INTRODUCTION

A long-term controversy exists regarding the influence of pelvic joints on low back pain (LBP). While some clinicians claim success following LBP reduction post-treatment directed to the pelvic area, some researchers argue that motions at the sacroiliac and symphysis pubis joints are not large enough to affect LBP.[1] Weisl's anatomical study on normal subjects demonstrated 5.5 mm of anterior promontory motion during nine position changes.[2] These nine positional changes included movements of the trunk on a fixed lower body and movements of the hips in combination with trunk motion. Another researcher, Stuerrson, studied sacroiliac motion in twenty-five LBP subjects during five functional position changes, noting averages of 2 degrees of rotation and 0.5 mm of translation.[1] Through cadaveric dissections, others have shown that sacroiliac motion normally decreases with age. Over 50% of cadaveric specimens in their sixth decade of life demonstrated total sacral fusion.[3] Although these findings give support to arguments that limited pelvic motion (at the sacroiliac and pubic symphysis joints) may not contribute to LBP, clinicians have continued to treat these areas in their LBP patients. One may question why any clinician would continue treating pelvic joints, when such evidence exists. This investigator believes that clinical success reducing symptoms of LBP has been enough of an impetus to continue delivering treatments directed to the pelvic joints.

Generally, manual therapists believe that the purpose of pelvic treatment, in any form, is to attempt to realign pelvic joints thought to be malaligned and/or possibly mechanically locked. Clinicians, who use forms of pelvic treatment, suspect that once pelvic bony realignment has been restored, all corresponding mechanics shall additionally be restored. This thinking does seems scientifically based. .It is conceivable that normal mechanics lend themselves to normal

tissues, and abnormal mechanics lend themselves to abnormal (inflammed) tissues. Surprisingly, no known research exists specifically on whether these assumptions hold true in the pelvic joints. Many differing evaluative and treatment approaches exists in recent history. Each technique not only attempts to identify subjects with pelvic malignment or dysfunction, but also offers specific treatments designed to realign pelvic landmarks.

In 1962, Stoddard, an osteopathic physician, developed a manipulative technique directed to relieving sacroiliac dysfunction.[4] These high velocity manipulative techniques exceed normal physiological joint limits, yet have shown to be effective in populations with acute mechanical LBP. Because such rigorous techniques pose the risk of possible injury if applied incorrectly, many clinicians may opt to use mobilization techniques. Mobiliation techniques are slow velocity maneuvers with low loads delivered within the physiological limits of the joint.

In 1979, Mitchell, Moran and Pruzzo proposed one well-known approach to pelvic joint malalignment, incorporating both evaluation and treatment.[5] The evaluation assessed positions of bony pelvic landmarks at rest and coupled this information with results from joint motion tests, including standing and sitting forward bend tests. Treatment consisted of muscle energy techniques employing strategic muscle contractions in an attempt to realign pelvic landmarks to reduce patient pain. The assessments and treatments were oriented parallel to the triplanar surface of the sacroiliac joint, thus introducing the concept that motion at these joints may occur about an oblique axis.

Mitchell et al's pioneering technique has formed the cornerstone for many other approaches developed to treat sacroiliac and pubic symphysis dysfunctions. Greive, for example, advocates the addition of pain provocation tests to the evaluation, using mobilizations with either sustained pressures or oscillatory techniques.[6] Greenman's assessment contains the same positional and motion tests described in Mitchell's work, with the addition of both muscle energy techniques and manipulative thrusts during treatment.[7] Bourdillon and Day also base their approach on Mitchell's work and add two simple spring tests to the evaluation: one performed with the patient supine and the other with the patient prone.[8] Spring tests are manual therapy manuevers, performed by clinicians on joints passively moved to end-range. Spring tests appear as small, bounce-like manuevers, and purport to assess a joint's ability to move and/or absorb shock. Spring tests at the SI joint claim to assess the mobility between the sacrum and the ilia.

Another method for assessment of pelvic malalignment was developed by Hesch in 1981[9]. Similar to the other approaches, Hesch incorporated established mobilization and muscle energy techniques in treatment. However, his method differs from previous work in two ways. First, by the addition of spring testing to the assessment. Second, by the use of cardinal plane orientation for both evaluation and treatment of the pelvic joints. Reportedly, this method evolved from necessity; Hesch himself sustained an injury to his pubis symphysis in 1974, leaving him with an unstable pelvis. From his own experience, he then devised a theory about the influence of the pelvic joint complex on LBP. From this theory, he developed assessment and treatment techniques for both patient and clinician. However, Hesch conducted no research on his method, relying solely on personal experience and anecdotal accounts of successful treatment outcomes.

At present, it is not known why clinicians (who decide to treat the pelvic joints in the LBP patients) select one form of pelvic treatment over another. Perhaps multiple factors determine ultimate technique selection. Positive anectdotal reports may drive some clinicians to investigate techniques. Whereas, required skill levels and associated risk levels may also affect choices. Or perhaps, techniques are simply chosen based on availability of information. Whatever the inital reasons for specific treatment selection are, continued attempts (from clinicians) to treat the pelvic joints (in their LBP patients) would only occur if the patients report positive outcomes.

Currently, low back pain reduction remains the most common outcome measure of successful treatment directed to the pelvis. Cibulka, Delitto and Erhard have demonstrated that pelvic manipulations coupled with exercise are more effective than exercise alone in reducing LBP, as measured by the Oswestry questionnaire.[10] However, pain alleviation may not be the only significant outcome measure. Cibulka documented improved symmetry of pelvic inclination angles immediately following treatment.[11]

If pelvic mobilization reliably demonstrates improved pelvic symmetry post-treatment, perhaps this improved symmetry will directly affect mobility in adjacent areas. If so, an examiner should be able to observe measurable changes in either lumbar sagittal motion or straight leg raise performance immediately following such pelvic treatment. These anatomical changes may also indicate a positive treatment result if there is a simultaneous decrease in pain. To date, no study exists investigating whether movement changes occur in neighboring muscular skeletal area and if that movement corresponds to a decrease in pain.

With different forms of pelvic treatment utilization present in physical therapy clinics accross the United States, one must wonder why so few formal research studies exist to substantiate these techniques. Insurances companies increasingly request formal evidence of efficacy, prior to payment. If clinicians expect payment for services, then research needs to provide measurable outcomes as a result of those treatments. Therefore, the intent of this study is to document any changes in neighboring musculoskeletal areas following pelvic mobilization, both immediately and two-weeks later. Changes in subject's self-report of pain will also be monitored. This investigator has chosen to use the Hesch method of pelvic mobilization in this investigation. This method was selected for two reasons. The first was investigator preference. The second was this investigator's perception of high incidences of successful pain reduction with her LBP subjects when utilizing this method.

LITERATURE REVIEW

Anatomy

Due to the vastness of literature, this anatomical review will remain limited to structures specifically related to the sacroiliac joint, the pubic symphysis, and the lumbosacral junction.

General Information

The pelvic girdle is comprised of three separate bones; the two coxal bones and one sacrum.[12] These bones are united by two sacroiliac joints posteriorly and one pubic symphysis anteriorly. Each coxal bone is a combination of three bones; the ilium, ischium and the pubis.

The sacrum is made up of 5 fused vertebrae and is roughly triangular in shape.[12] The coccyx consists of four fused vertebrae. The coxal bone articulates in two planes; with the sacrum

posteriorly and with itself anteriorly at the pubic symphysis. The sacroiliac joint is synovial anteriorly and fibrous posteriorly. The pubic symphysis is a secondary cartilaginous joint.

The primary functions of the bony pelvis are:

1. Force transmission of incumbent weight to the floor and transmission of the ground reaction forces superiorly to the trunk.
2. The pelvis provides a large surface for attachments for muscles and ligaments. Muscles that attach to the pelvis have actions on both the upper and lower extremities as well as the trunk.
3. The pelvis supports and protects the viscera contained within it while providing bony support for the birth canal.
4. The pelvis also houses the center of gravity. Movement of the pelvis during gait helps to minimize the movement of the center of gravity, thereby conserving energy.

Ilium

The superior potion of the pelvis is the ilium.[12] It forms the pelvic brim which lies between the acetabulum and the SI joint. The area of the ilium that articulates with the sacrum is the thickest. The iliac crest ends anteriorly with the anterior superior iliac spine. It ends posteriorly with the posterior superior iliac spine. Both of these spines are palpable and are frequently used as landmarks by clinicians.

The auricular area of the ilium, which articulates with the sacrum, extends from the pelvic brim to the PSISs. It's surface changes gently, being convex above to concave below. The surface is roughened by numerous tuberosities and depressions. This articular surface is covered with cartilage, and most authors agree it is fibrocartilage.[14,15]

Pubis

The pubis is a highly angulated bone.[12] It joins the ilium via the superior ramus while it joins the ischium at the acetabulum. The surface of the pubis at the symphysis is oval in shape. The surface is coated with hyaline cartilage crossed by several transverse ridges. Fibrocartilage attaches .

Sacrum

The sacrum consists of five fused bones.[12] Triangular in shape, its base lies superior and the apex inferior. The anterior surface is concave and relatively smooth. The dorsal surface is convex and very irregular. Four anterior sacral foramina can be seen for exiting spinal nerves. The posterior surface also has four sacral foramina. Medial to the posterior foramina are lamina which are closed. Exceptions occur at the 4th and 5th levels. This remaining opening is called the sacral hiatus. This hiatus is an important opening utilized for nerve blocks during the delivery of a fetus.

The lateral surface of the sacrum articulates with the ilium. The anterior aspect is covered with hyaline cartilage. It is roughened in order to articulate with prominence on the ilial surfaces in a

near mirror image. The posterior aspect is irregular enabling attachment of the powerful dorsal sacroiliac ligaments.

The base of the sacrum articulates superiorly with the inferior portion of the fifth lumbar vertebra. The articulating surfaces are large and oval. They are supported by heavy pedicles.

SI Joint

Most authorities consider the SI joint to be synovial anteriorly and fibrous posteriorly.[14,15] The auricular surfaces are L-shaped with the convexity of the L facing anterior. The joint is broader above and narrower below. The central part of the sacral articular surface is concave, with elevations on either side. In contrast, the ilium has two furrows separated by the central crest. The joint usually spans the S1 to S3 segments.

Comment [IT1]:

Interestingly enough, this joint is much flatter and allows for greater mobility prior to puberty.[14] At puberty, reciprocal elevations and depressions begin to form, initially limiting available motion. These elevations and depressions continue to develop and mature, significantly restricting motion around the third decade of life. Fibrous bands begin to form between the two joint surfaces around the sixth decade of life. While mobility may still present, it may be significantly reduced as compared to the prepubescent pelvi. Some pelvi have been reported to be ankylosed by the eighth decade of life.

Weisl believed that the sacrum is essentially non-weight bearing, suspended between two coxal bones by the dorsal ligaments.[16] Weisl determined that this suspension was maintained by both

the cranial and caudal dorsal ligaments. Other authors also believe that the ligaments are the structures which bear the incumbent weight of the body. Cunningham has been quoted to be the investigator who said that the sacrum is actually suspended by the dense dorsal ligaments.[13] Another researcher, Grant, supported the suspension theory and further defined the position of the sacrum in standing.[13] He determined that the sacrum tends to sink forward into the pelvis, in standing. He further theorized that this position would tighten the posterior SI ligaments, drawing the ilia together.

