificity for indicating LBP or pubic symphysis pain. [6] Positive test results for PSIS

asymmetry [7] and the Gillet test [8] have also been found positively associated with LBP. Although researchers attempted to uncover an association between SIJ test results and SIJ involvement, comparing test results with LBP does not isolate SIJ syndrome. On the contrary, LBP may indicate a number of lumbar pathologies, SIJ syndrome, or both. Diagnosticians are left without answers on how to distinguish between these two closely-knit regions.

The sacroiliac joint (SIJ) is difficult to differentiate from facet or discogenic pathology, as they result in similar pain presentations. As a result, studies have been performed to better identify pain referral patterns of the SIJ. Schwarzer et al [9] found that subjects who experienced significant pain relief after SIJ injection identified their pain below L5-S1. Groin pain was also found associated with SIJ syndrome. Dreyfuss et al [2] discovered that subjects who responded positively to diagnostic SIJ injections, ≥90% pain relief, experienced pain in the buttock, thigh, calf, and/or foot. The pain presentations were no different than of subjects who did not experience relief after the SIJ injections. Slipman et al [10] also described SIJ pain patterns, reported by subjects who experienced ≥80% pain relief after SIJ injections. Authors found SIJ pain patterns to include the buttock and/or aspects of the entire lower limb. Subjects reported pain in the following locations: buttock (94% of subjects), lower lumbar (72%), lower limb (50%) and groin (14%). Fortin et al [11] identified pain referral patterns of the SIJ by injecting asymptomatic subjects with contrast material under fluoroscopy. Pain was recorded in the buttock extending laterally to the greater trochanter, and inferiorly to the posterior superior iliac spine (PSIS), gluteal fold and posterior knee. An

area inferior to the PSIS, 3 x 10 cm in diameter, was found common to all subjects.

Sacroiliac joint syndrome is also difficult to differentiate from internal organ diseases that refer pain to the SIJ. Viscerogenic referral to the region of the SIJ includes: prostatitis, prostate cancer, gynecologic disorders, enteropathic disorders (ulcerative colitis, Crohn's disease, colon cancer, irritable bowel syndrome), endocarditis, spondyloarthropathies (ankylosing spondylitis, Reiter's syndrome, psoriatic arthritis associated with inflammatory bowel disease), and Paget's disease. Psychogenic factors must also be cleared before assuming SIJ pain is musculoskeletal in origin. [12]

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APPENDIX II.
TABLES

Table 6. Right Posterior Short SI Ligament Test: Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value

	Positive Tenderness	Negative	Total
Pain Relief ≥ 75%	6	2	8
Pain Relief < 75%	7	4	11
Total	13	6	19

Sensitivity = 6/8 = 75% PV+ = 6/13 = 46%

Specificity = 4/11 = 36% PV- = 4/6 = 67%

Table 7. Left Posterior Short SI Ligament Test: Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value

	Positive Tenderness	Negative	Total
Pain Relief ≥ 75%	3	5	8
Pain Relief < 75%	9	2	11
Total	12	7	19

Sensitivity = 3/8 = 38% PV+ = 3/12 = 25%

Specificity = 2/11 = 18% PV- = 2/7 = 29%

Table 8. Right Posterior Long SI Ligament Test: Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value

	Positive Tenderness	Negative	Total
Pain Relief ≥ 75%	5	3	8
Pain Relief < 75%	9	2	11
Total	14	5	19

Sensitivity = 5/8 = 63% PV+ = 5/14 = 36%

Specificity = 2/11 = 18% PV- = 2/5 = 40%

Table 9. Left Posterior Long SI Ligament Test: Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value

	Positive Tenderness	Negative	Total
Pain Relief ≥ 75%	5	3	8
Pain Relief < 75%	8	3	11
Total	13	6	19

Sensitivity = 5/8 = 63% PV+ = 5/13 = 38%

Specificity = 3/11 = 27% PV- = 3/6 = 50%

Table 10. Right Sacrotuberous Ligament Test: Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value

	Positive Tenderness	Negative	Total
Pain Relief ≥ 75%	4	4	8
Pain Relief < 75%	5	6	11
Total	9	10	19

Sensitivity = 4/8 = 50% PV+ = 4/9 = 44%

Specificity = 6/11 = 55% PV- = 6/10 = 60%

Table 11. Left Sacrotuberous Ligament Test: Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value

	Positive Tenderness	Negative	Total
Pain Relief ≥ 75%	3	5	8
Pain Relief < 75%	6	5	11
Total	9	10	19

Sensitivity = 3/8 = 38% PV+ = 3/9 = 33%

Specificity = 5/11 = 45% PV- = 5/10 = 50%

APPENDIX III.