Ligaments

The anterior sacroiliac ligaments are thickenings of the anterior capsule.[12] The ligaments are broad and flat. Females tend to have a stronger anterior ligament than males.

The posterior SI ligaments are noted to have three distinct layers. The interosseous ligament is the deepest. It is extremely strong and it spans the narrow cleft between the rough areas on the posterior joint surface. The short oblique fibers lie superficial to the interosseous ligament, and are considered to be the intermediate layer. These short oblique fibers run downward and lateral and resist flexion of the sacral promontory. The most superficial layer of the dorsal ligaments are the longer vertical ligaments. These longer vertical ligaments resist the downward movement of the sacrum with respect to the ilia.

Three other ligaments are associated with the sacroiliac joint. They include the iliolumbar ligament, the sacrospinous, and the sacrotuberous ligament. The iliolumbar ligament connects the transverse process of L_5 to the illium.[12] The iliolumbar ligament has two bands; one anterior

and one posterior. This ligament limits the extension of L_5 and prevents the forward slippage of L_5 off the sacral base. The sacrospinous ligament is triangular in shape. It attaches medially to the lateral margins of the sacrum and coccyx. Laterally, it attaches to the spine of the ischium. The sacrospinous ligament lies anterior to the sacrotuberous ligament. The sacrotuberous ligament is a large, dense ligament that spans a wide area. Superiorly it attaches to the posterior inferior spine of the ilium, to the fourth and fifth transverse tubercles of the sacrum, and to the inferior part of the lateral margin of the sacrum and the coccyx. It passes obliquely inferiorly and laterally, becoming narrower until it attaches to the medial side to the ischial tuberosity.

Blood and Nerve Supply

The SI joint receives its blood supply from branches of the iliolumbar artery anteriorly.[12] Posteriorly, it receives blood from branches of the superior gluteal artery. The lateral sacral arteries provide a limited collateral circulation.

The nerve supply has been shown to vary between and within individuals.[12] The posterior portion of the SI joint is typically supplied by the lateral branches of L5, S1 and S2. The anterior portion of the SI joint is supplied by L3 through S1 and branches from the superior gluteal nerve.

Pain

Pain at the SI joint may result from; SI joint dysfunction, neighboring or secondary joint dysfunction, or from visceral pathology.[12] Mechanically, SI joint dysfunction can refer pain to either PSIS, while pubic symphysis dysfunction usually refers pain to the hip. Yet, not all pains in the regions of the PSISs and hip joints are directly attributable to pelvic joint dysfunction.

Secondary joint dysfunction, occurring at either the lumbar spine or hip, may also mimic pelvic joint dysfunction. Lumbar spine can refer pain distally to the SI joint. Additionally, hip pain may be indicative of direct hip pathology.

Visceral organs may also refer pain to the SI joint. A medical dysfunction or neoplasm of any organ contained within the pelvic bowl has the capability of referring pain to this area. These organs include; intestines, ureters, bladder and the reproductive organs.

Since pain at the pelvic joints may be due to dysfunction from multiple origins, clinicians must have systematic methods to differentially diagnoses. The sources of pain must be determined. Generally, mechanical pains are reproducible with mechanical stimuli (i.e. with movement or weight bearing), whereas visceral pains are not usually influenced by mechanical stimuli. Once clinicians differentiated the pain source to be mechanical, further tests are required to determine if the source is from primary or secondary dysfunction.

Biomechanics

With a high degree of anatomical variability between subjects, the SI joint doesn't easily lend itself to definitive conclusions regarding available motion. Study results vary depending upon methodology.

Kapandji defined anterior inferior movement of the sacral promontory as nutation.[13] He also noted that the ilia approximated one another during nutation while the ischial tuberosties separated. The reverse occurs when the sacral promontory moves posteriorly, which is referred to as counternutation.

One motion study, by Colachis, inserted Kirschner wires into the PSISs of twelve subjects.[19] The subjects were asked to move in nine different functional positions. Positions included prone, short sitting, sidelying with and without rotations, standing, one-leg stance, and forward bending. The greatest movement occurred during subjects attempts to bend forward from the standing position. This recorded difference was 5 mm. at the base of the Kirschner wires.

Weisl stated that the greatest SI joint motion occurred in moving from the recumbent position to standing.[2] He studied 91 living subjects, measuring SI joint movement with conventional Xrays. He found the greatest sacral promontory to occur during position changes from recumbency to standing. He noted the sacral promontory to move about 5.6 mm. and noted the axis to be 10cm below the promontory.

Joint Motion and Axes

In the attempt of defining SI joint axes, research results are also quite variable. Lavignolle et al looked beyond the SI joint and concluded that the axes of motion were centered in the pubic symphysis.[13]

Another researcher, Mitchell, described multiple axes at the SI joint proper; 3 horizontal innominate axes, 3 horizontal sacral axes, and two diagonal sacral axes.[5] Mitchell defined the role of each axes with respect to specific force transmissions, occuring either above or below the SI joint. Mitchell created the diagonal sacral axes in an attempt to explain effects from a unilateral piriformis contraction.

Wilder was unable to identify a single rotational axis due to the great variability between eleven samples.[20] Yet, Wilder did conclude that if any rotation occurred, it would have to be coupled with a translation. He also concluded that the main function of this minimal movement was to absorb energy.

Egund et al used roentgen stereophotogrammetry to study four individuals without LBP.[21] Tantalum balls were inserted into the sacrum and the paired ilia were viewed under flouroscopy. Subjects moved into the following positions; supine, prone, prone with manual pressure in the ventral direction at the sacral apex, erect standing, standing on unilateral limbs (right then left), and finally, standing with a maximum lordosis. They determined the maximum rotation to be 2 degrees of rotation with a maximum of 2 mm of translation.

Sturesson et al used the same technique to study 25 subjects with LBP.[1] He measured sacroiliac joint motion before and after placing his subjects in prescribed postures. Difference in bony position within subjects reflected movement occurring between the following positions changes; supine to standing, supine to long sit, standing to prone, and lastly, prone with unilateral hip extension. The mean maximum mobility of the sacroiliac joint was 2.5 degrees. There was an average translation of 0.7 mm. Sturesson concluded that the movement of the SI joint is clinically negligible.

Recently, a metrecom skeletal analysis system was used to detect ilial positions in a reciprocal straddle posture.[22] The study found a mean oblique sagittal motion of 9 degrees.

After reading the above literature, one should note the variablity of documented motions available and their associated axes. Seemingly, motion varies between sample populations and the methodology used for study. Some studies used only normal subjects, while other studies used subjects with LBP. Perhaps subjects with LBP have less availiable SI joint motion than subjects without pain. If Wilder was correct in concluding that SI joint motion exists as a shock absorber, then perhaps it makes sense that studies which examined subjects with LBP noted less available motion.[20] In theory, subjects with less available SI joint motion could eventually end up overloading neighboring joint structures that breakdown and give rise to LBP.

Since no gold standard for assessing joint motion has been accepted to date, readers may have difficulty in determining the exact amount of available SI motion. With variablity between sample populations, one might conclude that some small motion probably exists at the SI joint. It is conceivable that the purpose of this motion is probably to absorb shock, just as Wilder had concluded.[20]

Lumbar Flexion

Limited lumbar flexion range-of-motion has been shown to be related to LBP.[23,24] The American Medical Association's system determines percents of total disability based on lumbar motion restriction.[23] Although all spinal motions are used in determining this percentage, sagittal motions have received the most investigation. Pearcy et al showed that flexion was more restricted than extension in LBP patients.[24] Physical therapy often focuses treatment based on improving limited spinal motion. Many times, limited lumbar flexion values have demonstrated

needs for continued treatment. In fact, some treatment rationales, such as the McKenzie extension exercise protocol, have based their entire low back approach on the restoration of spinal motion.[25]

While lumbar motions can be measured by various methods, the AMA recommends the double inclinometer method.[23] Reported errors in these various measurement techniques range from as small as two degrees in one study,[26] to others which report errors up to 10 degrees.[27]

Mayer utilized the double inclinometer method, as proposed by Leobl, to measure lumbar flexion/extension.[26] Mayer was able to compare the double inclinometry measures of flexion/extension to the gold standard of Xray in a subgroup of LBP patients. The double inclinometry measurements were taken simultaneously during routine forward bending and backward bending Xrays in twelve pateints. Mayer et al reported no significant difference in the two measures of lumbar sagittal motion at the $p< 0.01$ level. The mean inclinometry measurement at the time of radiographic evaluation was 60.5 degrees, while mean sagittal motion measured from the comparison Xrays was 58.5 degrees; therefore, the actual difference between the means of these two different measures was two degrees.

The investigation by Keeley et al, in 1985, also found excellent intertester reliability after looking at the use of inclinometers to assess lumbar flexion/extension and right/left rotations.[28] This study utilized two different methods: a non-blinded and a blinded format. In the former, two examiners were allowed to compare their subjects' measurements before moving on to the next subject. The non-blinded method was thought to allow the examiners to improve their

measurement technique. The latter method employed a blinded format where neither examiner was allowed to compare the results of any test with each other. Both methods utilized two groups: subjects without LBP and patients with LBP. The non-blinded group consisted of 11 normals and 9 chronic LBP patients; the blinded group had 20 normals and 23 chronic LBP patients. Most reliability measures were reported above the 0.90 level using the Pearson r with levels of significance at $p < 0.001$. The only measures with reliabilities below 0.90 were in the blinded group with specific reference to the measure of pelvic motion (hip motion). The reliability values demonstrated an r of 0.74 for the measure of hip motion in the normal subjects, and an r of 0.82 for the same measure in patients. The authors concluded that double inclinometry methods provided reliable measures of lumbar flexion/extension and right/left rotations.

Rondinelli et al analyzed results from three different measures of lumbar flexion: single inclinometry, double inclinometry, and back range-of-motion inclinometry.[29] This study used eight normal subjects with two examiners, repeating each measurement three times in random order. The inclinometry techniques followed AMA guidelines. The authors reported the back range-of-motion inclinometry was measured per manufacturer guidelines. Differences in the measurement outcomes for each tool were determined to be the variance, or error, of the measurement. Resultant errors were 8.5 degrees for the single inclinometry method, 10.5 degrees for the double inclinometry method, and 16 degrees for the back range-of-motion inclinometry.

Boline et al reported a similarly large error with the double inclinometer method, examining 50 subjects using two examiners.[27] Twenty-five of the subjects had no low back pain history, while the other twenty-five suffered chronic pain. Right and left lumbar rotations were the only motions tested, and each measure performed once by two investigators. Each investigator recorded their measurements onto separate data collection sheets. Interexaminer measurement disagreements were calculated with an interexaminer measurement error statistic, a specific measure of the absolute difference between examiner values. Errors ranged from 3.8-10.4 degrees, the lower noted in the chronic LBP group during right rotation; the 10.4 degree error was applied for total rotation in the asymptomatic group.

Williams compared the double inclinometer method to the modified-modified Schober method with 15 patients with chronic low back pain.[30] Three examiners tested lumbar flexion and extension with these methods twice, two days apart, and calculated test-retest reliability statistics for both methods. The Pearson product results for the modified-modified Schober method ranged from .78 to .89 for lumbar flexion, and .69 to .91 for lumbar extension. Test-retest results for the double-inclinometer method were .13 to .87 for flexion and .28 to .66 for extension. Intertester reliability was calculated with a ANOVA-ICC, and the modified-modified Schober intertester reliability was .72 for flexion, and .76 for extension. The same statistical tool used on the double-inclinometer method showed values of .60 for flexion and .76 for extension. The authors concluded that the double inclinometer method yielded moderately reliable results while the modified-modified Schober method had results that were very reliable.

In summary, most of the above literature have reported variable reliabilities and errors for the double inclinometry method of assessing lumbar flexion/extension. Two studies noted the double inclinometry method to be extremely reliable, while another two studies found relatively large errors. And to add to the confusion, the last mentioned study noted another measurement technique, the modified modified Schober method, to be more reliable than the double inclinometry method. The reliability of any measurement technique is dependent upon the method, the examiners and the subjects. Since it is unclear at this time which measurement method (double inclinometry or modified modified Schober) will demonstrate greater reliability with the examiners in this study, a pilot study will be employed to determine which technique to use in the study.

Straight Leg Raise

Many clinicians use straight leg raising as a measure of hamstring length.[31] Gadjosik et al have investigated four methods for assessing straight leg raise performance.[32] These authors evaluated the differences among four known clinical tests used to assess hamstring length, in thirty normal male subjects. Right hamstring lengths were assessed using hip motion (with the knee stabilized) or knee motion (with the hip secured at 90 degrees flexion). Two hip motion tests were performed to assess hamstring length. One requires pelvic and opposite leg stabilization with straps (Straight Leg Raise with stabilizing straps (SLR with SS)), while the second test additionally necessitated the patient performing a posterior pelvic tilt (Straight Leg Raise with Low Back Flat (SLR with LBF)) during the examination. The remaining two tests used knee motion to determine hamstring length. One used a passive method (Passive Knee Extension (PKE)), while the other an active one (Active Knee Extension (AKE)). In the passive test, the

supine subject required stabilization as previously described. While the examiner maintained the hip at 90 degrees flexion with one hand, the other hand extended the leg into extension until firm resistance occurred. In the second method, the subject had similar strapping. Yet, the examinee actively maintained the 90 degrees of hip flexion while knee extension progressed until myoclonus ensued. At that point, the subject flexed the knee slightly to stop the myoclonus and thereby define the end-point of the motion.

ICCs (2,1) were calculated to illustrate intratester reliability. Reported data for the straight leg raise with the opposite limb stabilized (SLR with SS) was 0.83; the ICC for the straight leg raise with the low back flat (SLR with LBF) was 0.88. ICCs for the active knee extension tests were 0.86 and for passive knee extension = 0.90. The study concluded that the two straight leg measures utilizing hip motion (SLR-SS + SLR-LBF) yielded interchangeable results, while the active knee extension test showed significantly greater knee angles than the passive one. The authors determined that the active knee extension represented the initial length of hamstring extensibility, while the passive one represented maximal length of hamstring extensibility.

The AMA's Guide to the Evaluation of Permanent Impairment offers another method for measuring straight leg raising performance.[23] The examiner stabilizes the leg not tested with one hand on the anterior distal portion of the thigh. The examiner then uses the other hand to support the tested leg's distal third, while simultaneously maintaining an inclinometer on the tibial spine. With the subject in this initial position, the inclinometer reading should be recorded. The leg tested is then elevated until a firm end-feel is noted, or until the same knee

begins to flex. At this point, the final inclinometer reading is noted. The resulting straight leg raising measure is the difference between the initial and final values.

The above literature demonstrates several methods for assessing straight leg raising. Since it is the purpose of this study to utilize a method with established high intrarrater reliability, this study has selected the SLR -SS method (straight leg raise with stabilizing stratps), as described by Gadojsik.

Pelvic Inclination

Cibulka measured pelvic inclination angles using the pelvic inclinometer described by Piktin and Pheasant in the 1930s.[11] This instrument was composed of a carpenter's caliper, with an attached inclinometer. A gravity needle indicates the angle. Intratester reliability using this tool was reported as $r = 0.84$.[33]

Cibulka's results showed changes in pelvic inclination angles following manipulation, and he demonstrated that bilateral changes occur following unilateral ilial treatment. Inclination angles showed greater symmetry following pelvic manipulation.

This tool demonstrates an established high level of intrarater reliability. Therfore, it has been selected as the method of measurement of pelvic inclination angles in standing in this study.

Oswestry Pain Questionnaire

Past research on pelvic treatment outcomes have utilized the Oswestry pain questionnaire to document patient's self-report of pain. The Oswestry pain questionnaire allows patients to assess their pain in ten categories, each on an ordinal scale of 0 - 5.[10,39] Raw scores may range from 0 to 50. In practice, the raw score is doubled, which results in scores that range from 0 to 100. One researcher , Cibulka, determined that an Oswestry score below 11 was criteria for discharge or return to work following treatment to the pelvic joints.

Past research, by Fairbanks et al, on this questionnaire has shown excellent test-retest reliability.[40] Twenty-two subjects with chronic LBP were administered questionnaires on two consecutive days. An excellent correlation coefficient of $r = 0.99$ was noted ($p < 0.001$). This questionnaire also appears consistently responsive to differences, as concluded after monitoring 25 patients via questionnaires on a weekly basis for three weeks during their first bout of acute LBP. The authors anticipated a high probability of spontaneous recovery with this population, which was reflected in the decline in scores.

Fairbanks also included a method to interpret disability scores.[40] Refer to Table 4 for score ranges and their intended meanings.

Table 4 Interpretation of Oswestry Disability Scores[40]

0% - 20%	Minimal Disability	Patient can cope with most activities. Usually no treatment necessary. Some patients have difficulty sitting.
20% - 40%	Moderate Disability	This group has more difficulty with sitting, lifting and standing. May be off work, but personal care activities OK. Back condition can usually be managed by conservative care.
40% - 60%	Severe Disability	Pain is the major difficulty. Personal care, travel, social life and sexual activity and sleep are affected. These patients require investigation.
60% - 80%	Crippled	Back pain impinges on all aspects of their lives. Positive intervention required.
80% - 100%		These people are either bed-bound or exaggerating their symptoms.

Reliability of Established Pelvic Examination Tests

Recently, Dreyfuss attempted to evaluate twelve "best" clinical tests against a criterion standard of unequivocal pain relief following an intra-articular injection of local anesthestic into the sacroliac joint.[33] A panel of multidisciplinary experts ranked twenty examination tests for acceptance in the literature across disciplines. Refer to Table 1 for both potential and selected ranked tests. Two examiners independently performed the accepted twelve tests on eighty-five patients. All patients were asked to reevaluate their pain level twenty minutes post-injection on a 0 - 100% scale. The study defined a pain reduction of 90% post-injection as evidence of criteria for a diagnosis of sacroiliac joint pain. Forty-five subjects reported pain relief greater than 90%, while the remaining forty subjects did not. Interrater reliability for each of the twelve tests had Kappa values that ranged from 0.15 to 0.70. The least reliable tests between raters were the spring test ($k = 0.15$) and the Gillet test (0.22). The study determined that neither the subject historical data nor any of the twelve "best" tests demonstrated worthwhile diagnostic value.

Table 1: Potential tests of sacroiliac dysfunction and the selected "best" tests in ranked order.[33]

Potential Tests	Selected Tests
abnormal sitting posture	1) pain drawing depicting pain over the SI joint
groin pain	2) pain drawing depicting pain into the buttock
buttock pain	3) pain drawing depicting pain into the groin
sacroiliac joint pain	4) pointing to within 2 measured inches of the PSIS to indicate site of maximal pain
sacroiliac joint compression test	5) sitting with partial elevation from the chair of the buttock on the affected side
sacroiliac joint distraction test	6) Gillet test
thigh thrust	7) thigh thrust
Gaenslen's test	8) Patrick's test
Patrick's test	9) Gaenseln's test
sacral sulcus tenderness	10) midline sacral thrust
gluteal trigger	11) sacral sulcus tenderness
pointing to the PSIS as the main site of pain	12) joint play
iliopsoas tenderness	
pubic symphysis tenderness	
standing flexion test	
Gillet test	
superior sacroiliac joint "restriction" to spring testing	
inferior sacroiliac joint "restriction" to spring testing	
midline sacral thrust	
lower quadrant abdominal pain	

Other authors have evaluated various clinical tests used to examine the pelvic joints.[5,35,36] These studies have also reported evidence of poor intertester reliability with selected tests of pelvic dysfunction. Potter and Rothstein studied 13 selected tests used by clinicians, (see Table 2) including positional, motion, and two pain provocation tests.[35] They used eight skilled therapists to perform these selected tests on 17 subjects with diagnoses of low back strains. Results indicate only the pain provocation tests had acceptable levels of agreement among therapists, above 70%; the motion tests had poor levels, between 40 - 50%; and position tests showed the least interrater reliability, ranging between 23-41% of agreement.

Table 2 - List of Tests used to examine the sacroiliac joint[35]

1	Iliac crest levels (standing)
2	PSIS levels (standing)
3	ASIS levels (standing)
4	Standing flexion test
5	Standing Gillet Test
6	Iliac crest levels (sitting)
7	PSIS levels (sitting)
8	ASIS levels (sitting)
9	sitting flexion test
10	Supine iliac gapping test
11	Supine - long sitting test
12	Side-lying iliac compression test
13	Prone knee flexion test

Research has also shown that motion tests used to assess pelvic joint dysfunction may demonstrate abnormal findings even in asymptomatic populations.[37] Dreyfuss et al performed a single blinded study on 101 such subjects. To assess their specificity, they selected three motion tests; the Gillet, the standing forward bend test, and the seated forward bend test. Results showed that 20% of all asymptomatic examinees achieved a positive result on at least one of these three tests. The Gillet test had the poorest specificity. With this in mind, the authors cautioned clinicians not to base their sacroiliac evaluations solely on these test results due to possible inaccuracy.[33,35,36]

Cibulka describes a method of using four specific motion tests to identify pelvic dysfunction.[11] He reasoned that multiple pelvic dysfunction tests improve the accuracy of identifying patients having this condition. He indirectly demonstrated the effectiveness of these four motion tests (in identifying subjects with pelvic dysfunction) with positive outcomes following treatment. Treatment included a pelvic manipulation described by Stoddard. Positive outcomes included either improved pelvic symmetry or pain reduction following treatment. Improved pelvic symmetry was noted in ten subjects immediately post-manipulation. Pain reduction was noted

one week post-treatment; nine out of twelve subjects improved sufficiently to allow discharge (from physical therapy) as measured by an Oswestry score of eleven or less.[10]

In summary, the intertester reliabilities for most of the established tests used to identify pelvic dysfunction are generally poor. Multiple researchers with different populations have essentially concluded that most tests, used clinically to identify patients with pelvic dysfunction, are useless. Even the most recent study, which attempted to correlate thirteen tests to SI pain reductions following intrarticular injections, noted poor interrater reliabilities and poor test specificity. Only one set of authors, including Cibulka, was able to demonstrate positive outcomes (improved pelvic symmetry and pain reduction) after the identification and treatment of subjects with pelvic dysfunction. Since it is possible to obtain positive outcomes following pelvic manipulatins (in subjects with signs of pelvic dysfunction), perhaps research should continue to search for alternate methods of identifing subjects with pelvic dysfunction.