INTRA-RATER RELIABILITY STUDY

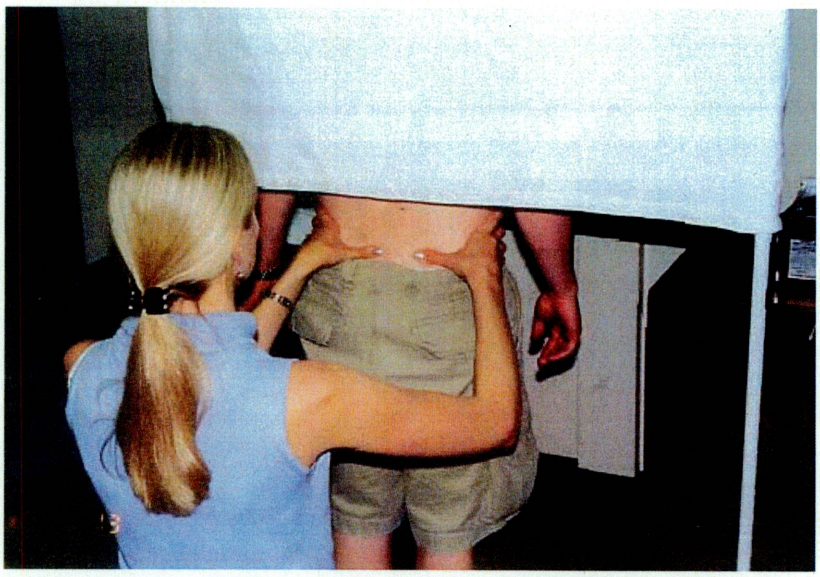
The examiner (LW) completed a test-retest study to determine her reliability in administering the four SIJ tests. This was especially important, as literature finds SIJ reliability testing to range from none to fair reliability. [26,27,28,29,30] Intra-tester reliability has been found to be more reliable. Among the tests chosen for this study, prior research had found the PSIS asymmetry test to be slightly to moderately reliable, [29] and the march test reliability varied from none, [28] fair, [26] to reliable. [27,46] No published reliability studies were found for sacroiliac ligament palpation or the supine to long-sit test, although palpation for pain of the PSIS had excellent reliability. [47]

Intra-rater reliability of the examiner was determined by the following study. Ten healthy physical therapy students volunteered for the study as part of a classroom activity. The subjects were lead to an examination area by an assistant. The assistant assigned each subject a code number, and prepared the subjects for the examination. The examiner performed the SIJ tests on all subjects in the same sequence, to prevent ordering error. The order of testing were as follows: PSIS symmetry test, sacroiliac ligament tenderness, supine to long-sit test, and the march test. The examiner was blinded to the subject's identity by a cloth screen, which covered the subject's upper body during all tests (photo on the following page). The assistant documented the test findings. An hour later, LW re-tested the subjects in a different order. The SIJ tests were performed in the same order as during the initial test.

Percentage agreement was utilized to determine intra-rater reliability for each sacroiliac test. The examiner was found to be 100% reliable for testing posterior short and long sacroiliac ligament tenderness, and 90% reliable for sacrotuberous ligament tenderness. She was 100% reliable in performing the supine to long-sit test, and 90% reliable for the PSIS symmetry and the march test. These findings are consistent with good to excellent intra-rater reliability.

Results of this reliability study were limited in the following ways. Healthy subjects were tested, who may be less likely to exhibit sacroiliac asymmetry, hypomobility, or tenderness than people seeking treatment for SIJ pain. The sample size was small, so reliability findings may not be similar in a larger group.

Intra-rater Reliability Study



APPENDIX IV.

DATA COLLECTION FORMS

Research Screening Form

Predicting Sacroiliac Syndrome: The Association Between Noninvasive Sacroiliac Joint Tests and Sacroiliac Joint Injections

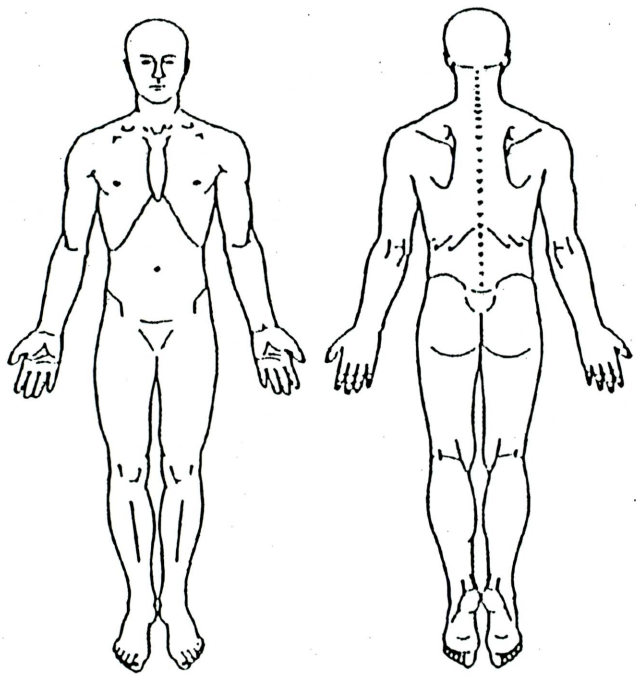
Please complete this form entirely. Do not leave any questions unanswered. If you have questions, please ask the researcher. All information that you share in this document will be confidential. No one other than the researcher will know your responses. Do not write your name on this form.