A New Method of Evaluating Pelvic Dysfunction

A relatively new technique in pelvic evaluation and treatment is the Hesch method.[9] While this assessment stems from the osteopathic literature, it differs by incorporating spring tests in the pelvic joint evaluation scheme. These simple tests are used to assess the ability of a joint to tolerate specific directional stress. The Hesch method recognizes the majority of pelvic lesions as described by the osteopathic model, except for those involving the sacrum. Hesch believes that most dysfunctions should be evaluated within the cardinal planes; therefore, his method does not utilize sacral torsions as described by Mitchell et al. For example, the osteopathic literature defines sacral torsion occurring about an oblique axis. When viewing the sacrum posteriorly,

this deviation appears when an upper sacral corner moves either forwards or backwards, allowing reverse motions to occur at the opposite inferior lateral angle. In contrast, the sacral deviations recognized by Hesch remain within the framework of the cardinal planes. He maintains that sacral torsion simply combines three cardinal plane motion segments; either flexion or extension, and side bending, and sacral rotation. Refer to Table 3 for comparative listings of pelvic dysfunctions among the methods described by Mitchell et al and Hesch.

Table 3: Comparisons of pelvic lesions from the Osteopathic and Hesch models

OSTEOPATHIC MODEL	**HESCH MODEL**
SACRAL LESIONS	*SACRAL LESIONS*
Forward sacral torsions	Forward bent sacrum
Backward sacral torsion	Backward bent sacrum
Unilateral sacral flexions	Sidebent sacrums
	sacrum with superior glide fixation
	Sacrum with inferior glide fixation
	Anteriorly displaced sacrum
	Posteriorly displaced sacrum
ILIAL DYSFUNCTIONS	*ILIAL DYSFUNCTIONS*
Anteriorly rotated ilium	Anteriorly rotated ilium
Posteriorly rotated ilium	Posteriorly rotated ilium
Iliac In-Flare	Iliac In-Flare Types I & II, unilateral & bil.
Iliac Out-Flare	Iliac Out-Flare Types I & II
Superior Iliac Subluxation	Upslip
Superior Pubic Subluxation	Superior Pubic Subluxation
Inferior Pubic Subluxation	Inferior Pubic Subluxation
	Anterior Pubic Subluxation
	Posterior Pubic Subluxation
	ISCHIOSACRAL DYSFUNCTION
	Medial Ischium
	Posterior Ischium - either due to a sagittal or transverse plane rotation
	Lateral Ischium
	Anterior Ischium- either due to a sagittal or transverse plane rotation.

The osteopathic model proposes an evaluation of a pelvis via positional information, from bony landmark palpation and motion testing.[5] The method described by Mitchell et al include the patient's performance of forward bending tests in both the standing and sitting positions. The

former examines the ilium's ability to move upon the sacrum, whereas the latter purports to evaluate the sacrum's freedom of movement between the ilia. In this method, a definitive diagnosis of dysfunction is based on combined abnormal positional and motion test findings.

Hesch contends that information from spring testing the pelvis in multiple directions enhances a clinician's ability to detect pelvic dysfunction.[9] The basic sequence consists of ten spring tests, which will be utilized in this investigation. Hesch additionally utilizes positional testing of bony landmarks to enhance information gained from spring testing. Hesch warns that positional tests alone may result in unreliable information, as pelvi demonstrating multiple lesions may have normal landmark positions in two out of the three planes.

Hypomobility in any of the ten tested directions implies a motion restriction in that direction. Treatment consists of a mobilization technique, rather than a manipulative one. To mobilize the pelvis, the part that is restricted is moved to the end range in the restricted direction; then it is maintained in that position for two to five minutes. A gentle force, no more than 20 pounds, is applied at a slow rate to achieve mobilization. Hesch instructs clinicians in springing and weight transfer using a bathroom scale.

When the Hesch treatment is clinically successful, the examiner may detect a minor shift in the restricted part's mobility. The patient may not be aware of the changes noted by the clinician. Immediate re-evaluation should demonstrate changes in both position and spring test results. Patients may require only one or two treatments in acute cases. Exercises may or may not be

required to maintain the correction in acute cases, while exercises usually are required to maintain the effect of treatment in the more chronic cases.

RESEARCH DESIGNS

This research utilized four separate research designs. The first design intended to determine the reliability of all inclinometry measures (straight leg raising, lumbar flexion with double inclinometry, lumbar flexion with the modified modified Schober, and pelvic inclination angles in standing)over a two-week time period, in a pilot study. After the reliability of each measure had been established (in the pilot study), the more reliable method for assessing lumbar flexion was chosen for use in the larger study.

The second research design was a double-blinded format designed to investigate the effects of pelvic mobilization, via the Hesch method, on 1) lumbar flexion 2) straight leg raising performances 3) pelvic inclination angles in standing and 4) subjects' self-report of pain. This second design was additionally intended to compare the pain reduction outcome results with other known works. A third design included a single-blinded format to assess the reliability of both spring and position tests suggested by the Hesch method. The fourth design was a single-blinded format used to describe the primary investigator's ability to reliably deliver treatment forces of twenty pounds.

PURPOSES

This research study has purposes in each of the research designs:

Research Design I - The Pilot

1) To determine the reliability of three measure over a two-week period. These measures include straight leg raising, two different measures of lumbar flexion, and pelvic inclination angles in standing

Research Design II -

2) To determine if an indirect measure of pelvic mobility exists. The three variables selected as potential indirect measures were the measures assessed in the pilot study (straight leg raising, lumbar flexion, and pelvic inclination angles in standing.

3) To evaluate changes in pain following pelvic mobilization

4) To compare outcomes of changes in patient self-report of pain from this study with other established research outcomes.

Research Design III -

5) To assess the reliability of the spring tests utilized in the Hesch method.

6) To determine the intratester reliability of the fifteen positional tests of the Hesch method.

Research Design IV - Reliability of Force Delivery

7) To determine the reliability of force delivery during treatment

METHOD

Subjects

All twenty-eight subjects were volunteers who were recently diagnosed by a physician (within one month) as having mechanical LBP. Prior physician evaluation was used to determine diagnosis and screen out inappropriate subjects.

All subjects had evidence of pelvic involvement both subjectively and objectively. Subjectively, patients had complained of pain near the PSIS. A 3 cm (width) X 10 cm (height) area would define the area near the PSIS.[41] Objectively, all subjects had evidence of abnormal spring test results, as described by Hesch, and as determined by this investigator. Subjects may also have had evidence of radiating pain, as distal as the knee.

All subjects were over age 18. No pregnant subjects participated in this study; likewise subjects with diagnoses of ankylosing spondylitis or spinal osteoporosis were excluded. Subjects with areas of cutaneous anesthesia or evidencing diminished or absent deep tendon reflexes in lower extremities were disqualified. No patient had any profound muscle weakness in lower extremities. A short neuromuscular screening examination, described in the Appendix, identified these specific exclusion criteria. Minimum required results included normal reflexes and strength no less than a 3+/5 in specific lower extremity musculature.

Testers

The primary investigator is a licensed physical therapist with seventeen years of clinical experience. This investigator has been using the Hesch method in clinical practice for approximately three years prior to the beginning of this study.

The study also engaged the assistance of two licensed physical therapist assistants. The first measuring assistant had five years of clinical experience, while the second recording assistant

had one year. Both assistants were blinded to subjects group identity throughout. The measuring assistant was responsible for; manual landmark identification, marking them with a permanent pen, and all of the inclinometry measures (lumbar flexion, straight leg raise, and pelvic inclination angles in standing). The recording assistant responsibility was to; record all measures verbalized by the measuring recorder, assisting the measuring assistant when needed, and preparing data collection forms for the primary investigator during the reliability testing of both the positional and spring tests.

Services of an osteopathic physician were obtained for this study. The physician's role was to evaluate subjects, according to the guidelines described. The physician additionally provided a medical diagnosis of low back pain. While subjects were allowed to use their own personal physician for referral to this study, subjects without a personal physician referral were evaluated by this study's osteopathic physician.

Instrumentation

Instrumentation consisted of two inclinometers, a chest depth caliper, and a bathroom scale. One inclinometer was a fluid filled inclinometer, the plurimeter-V (Preston, Grand Rapids, MI). This device had 2 degree intervals and a rotatable base to permit zeroing. The other inclinometer was a less-expensive, straight-edge model purchased from Sears (Chicago, IL), with one degree increments. Both inclinometers were calibrated against a protractor.

The chest depth caliper was similar to the tool used in Cibulka's previous study measuring pelvic inclination angles before and after manipulation (Preston, Grand Rapids, MI). No calibration was required of this tool.

The bathroom scale was a Health-O-Meter professional model (Service Merchandise, Norridge, IL). Prior to the start of this study, it was zeroed and calibrated with one pound increments for accuracy. Calibration was considered complete at 22 pounds.

PROCEDURE

Reseach Design 1- The Pilot

In order to determine the reliability of this study's measurements (lumbar flexion, straight leg raise, and pelvic inclination angles in standing) over time, a pilot study was performed. Subjects included ten physical therapist assistant students from Oakton Community College who volunteered. All subjects had complaints of LBP. This study's designated measuring assistant performed all measures three times, on two occasions, two-weeks apart.

Since it was unclear from the literature review as to which measure of lumbar flexion was more reliable over a two-week period, lumbar flexion was assessed by two methods. The first method was the double inclinometry method. The description for the double inclinometry method of measuring lumbar flexion is included later in this Procedure Section (pp. 39). The second method of measuring lumbar flexion was the modified modified Schober. The modified modified Schober included the use of a tape measure, spanning from S2 to 15 centimeters superiorly. The skin was marked with a pen 15 centimeters superior to S2 , with the subject in

erect standing. The subject was instructed to "bend over as far as you can". The measuring examiner noted the new distance from S2 to the skin marked previously with the pen. Three measures were recorded, with the mean used for statistical analysis.

Research Design II - Changes In Inclinometry Measures And Subjects' Self Report Of Pain

One-half of the twenty-eight subject were randomly assigned (prior to the study) by lottery to the experimental group; the remaining half comprised the controls. All measures of lumbar flexion, straight leg raises, and pelvic inclination angles were measured with inclinometers. Full descriptions of the measurement methods utilized are described later in this method section. Each measurement was taken three times, with averages used in statistical analyses.

Each inclinometry measures were assessed on three occassions. The first was prior to any spring or positional testing. The second was immediately post-treatment. The third was two weeks post either real or mock treatment. This investigator maintained equal time intervals between the first and second measurements in both the experimental and control groups.

Two assistants, who were blinded to all subjects' group assignment, obtained and recorded each inclinometry measure. Following the initial set of inclinometry measurements, the primary investigator assessed subjects' positional and spring tests information in subject groups of 2 or more. (Information regarding the pelvic evaluation and treatment will follow). The spring and positional tests were assessed twice, prior to any real or mock treatments. Post-treatment, all subjects were subjected to a second set of inclinometry measures. Subjects returned two-weeks later for a third set of inclinometry measures.

Lumbar Flexion with the double inclinometry method.

This study used the double-inclinometry method of assessing lumbar flexion. Each subject warmed up with five toe touch motions immediately prior to measurement, during which the subject placed his/her feet within a set of footprints secured to the floor. Footprint heels were 15 cm apart. The subject stood erect with eyes horizontal and arms laterally positioned. The measuring examiner placed the plurimeter-V inclinometer over the sacrum at S_2 , and the second one over the T_{12} - L_1 spinous processes. The PSIS landmarks indicated the S_2 level. The T_{12} - L_1 interspace was located after the examiner had determined L_4 from the subjects' iliac crest height and palpated up the spinous processes. Initial angular readings from both inclinometers were taken in erect standing position. The patient was then instructed to "bend over as far as you can". After motion completion, angular readings again were noted from both tools. Following written notation from the second assistant, the patient returned to standing. The top inclinometer measured gross motion, while the lower measured pelvic, or hip motion. True lumbar flexion was the difference between the gross and the hip motions.[23,26,30] Each of the three measures were recorded separately with the mean used for statistical analysis.

Straight Leg Raising measured with inclinometry

A straight-edge inclinometer with one degree increments was utilized to measure subjects' right and left straight leg raises. Subjects were positioned supine. The measuring examiner placed the inclinometer onto the tibial spine of the leg to be tested. Two straps stabilized each subject. One strap stabilized the leg opposite to the side being tested (at mid-thigh) to the table. The second strap secured the pelvis to the table. The leg to be tested (with the inclinometer held on its tibial

spine) was lifted by the measuring examiner, and lifted until the contralateral thigh began moving superiorly. The angular degree was read by the measuring examiner, and noted by the recording examiner. The mean of the three measurements was utilized in the statistical analysis.

Pelvic Inclination Angles measured with inclinometry

A chest caliper with a straight-edge inclinometer with one degree increments affixed to the connecting bar was used to assess pelvic inclination angles in standing. Prior to measurement. the measuring assistant had located and indicated pelvic landmark locations (on the ASISs and the PSISs) with pen dots. Subjects, without shoes, were asked to stand erect with their feet placed in preestablished footprints The measuring assistant then placed one caliper point on the subject's ASIS, at the dot's midpoint. The second caliper point was positioned on the ipsilateral midpoint PSIS. The measuring assistant read the angular measurement from the attached inclinometer. Degrees were recorded in whole numbers. Three measurements were taken for each subjects' right and left sides. Statistical analysis utilized the mean of three scores.

Subjects' Self-Report of Pain

All subjects received and completed an Oswestry Pain Questionnaire prior to clinical measurements, before the Hesch evaluation and treatment. Questionnaires were readministered two weeks later.

Research Design III - Reliability of the Hesch Pelvic Evaluation (Spring & Positional Tests)

The pelvic evaluation consisted of two parts, the first was a positional exam. (Refer to the Appendix C for a listing of the positional information obtained.) The second part consisted of

pelvic spring tests, as described by Hesch. The examiner was blinded during both the positional and spring tests. The latter's results will be rated: hypermobile, normal, or hypomobile. Forces required to manually assess the SI joint are defined.

A total force of up to 40 pounds may have been required to spring test. The initial twenty pounds may have taken up the joint's slack, followed by an additional gentle force, the spring test. This additional force was not to exceed 20 pounds; therefore, no force spring test ever exceeded twenty pounds over the force taking up the slack. The individual spring tests are described in the next section.

Basic Spring Tests[9] (Tests are performed individually on each SI joint, unless otherwise indicated)

Subject supine

1. Posterior rotation of the ilium

   The examiner's two hands mold to each ilium around the patient's ASIS. Up to twenty pounds of pressure should take up the slack of the joint during posterior rotation. This gentle spring test is maintained as a posterior rotary force.

2. Inferior spring test

   The examiner hands are placed on each iliac crest, just above the ASISs. During the separate side tests, each ilium is mobilized in an inferior direction.

Prone Spring Tests

1. Anterior rotation of the ilium

The examiner's hands are placed on the posterior superior ilium, superior and lateral to the PSIS. The examiner gently takes up the joint's slack by pressure in an anterior rotational movement.

2. Sacral rotation

   The ulnar border of the examiner's hand is placed at the SI joint (S_1 - S_3) unilaterally on the sacrum and medial to the PSIS. An anteriorly directed force takes up the slack, while testing requires additional force in the same direction.

3. Prone Sacral Side Bending

   The ulnar border of the examiner's hand contacts the inferior lateral angles of the sacrum. Direction of the spring test is superior.

4. Lateral Ilial Spring Test

   The heel of the tester's hand medially encompasses the PSIS, the examiner's fingers resting laterally on the ilium. Hand placement should exclude the sacrum, or the test becomes invalid. The maneuver should be directed at 45 degrees anterolaterally in the transverse plane.

5. Superior Spring Test

   The examiner's hand is placed on each ischial tuberosity. The directed force should be superior with a slight lateral component.

6. Inferior Spring Test to the Ilia

   An inferior stress is applied to the ilia via the posterior portion of the iliac crests.

7. Inferior Spring Test to the Sacrum

   The examiner's open palm is placed onto the sacrum. The examiner places the middle finger on the coccygeal tip and then lets the palm gently rest on the inferior sacrum. An inferiorly directed force is applied as the spring test.

8. Sacral Backward Bending

   A force is anteriorly applied to the sacral apex, one inch above the sacrococcygeal junction. The force is applied with the examiner's thenar eminence.

Research Design IV - Reliability of Force Delivery

Hesch recommends the application of specific forces when delivering mobilizations.[9] To assure that proper amounts of force are delivered, this researcher demonstrated that she could blindly deliver forces of twenty pounds with at least 90% accuracy. Prior to beginning this study, this blinded examiner delivered bouts of forces onto a bathroom scale until all in three consecutive bouts were delivered within 10% of the targeted force. An accurate bout was defined as having demonstrated all ten attempts between 18 - 22 pounds. An outside examiner recorded the forces delivered onto data collection sheets. Each treatment session was begun after the successful completion of three, accurate, consecutive bouts.

Pelvic Treatment via the Hesch Method

Hesch describes an integrated approach to pelvic treatment. Treatment may consists in any of the following forms: 1. self-treatment, 2. muscle energy techniques, and 3. gentle mobilizations.[9] This study only used one of the suggested forms of treatment; gentle mobilizations. Gentle mobilizations were the most appropriate treatment form for a blinded approach, since subjects

are not involved in treatment application. Gentle mobilizations were applied to all experimental group subjects. Mock treatments, that delivered no force, were administered to subjects in the control group.

Spring tests have a relatively straight-forward interpretation. When a spring test result denotes hypomobility, that pelvic segment usually is blocked and unable to move in the direction of the spring test. Treatments are usually directed towards the hypomobile direction. Treatment included maintaining the blocked segments in the direction of the restriction for 2 to 5 minutes or until a loosening or complete reduction in movement restriction is noted. The force of treatment was up to twenty pounds, in addition to twenty pounds required to take up the slack of the joint.

Hesch contends that pelvic hypermobility and hypomobility usually coexist in dysfunctional states. He further contends that treatments solely directed to hypomobilities, usually resolve the coexisting hypermobilities. He illustrated this principle with an example of a positionally rotated anterior ilium. He believes that dysfunctional states do not necessarily occur at full end range. He claims that the anterior ilium is restricted from posterior movement, but still free to move anteriorly. Refer to Table 5 for listings of spring test interpretations.

Table 5: Listings of the different hypermobilities and hypomobilities with varying pelvic dysfunctions[9]

	POSITIONAL				DYSFUNCTION			
Tests	Sacral Rotation		Sacral Sidebend		Anterior Ilium		Inflare	
	hyper-mobile	hypo-mobile	hyper-mobile	hypo-mobile	hyper-mobile	hypo-mobile	hyper-mobile	hypo-mobile
SUPINE								
post. ilium						X		
inf. ilium					X			
PRONE								
sacral rotation		X						
sacral side bend				X				
ant ilium					X			
sup str. Ischium					X			
inf. ilium						X		
inf. To sacrum								
Back Bend to Sacrum								
antero-lateral ilium					X		X	
post. ilium				X				X
inf. ilium			X			X		X
PRONE								
Sacral rotation								
Sacral Side bend								
ant. ilium			X				X	
sup.ishium			X		X		X	
inf. ilium				X		X		X
inf. sacrum								
Back bend of Sacrum								
ant. Lat. ilium		X					X	

Table 5 coninued: Listing of the hypermobilities and hypomobilities with varying pelvic dysfunctions[9]

	POSITIONAL				DYSFUNCTION	
Tests	Downslip		Post. Ilium		Post. Ilium with Upslip	
	hyper-mobile	hypo-mobile	hyper-mobile	hypo-mobile	hyper-mobile	hypo-mobile
SUPINE						
Post. Ilium			X		X	
Inf. Ilium	X			X		X
PRONE						
Sacral rotation						
Sacral Side Bend						
Ant. Ilium				X		X
Sup. Ischium		X		X		X
Inf. Ilium	X		X			X
Inf. Sacrum						
Back Bend Sacrum						
Ant. Lat. Ilium				X		X

Once an examiner has successfully treated a blocked segment with gentle mobilization, the same examiner should repeat all ten spring tests. If all spring tests were equal following mobilization, the treatment would be deemed complete. If any new or remaining blocks were noted during the repeat set of spring tests, then those hypomobilities received similar treatment. This process of evaluation, treatment, and reevaluation repeats until all spring tests are determined to be equal during one treatment session. With the average treatment time unknown, initial experimental treatment times were used to ascertain a standard treatment time for all subjects. Although, no one treatment was permitted to exceed 45 minutes. Once the standard treatment time was determined, the same timeframe was used when working with the control group. Controls received a predetermined mock treatment sequence (in the Appendix C), while experimental subjects' treatments time depended on the encountered hypomobilities and hypermobilities.

Refer to Table 6 for the specific treatment sequence.

Table 6: Treatment sequence as purported by Hesch.[9]

TREATMENT SEQUENCE FOR COMBINATION DYSFUNCTIONS
1. vertical pubis dysfunction
2. anterior/posterior pubis dysfunction
3. sacral rotary dysfunction
4. sacral side bending
5. upslips/downslips
6. Any other ilial dysfunctions
7. anterior/posterior ishium next
8. rotary and side bending lumbar spine dysfunctions
9. oblique axis dysfunction of pelvis/ilium along with any side glide dysfunction of the lumbo pelvic region.
10. Lumbosacral dysfunction (inferior glides of the sacrum), limited forward and backward bending of the sacrum, segmental flexion/extension of lumbar motion
11. Coccygeal dysfunction
12. treat other areas of the kinetic chain that demonstrate biomechanical dysfunction

DATA ANALYSIS

Research Design 1 - The Pilot

Results from all measures were in the form of interval/ratio data. Measures included; straight leg raising with inclinometry, lumbar flexion with double inclinometry, lumbar flexion with the modified modified Schoeber, and pelvic inclination angles with inclinometry. ICCs (3,3) were calculated for each of the four measures. The preferred measurement method of lumbar flexion for Design II was determined from the ICCs in this pilot study.

Research Design II - Changes In Inclinometry Measures And Subject's Self Report Of Pain

Between group difference were analyzed with One-Way ANOVAs. Within group differences were noted with General Linear Models for repeated measures. Independent t-tests evaluated between-group differences, and paired t-tests for within-group changes. Significance levels were selected at 0.05.

Comparisons of subject's self report of pain were based on Oswestry scores. Difference scores between the initial and 2-week questionnaires were calculated for both experimental and control groups. Analysis of these difference scores incorporated two different statistical methods. The first method was a Rasch analysis, which converted ordinal data into interval data. The second test used was the Mann Whitney U test, keeping the differences in ordinal data. Again, the significance level for both tests was set at $p = 0.05$.

The results of this study were compared to other known works, such as that of Cibulka.[39] who demonstrated that nine out of twelve subjects with LBP receiving pelvic manipulation had

positive outcomes (or had improved enough to warrant discharge from an outpatient setting). In that 1993 study, Cibulka defined a cut-off Oswestry score of eleven or less as indicating a positive outcome. A positive result was defined as a decreased Oswestry score difference of five or more. This cut-off score was based on work from Stratford.[44] With these definitions, the number of positive outcomes were compared to the number of positive outcomes from Cibulka's work. The statistic used to analyze this association was the weighted Kappa.