Date _____ Phone # _____ Subject # _____

Age _____ Sex _____ Height _____ Weight _____

A. Have you or are you currently receiving physical therapy or chiropractic treatment? Yes No

B. With the assistance of the researcher, fill in the body diagram to indicate where you feel pain. Draw lines on areas of pain, and "x" on areas of numbness or tingling.



C. Do you have any of the following medical problems? Mark yes or no.

Yes ❒ No ❒ Disc injury of the low back
Yes ❒ No ❒ Low back surgery within the last year
Yes ❒ No ❒ Problems using the bathroom (bowel and/or bladder)
Yes ❒ No ❒ Numbness in your legs or buttock
Yes ❒ No ❒ Very weak legs
Yes ❒ No ❒ Cancer of the colon
Yes ❒ No ❒ Cancer of the prostate, or inflamed prostate
Yes ❒ No ❒ Irritable bowel syndrome
Yes ❒ No ❒ Ulcerative colitis (disease of the large intestine)
Yes ❒ No ❒ Endocarditis (disease of the heart valves)
Yes ❒ No ❒ Ankylosing spondylitis (disorder where the spine fuses)
Yes ❒ No ❒ Reiter's syndrome
Yes ❒ No ❒ Crohn's disease (disease of the bowel and intestine)
Yes ❒ No ❒ Psoriatic arthritis with inflammatory bowel disease (psoriasis and arthritis)
Yes ❒ No ❒ Paget's disease (too much bone)
Yes ❒ No ❒ For Women – Gynecologic disorders (sexually transmitted diseases, uterus, cervical, or breast diseases)
Yes ❒ No ❒ For women - Are you pregnant?

Research Screening Form

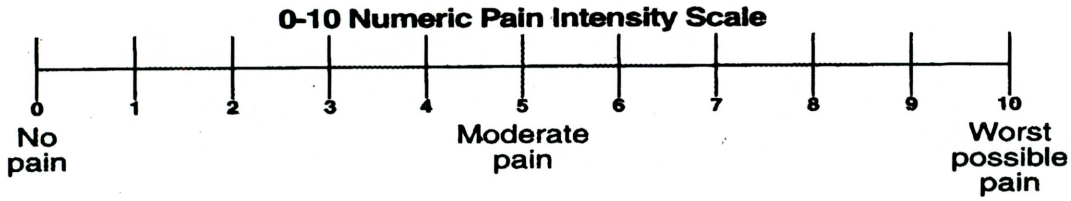
Predicting Sacroiliac Syndrome:
The Association Between Noninvasive Sacroiliac Joint Tests and Sacroiliac Joint Injections

Please complete this form entirely. Do not leave any questions unanswered. If you have questions, please page the researcher at 909-715-1905. All information that you share in this document will be confidential.

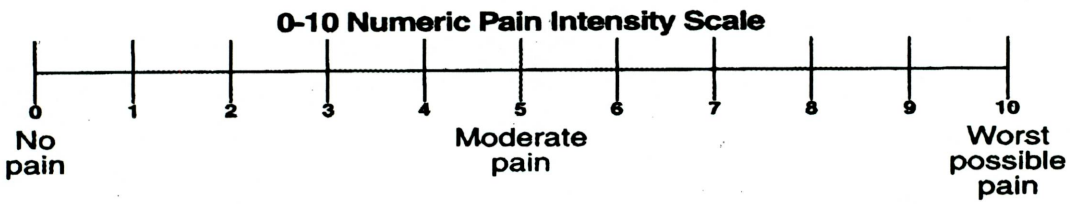
1. How much did your pain decrease 15-30 minutes after the shot (indicate in percentage)? For example, write 0% if the pain did not improve, 100% if you felt no pain after the injection. What percentage (0% to 100%) did YOUR pain *decrease*? _____

2. Circle the number that best describes your pain *before* and *after* the shot using the scale below.

   A. Pain Before Shot:



   B. Pain 15-30 Minutes After Shot:



Data Collection Form
Loma Linda University

Lorraine D. Webb M.P.T., candidate for D.P.T.Sc.

Predicting Sacroiliac Syndrome: The Association Between Noninvasive Sacroiliac Joint Tests and Sacroiliac Joint Injections

ID #	Sacral Base, I.L.A. cleared	PSIS symmetry (L,R sup, inf, med, lat)	Post. Short SI ligt tender (L,R)	Post Long SI ligt tender (L,R)	Sacro-tuberous ligt (L,R)	Supine Long Sit (L,R short, long)	March (L,R ant, post rot.)