Research Design III - Reliability of the Hesch Pelvic Evaluation (Spring & Positional Tests)

Cohen's weighted Kappa was used to assess intratester reliability.[43] Data was ordinal for all data. The spring tests were evaluated to be hypermobile, normal, or hypomobile. The positional tests were also evaluated on a three point scale, although the labels varied depending upon the area assessed.

Research Design IV - Reliability of Force Delivery

Simple descriptions of all force delivery attempts prior to treatment sessions were reported. Frequency tables were added to visually display the same attempts.

RESULTS

Research Design I - The Pilot

The pilot study was performed in an attempt to determine the reliability of the dependent variables over a two-week period. Besides assessing the stability of these measures over time, an attempt was also made to determine which measure of lumbar flexion demonstrated greater reliability with the blinded testers. The pilot subjects were ten physical therapist assistant

students, with complaints of LBP. Demographics and results are shown in Tables 7 -8. ICC's were calculated for each of the following; pelvic inclination angles in standing, lumbar flexion with double inclinometry, lumbar flexion with the Modified-modified Schoeber method and straight leg raise. The ICCs for right and left pelvic inclination angles were not valid with values -1.131 and -2.009 respectively. Values that are not valid can be obtained when measures are widely variable.[45] The double inclinometry method of assessing lumbar motion demonstrated poor to moderate reliability at the T_{12} level with an ICC of 0.73. The ICC at the S2 level had good reliability at 0.77.[45] The Modified-modified Schoeber method demonstrated poor reliability with an ICC of 0.13. Straight Leg Raising displayed excellent reliability with both ICCs = 0.94.

Table 7 : Pilot Subject Demographics

Subject #	Pain Level (Oswestry Final Score)	Gender (M/F)	Age (Years)	Height (Inches)	Weight (pounds)
1	12	F	22	66	135
2	32	F	32	71	180
3	18	M	18	64	220
4	28	F	27	63	230
5	0	F	22	66	140
6	34	F	46	61	110
7	20	F	24	66.5	117
8	6	F	35	62.5	144
9	14	F	26	61	115
10	14	F	24	60	132
Means	17.8		**27.6**	**64.1**	**152.3**

Table 8 : Reliability values of selected tests over a 2 week period on 10 pilot subjects

TEST	**MEAN 1**	**MEAN 2**	**S.D. 1**	**S. D. 2**	**ICC**
MM Schoeber	20.86	21.07	1.93	.77	.1312
Right SLR	89.75	88.5	11.66	8.61	.9219
Left SLR	91.94	89.45	9.36	9.21	.9260
Right PI Angle	7.57	11.33	5.76	2.23	-3.404
Left PI Angle	5.04	8.67	3.39	3.74	-0.620
Double Inclinometer - T_{12}	49.68	60.16	13.07	7.34	.7768
Double Inclinometer - S_2	75.56	79.92	9.16	11.71	.7347

MM = Modified modified
SLR = Straight Leg Raise
PI = Pelvic Inclination

Selection for the method of testing lumbar flexion in the larger study was made by comparing reliability values of the double inclinometry method with the modified modified Schoeber. The double inclinometry method displayed greater reliability and was, therefore, chosen.

Research Design II - Changes In Inclinometry Measures And Subjects' Self-Report Of Pain

Inclinometry Measures

Changes in the three measures (straight leg raise, lumbar flexion and pelvic inclination angles) were analyzed for between-group differences and within-group differences. One-Way ANOVAS were used to evaluate between-group differences, and within-group differences were analyzed with General Linear Models for Repeated Measures. The significance level was set at $p = .05$. Subject demographic summaries are listed in Tables 9 - 10. Results and analyses are reported in Tables 11 - 17. Following T-test analysis, a significant between-group difference was noted for right straight leg raising between the initiation of treatment and two-weeks following pelvic mobilization. (Table 18, pp. 62) The experimental group's mean right straight leg raise increased by 10.62 degrees over a two-week period, whereas the control group's mean right straight leg raise increased by 5.3 degrees.

Within-group changes were noted for straight leg raising in both the experimental and control groups. (See Tables 19 and 20, pp. 63) The experimental group's within group differences were noted two-weeks post treatment in right straight leg raising. These differences were noted following the comparison of measurements immediately post-treatment with corresponding ones

at the two-week post-treatment interval. Overall, the experimental group's straight leg raising demonstrated significant increases bilaterally.

The control group's within-group changes were noted in right straight leg raising immediately post-treatment and left straight leg raising at two-weeks post treatment. Overall increases in the control group's straight leg raising were noted bilaterally.

Table 9- Subject Demographics Summary for the **Control Group** (sham treatment)

	Pain duration	Age (years)	Height (inches)	Weight (pounds)
MEAN	10.25 years	47.21	67.67	182.2
STD DEV		12.15	4.33	42.6

Table 10 - Subject Demographics Summary for the **Experimental Group**

	Pain Duration	Age (years)	Height (inches)	Weight (pounds)
MEAN	9.86 years	40.64	66.85	173.07
STD DEV		12.38	4.6	42.17

Table 11: One-Way ANOVA Results for Right Straight Leg Raise between-group differences. (*) denotes significance with p = .05

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares	F Ratio
Among groups	3289.63	1	3289.63	**18.82***
Error	14327.11	82	174.72	
Total	17616.74	83		

Table 12: One-Way ANOVA Results for Left Straight Leg Raise between-group differences. (*) denotes significance with p = .05

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares	F Ratio
Among groups	2622.04	1	2622.04	**12.86***
Error	16716.42	82	203.85	
Total	19338.46	83		

Table 13: One-Way ANOVA Results for Lumbar Flexion between-group differences. (*) denotes significance with p = .05

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares	F Ratio
Among groups	380.24	1	380.24	2.20
Error	14151.68	82	172.58	
Total	14531.92	83		

Table 14: One-Way ANOVA Results for Right Pelvic Inclination Angles between-group differences. (*) denotes significance with p = .05

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares	F Ratio
Among groups	18.2	1	18.2	1.64
Error	906.34	82	11.05	
Total	924.54	83		

Table 15: One-Way ANOVA Results for Left Pelvic Inclination Angles between-group differences. (*) denotes significance with p = .05

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares	F Ratio
Among groups	19.49	1	19.49	1.96
Error	815.31	82	9.94	
Total	834.80	83		

Table 16: General Linear Model Results for Repeated Measures for the Control Group's variables. (*) denotes significance with p = .05.

Test	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent Parameter	Obs. Power
R SLR	Time	198.928	2	99.464	4.692	**.018***	9.384	.737
	Error (time)	551.152	26	21.198				
L SLR	Time	221.867	2	110.934	5.459	**.010***	10.919	.803
	Error (time)	528.313	26	20.320				
Lumbar Flexion	Time	169.318	2	84.659	2.198	.131	4.397	.408
	Error (time)	1001.22	26	38.509				
R PI Angle	Time	13.449	2	6.725	1.79	.187	3.581	.340
	Error (time)	97.651	26	3.756				
L PI Angle	Time	18.059	2	9.030	1.344	.278	2.687	.263
	Error (time)	174.734	26	6.721				

R SLR = Right Straight Leg Raise
L SLR = Left Straight Leg Raise
R PI Angle = Right Pelvic Inclination Angle
L PI Angle = Left Pelvic Inclination Angle

Table 17: General Linear Model Results for Repeated Measures for the **Experimental Group's** variables. (*) denotes significance with p = .05.

Test	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent Parameter	Obs. Power
R SLR	Time	913.960	2	456.980	15.659	**.000***	31.318	.998
	Error (time)	758.773	26	29.184				
L SLR	Time	674.223	2	337.112	7.205	**.003***	14.411	.903
	Error (time)	1216.43	26	46.786				
Lumbar Flexion	Time	105.691	2	52.845	.857	.436	1.714	.181
	Error (time)	1603.09	26	61.657				
R PI Angle	Time	3.284	2	1.642	.171	.844	.342	.074
	Error (time)	249.862	26	9.610				
L PI Angle	Time	2.290	2	1.145	.187	.830	.375	.076
	Error (time)	158.970	26	6.114				

R SLR = Right Straight Leg Raise
L SLR = Left Straight Leg Raise
R PI Angle = Right Pelvic Inclination Angle
L PI Angle = Left Pelvic Inclination Angle

Table 18 : Between Group T-Tests for all variables for all three time frames. Numbers listed for each group represent mean values. Alpha = 0.05. Significance is denoted with an (*).

Test	Pre-Treatment			Immediately Post-Treatment			2 weeks post treatment		
	Control	Exp	T-Test	Control	Exp	T-Test	Control	Exp	T-Test
Right SLR	72.4	81.38	0.091	75.2	83.02	0.138	77.73	92	**0.009***
Left SLR	73.17	80.02	0.235	73.92	83.54	0.071	78.38	89.72	0.060
Lumbar Flexion	17.01	14.78	0.643	15.11	13.82	0.818	19.99	13.9	0.229
Right PI Angle	5.98	6.14	0.911	5.17	5.59	0.764	4.6	5.51	0.386
Left PI Angle	4.64	5.54	0.517	3.54	4.96	0.677	5.91	5.27	0.524
Pelvic Symmetry (diff score)	1.34	0.60	0.503	0.74	0.62	0.916	-1.30	0.24	0.083

Table 19: Within Group T-Tests for the **CONTROL GROUP** with all variables for all three time frames. Numbers listed for each group represent mean values. Alpha = 0.05. Significance is denoted with an (*).

Test	Pre-Treatment/ Immed. Post - Rx			Immediately Post-Rx/ 2 wks post			2 weeks post /pre-treatment		
	Time 1	Time 2	T-Test	Time 2	Time 3	T-Test	Time 3	Time 1	T-Test
Right SLR	72.4	75.2	**0.012***	75.2	77.73	0.225	77.73	72.4	**0.022***
Left SLR	73.17	73.92	0.437	73.92	78.38	**0.041***	78.38	73.17	**0.021***
Lumbar Flexion	17.01	15.11	0.325	15.11	19.99	0.047	19.99	17.01	0.313
Right PI Angle	5.98	5.17	0.180	5.17	4.6	0.517	4.6	5.98	0.088
Left PI Angle	4.64	4.42	0.684	4.42	5.91	0.173	5.91	4.64	0.325
Pelvic Symmetry (diff score)	1.34	0.74	0.446	0.74	-1.30	0.106	-1.30	1.34	0.494

Table 20: Within Group T-Tests for the **EXPERIMENTAL GROUP** with all variables for all three time frames. Numbers listed for each group represent mean values. Alpha = 0.05. Significance is denoted with an (*)									
Test	Pre-Treatment/ Immed. Post - Rx			Immediately Post-Rx/ 2 wks post			2 weeks post /pre-treatment		
	Time 1	Time 2	T-Test	Time 2	Time 3	T-Test	Time 3	Time 1	T-Test
Right SLR	81.38	83.02	0.419	83.02	92.00	**0.0006***	92.00	81.38	**0.0002***
Left SLR	80.02	83.54	0.171	83.54	89.72	0.039	89.72	80.02	**0.002***
Lumbar Flexion	14.78	13.82	0.770	13.82	13.9	0.978	13.9	14.78	0.745
Right PI Angle	6.14	5.59	0.309	5.59	5.51	0.955	5.51	6.14	0.655
Left PI Angle	5.54	4.96	0.203	4.96	5.27	0.791	5.27	5.54	0.808
Pelvic Symmetry (diff score)	0.60	0.62	0.976	0.62	0.24	0.652	0.24	0.60	0.694

Subjects' Self-Report of Pain

Changes in pain were documented with the Oswestry Pain Questionnaire. Final Rasch data and conversion values are listed in Table 21. In addition to conversion, the Rasch Analysis assessed both the reliability and validity of the Oswestry questionnaire. The Rasch method gave three other measures. It assessed items, persons, and then identified misfits.

Table 21: T-test for Pain Logit Differences

Experimental Group	Control Group
0	-0.36
0.22	0.34
0	0
0.58	-0.31
-0.23	-0.27
0	0
-0.47	0
-1.52	0.12
-0.59	-0.47
-2.44	0
-2.56	2.27
-0.61	-0.25
-0.47	-0.71
-0.7	0
T-test	**0.046***

- negative numbers indicate pain reduction
- positive numbers indicate pain increases
*significance with p = .05

The person and item distribution map obtained through Rasch analysis of the Oswestry questionnaire is shown in Figure 1. Person ability refers to pain levels. The arrangement of the item difficulties is described at two levels. The first level (on the left) demonstrates the score separations for the subjects' low ratings (from 0 to 1, on a 4 pt. scale) and the second level (on the right) describes the separations at the subjects' highest ratings (from 3 - 4). Items are arranged from the easiest to the most difficult item. When

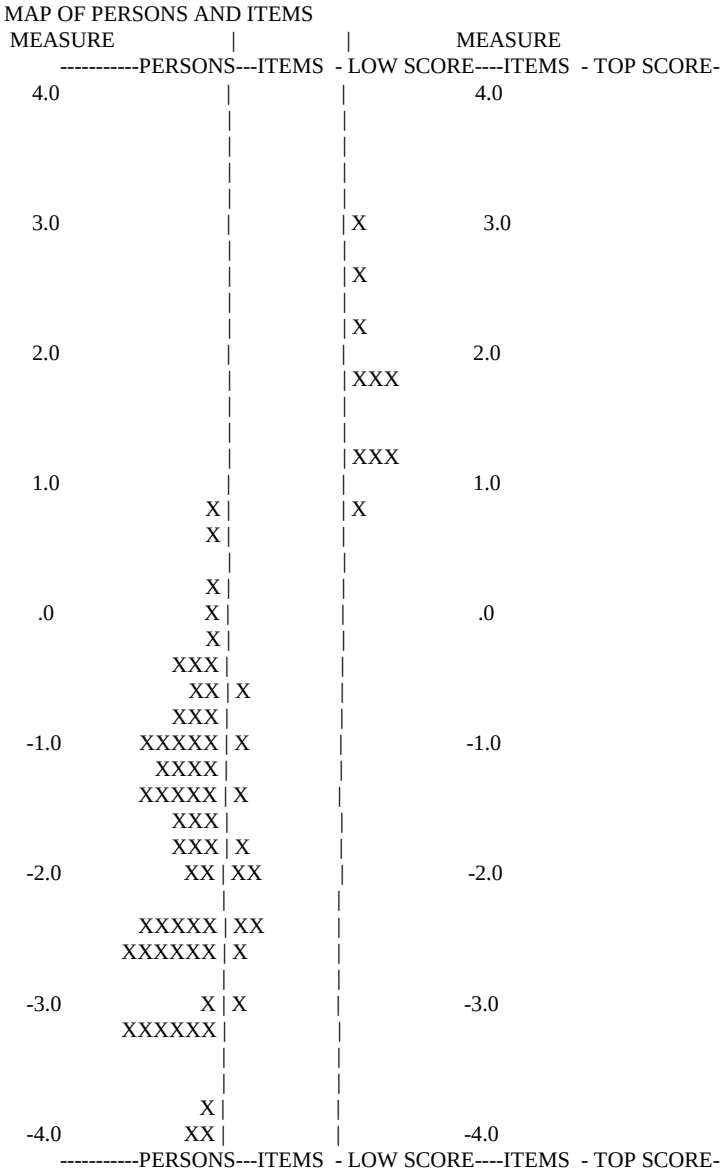
comparing the person ability map against the item difficulty map at the first level, it can be seen that 9 out of 56 people with the least pain levels were located below the lowest item. Sixteen percent of the subjects reported less pain than the lowest level on the Oswestry Pain questionnaire.

The items in difficulty order are listed In Table 21a. The items' associated standard errors are also listed.

Table 21a: Item Difficulty (from most difficult to least difficult)

Item Name	Category Number	Error
Personal Care	2	.28
Walking	4	.24
Sex Life	8	.23
Sleeping	7	.20
Social Life	9	.19
Traveling	10	.19
Standing	6	.17
Sitting	5	.16
Lifting	3	.16
Intensity	1	.15

Figure 1: Rasch Map of Persons and Items



As noted in Tables 22 - 23, the item separation reliability was calculated to be .92, and the person separation reliability was .76. High item separation reliability indicated that the questionnaire covered the variable of pain. The mean squares for both of these measures was 1.0, as was the expected score of this statistic. Mean square values substantially less than 1.0 would indicate dependency in the data, whereas values less than 1.0 indicate error. According to the Rasch analysis, one person misfit the Oswestry questionnaire. This person misfit demonstrated an abnormally high activity level as compared to other subjects with similar pain levels reported. The error (as a Z-score) for the activity level of this subject was 3.0. This Z-score exceeded the expected limit of 2.58.

Table 22: Summary of Pain Measures of 54 (non-extreme) persons as determined through Rasch Analysis

	MEASURE (IN LOGITS)	ERROR	MNSQI	MNSQO
MEAN	-1.62	.49	1.0	1.0
S.D.	1.05	.16	0.6	0.6
	Person Separation 1.77		Person Separation Reliability 0.76	

Table 23: Summary of 10 calibrated items on the Oswestry Questionnaire as calibrated by the Rasch Analysis. (n = 56)

	MEASURE (IN LOGITS)	ERROR	MNSQI	MNSQO
MEAN	0.00	.20	1.0	1.0
S.D.	0.69	.04	0.3	0.3
	Person Separation 3.29		Item Separation Reliability 0.92	

A misfitting item may be one that is not relevant as a measure of pain intensity. The Rasch analysis demonstrated two items that misfit. The first misfit item was pain intensity. The mean square value was reported to be 1.69 for the infit and 1.47 for the outfit. Since both of these values exceed the expected value of 1.0, it is felt that there is

error in the item's assessment. In other words, pain intensity is not being assessed accurately by this item.

The other misfit item was sleeping ability. The infit mean square was 1.38 and the outfit mean square was 1.42. Again, there is error in the measurement of the subject's ability to sleep (according to Rasch analysis).

An independent t-test analyzed the Rasch difference scores between the control and the experimental groups. The difference scores represented changes in pain levels from the pre-treatment time period to the post-treatment period, two weeks later. The result was significant with $p = .05$.

Keeping pain changes in ordinal form, a Mann Whitney U test was used to detect differences between the control and experimental groups. The limit used to determine significance was set at 0.1129. The calculated significance was found to be 0.1075. The Mann Whitney U test demonstrated no significant difference at $p = .05$.

Research Design III - Reliability of the Hesch Pelvic Evaluation (Spring & Positional Tests)

The reliability of the ten spring tests was assessed with a Kappa statistic. Individual spring test results are reported in the Appendix. Refer to Table 24 for summary results. All spring tests utilized a 3-point scale including hypomobility, normal and

hypermobility. Six of the ten tests demonstrated fair to good reliability, and the remaining four showed poor reliability.

Table 24: Kappa Results for the Ten Spring Tests (N=28)

Patient Position	Spring Test	Observed Agreement	Chance Agreement	Kappa
Supine	Post. Rotation	.643	.467	.33
	Inf. Stress	.607	.415	.329
Prone	Ant. Rotation	.821	.448	.666
	Sacral Rotation	.75	.416	.572
	Sacral Side- bending	.786	.529	.545
	Lateral Ilium Stress	.679	.425	.441
	Sup. Stress to Ischial tuberosity	.714	.463	.468
	Inf. Stress to Ilium	.75	.592	.388
	Inf. Stress to Sacral Glide	.714	.538	.381
	Sacral Backward Bending	.75	.526	.473

Interpretation of Kappa: < .40 = poor
≥ .4 to .75 = fair to good
≥ .75 = excellent

The Reliability of the fifteen positional tests was also assessed using the Kappa statistic. Results are listed in Table 25. Four of the positional tests demonstrated excellent reliability. Moderate reliability was noted in four tests, and poor reliability was noted in the remaining seven tests.

Table 25: Kappa Results for the fifteen Positional tests (N = 28)

Positional Test	Observed Agreement	Chance Agreement	Kappa
Leg ,Length	.643	.375	.429
ASIS (ant/post)	.857	.801	.282
ASIS (sup/inf)	.643	.52	.255
ASIS (med/lat)	.857	.796	.3
Ant. Iliac Crests (sup/Inf)	.607	.393	.353
Pubic Crests	.964	.964	0
Pubic Tubercles	1.0	.931	1
Inf. Pubic Bones	1.0	1.0	0
PSIS (ant/post)	.714	.577	.325
Post. Iliac Crests	.786	.45	.61
Ischial Tub.(sup/inf)	.929	.802	.639
Ischial Tub.(ant/post)	.929	.663	.788
Ischial Tub. (med/lat)	.964	.73	.868
Sacral (ant/post)	.964	.837	.781
ILAs	.857	.642	.601

Interpretation of Kappa: < .40 = poor
≥ .4 to .75 = fair to good
≥ .75 = excellent

Research Design IV - Reliability of Force Delivery

Results of the therapist's ability to reliably deliver forces of twenty pounds (within 10% error) immediately prior to treatment are displayed in Appendix A. Corresponding Frequency Tables include results of all attempts made on any given day. With six treatment days in total, it should be noted that the first treatment day required eleven attempts to get three accurate consecutive bouts. In contrast, only a minimal numbers of bouts (3) were required on the third through sixth days.

DISCUSSION

Research Design I - The Pilot

One purpose of this study was to determine the reliability of three possible indirect measures of pelvic mobility in a pilot study, prior to the larger study. The stability of

three measures (straight leg raising, lumbar flexion, and pelvic inclination angles in standing) was assessed over a two-week period. Please refer to Tables 34 - 37 for all raw data in Appendix A. This time frame was equal to the time frame used in the actual study. Pilot results showed straight leg raising and lumbar flexion to have excellent and good reliabilities, respectively. However, low values were noted for pelvic inclination angles in standing. Low ICC values (Right -3.404, Left -0.620) can be obtained from wide variations in measurements. Error in bony landmark identification might have accounted for the wide variations in values, as this measurement technique was new to the investigators. Or perhaps, the measure of pelvic inclination angles in subjects with LBP is variable over a two-week period. Previous studies assessing reliability of pelvic inclination angles over a one day period have showed excellent results ($r = .84$).[46] To date, no study has assessed the reliability of this measure over a period of time longer than one day. With regard to the low reliability coefficients for the pelvic inclination angles in this pilot group, the use of caution is recommended when interpreting pelvic inclination angle changes noted in the actual study.

Research Design II -

Inclinometry Measures

A third purpose of this study was to determine if an indirect measure of pelvic mobility existed. Three variables were selected as potential indirect measures. They included straight leg raising, lumbar flexion, and pelvic inclination angles in standing. One variable, right straight leg raising, did demonstrate a between-group difference. See Tables 18 - 20 (pp. 62-63). The experimental group's right straight leg raising was noted

to have increased by ten degrees at two-weeks post-treatment, as compared to a five degree increase noted within the control group during the same time period. What was interesting about this finding was the timing of the change. Manual therapists have usually been taught to re-evaluate joints immediately following treatment to determine success of the maneuvers based upon immediate increases in motion.[47] Yet, evidence from this study did not support this statement. The increase in straight leg raising in the experimental group was somewhat delayed. Since post-treatment measurements were taken only immediately after and again two-weeks later, the exact timing of this change is unclear. More frequent remeasures with smaller time intervals would be needed to better determine the timing of this change.

Manual therapy teaches clinicians to note immediate increases in motion following successful mobilization/manipulation. Yet, the results from this study indicated a non-immediate increase in straight leg raising. Prior to treatment, the experimental group showed a high incidence of restricted motion in the right sacroiliac joint, as documented from the restricted spring test results. Therefore, this study notes an increase in motion on the restricted side, but additionally demonstrates a delay in the result. This study only demonstrates the change to be non-immediate.

Another interesting change noted within the experimental group straight leg raising was a concomitant increase in length in the left straight leg raise at the two-week remeasure. This symmetrical change in length agrees with Cibulka's finding of improved pelvic angle symmetry following treatment.[11] This investigator theorizes that with improved

pelvic alignment, normal sacroiliac joint mechanics may have allowed the hamstrings to elongate fully during activities of daily living, without stimulating the joint's protective reflexes.# Perhaps any shortened noncontractile elements would have lengthened over time, and allowed for the greater range of motion noted on remeasure.

Surprisingly, the control group also demonstrated significant within group increases in straight leg raising, although the magnitude was less than that in the experimental group. The right straight leg raise improved immediately post-sham treatment, and another concomitant change in left straight leg raising was noted at the two-week remeasure. Additionally, overall straight leg raising improved bilaterally in this control group. Since no forces were rendered during the sham treatment, it was determined that perhaps the spring test themselves not only served as evaluative tools, but also served as a source of treatment.

Since right straight leg raising demonstrated a significant between group change, this investigator concluded that practitioners might expect to see potentially similar delayed increases in motion following pelvic treatment on the subject's restricted side. This improved straight leg raising also serves as a clinical sign of positive outcome. Yet, this research would need to be repeated to support this conclusion.

Subjects' Self-Report of Pain

A fourth purpose of this study was to evaluate changes in pain following pelvic mobilization. Two different statistical tools were used to assess the change; a Rasch analysis follwed by an independent t-test, and a Mann Whitney U test.

The Rasch analysis converted the ordinal data into interval measures while simultaneously assessing the reliability and validity of the Oswestry pain questionnaire. See Tables 44 -47 in Appendix A. The advantage of conversion to interval data is the acquisition of a probabilistic conclusion. Therefore, conclusions regarding pain reduction following pelvic mobilization would be generalizable to larger populations. Rasch analysis was also capable of concurrently determining the reliability of both the questionnaire items and persons using the survey. This analysis is also capable of determining the validity of the questionnaire itself.

The person and item distribution map produced through Rasch analysis of the Oswestry questionnaire showed nice separation (reliability) at both the lower and higher levels of the questionnaire. (See Figure 1, pp. 66) Nine subjects' pain rating fell below the lowest level of the pain scale. The distribution of these nine subjects was analyzed to determine if these painfree subjects belonged to the experimental group, as would be expected if the treatment was 100% effective. Six of those scores belonged to the experimental group, with five of them being final pain scores. The remaining three scores were from control subjects. One control subject reported no pain before or after the sham intervention, and was responsible for two of the no-pain scores. The last control subject's no-pain score

was noted before treatment. This same control subject also demonstrated a significant increase in pain two-weeks post-sham treatment. His straight leg raise performance had increased by twenty-one degrees on the left and fifteen degrees on the right. Additionally, his lumbar flexion demonstrated an overall increase of seven degrees. Since no forces were delivered during the sham treatment, other sources to account for the change must be investigated. Perhaps the Hesch evaluation, which includes the spring testing, may have not only served as an evaluation, but also as a possible source of mobilization.

High item separation reliability showed that the Oswestry questionnaire was able to adequately test a wide range of the pain variable. Additionally, the high person separation reliability showed that the survey was able to separate the subjects.

Item and person misfits were previously mentioned in the results section. The two misfitting items were pain intensity and sleeping activities. Both items had mean squares above one, indicating noise in the data.[48] Noise refers to an imprecise assessment of the item being measured. Notably, both items (pain intensity and sleeping activities) were measured via incremental increases in pain medication usage. Since pain medication usage can be associated with undesirable side-effects, this investigator wonders if patients wouldn't decide to go without them. According to Rasch analysis, both items need to be redefined in an attempt to reduce the error in these measurements.

One person misfit the questionnaire by reporting a high level of walking activity without a concurrent increase in pain medication usage. Perhaps this subject had just made a conscious choice to keep active regardless of pain level.

Two different statistical analyses were used to assess between-group pain changes. One test kept the Oswestry pain information in ordinal form, while the other test converted the ordinal data to interval. One strong advantage to interval conversion is the generalizability of the conclusions. Conclusions using ordinal data are only applicable to the population studied.

After conversion of the Oswestry raw scores to log odd units (logits) with Rasch analysis, an independent t-test was performed using difference scores. See Tables 44 - 47 in Appendix A. The test revealed a significant difference between groups. Therefore, according to Rasch analysis, the Hesch method of pelvic mobilization is effective in decreasing the patients' report of pain.

The second analysis of pain changes between groups came from a Mann Whitney U test. This test maintains the data in ordinal form. The Mann Whitney U test showed no difference between groups. This finding is in direct contrast to the Rasch analysis. Thus, further research would help to clarify results in additional populations.

Research Design III -

In analyzing the experimental group's abnormal spring test findings, most subjects did not demonstrate ilial rotations (either anterior or posterior). See Tables 48 - 58 in Appendix A. The only dominate abnormal spring test finding was a restricted inferior spring test to the ilium with subjects prone. In fact, all of the experimental subjects demonstrated this abnormal result on at least one of the two spring test sessions, with 10/14 experimental subjects displaying agreement between the two test sessions. The next two tests that displayed some form of agreement on right ilial motion restriction were the lateral ilium and the sacral rotation tests. Both tests demonstrated a restriction in five out of fourteen experimental subjects. The remaining seven spring tests did not show agreement in more than three of the fourteen experimental subjects. Perhaps the spring tests with common agreements denote common dysfunctional states. Further research with larger populations would help to determine incidences.

A fifth purpose of this study was to assess the reliability of the Hesch spring tests. Only six of the ten tests demonstrated fair to good reliability, as determined by the Kappa statistic, while the remaining four tests had poor reliability. The reader is encouraged to note the percents of agreement for each of the spring tests. (Please refer to Table 24, pp.) Note that none of the ten tests had less than 60% agreement, and seven out of these ten tests demonstrated better than 70% agreement. Potter and Rothstein used 70% agreement as criteria for acceptance of clinical tests used to evaluate pelvic dysfunction.[35] Therefore, these seven spring tests, with greater than 70% agreement, demonstrate clinical usefulness. Kappa results are dependent upon chance agreements. The lower the

chance agreement, the higher the Kappa value. Chance agreement is calculated upon the variability of results in the sample. With uniformity within a sample, chance agreement is high and the resulting Kappa value low. So, even though there were twenty-eight subjects in the studied sample, there was a lack of variability in the spring test findings. These findings may indicate that some abnormal spring tests are more common than others, or that the sample population used in this study was homogeneous. If particular spring tests findings are more common than others, then the testing procedure might be simplified. If other populations demonstrated greater variety of abnormal spring test findings, their Kappa values would be expected to improve.

Readers may question why percents of agreement for the spring tests were not higher than 60%. Refer to Table 26 for listings of spring test agreements by subjects. Interestingly, spring test agreement by subject did not demonstrate improved investigator performance over time, or a learning curve. Interestingly, other variables did demonstrate this investigator's learning curve. These variables include both positional testing and force delivery over the six treatment sessions. Numbers of subjects per session were nine, four, five, five, three, and two. No investigator learning curve was noted within these subject groupings. Instead, agreement levels varied among all twenty-eight subjects.

Spring tests were designed to assess the joint's ability to absorb shock. While assessing this shock absorption quality of the joint, some spring tests may have inadvertently induced mild discomfort. If true, some subjects might have learned to expect a similar discomfort from the second round of spring tests. These subjects potentially could have

prevented potential discomfort with muscular contraction during the second round of spring tests. Muscular contractions present on one set of spring tests and not the other would alter reliability. Further research might establish a potential relationship between spring test reliability and subject pain anticipation.

Table 58: Frequency Distribution of number of test agreements per subject

Number of Test Agreements	Subject Frequency	Total
2	1	1
3	0	0
4	0	0
5	1111	4
6	11111 1	6
7	11	2
8	11111	5
9	11111 11	7
10	111	3
	Total	28

A sixth purpose of this study was to determine the intratester reliability of fifteen positional tests. These tests were also evaluated with the Kappa statistic. Four tests demonstrated excellent reliability. Another four tests demonstrated fair to good reliability and seven were calculated to have poor reliability. Again, this author would like to direct the reader to the observed agreement levels. (Refer to Table 25.) No one test had less than 60% agreement and 12 tests had above 70% agreement. Again, according to Potter and Rothsteins's criteria of 70% agreement or better, these twelve tests demonstrate clinical usefulness. The remaining three tests might be reevaluated in a larger population to determine if greater population variability exists. Any test not demonstrating clinical usefulness, could potentially be excluded from the evaluation process.

Positional test agreement by subjects did demonstrate a learning curve. Please refer to Table 27. The lowest number of agreements was noted within the first four subjects and improved numbers of agreements were noted thereafter. Therefore, clinicians should expect their intrarater reliaiblity to improve with experience.

Research Design IV - Reliability of Force Delivery

Another purpose of this study was to determine the reliability of force delivery during treatment. See Tables 28 - 33 in Appendix A. This blinded investigator was able to accurately (within 10%) deliver three consecutive bouts of the targeted 20 pounds of force prior to each treatment session. The number of trials required to be successful decreased over the six sessions. Eleven bouts were required on the initial treatment day, whereas only three bouts were required on the third through sixth sessions. This decline most probably represents a learning curve of this investigator.

The seventh purpose of this investigation was to compare the pain outcomes of this study to other known works. (An Oswestry total score reduction of five or more is considered to be a significant pain reduction as determined by Frederick[40].) Forty-three percent (6/14) of the experimental subjects demonstrated significant pain reduction following a single treatment of pelvic mobilization, as compared to seventy-five percent (9/12) subjects who received pelvic manipulation coupled with exercise, as reported by Cibulka. While the Hesch method utilized in this investigation may not initially appear to have similar results, readers are directed to note that the comparisons are not identical. Besides the addition of exercise, some of the subjects, in Cibulka's study, were allowed to have a

second treatment as long as the subject still evidenced three out of four signs of pelvic dysfunction. Cibulka did not specify the number of subjects who received a second treatment. Therefore, these two treatments cannot be considered to be exactly equal, and readers should be cautious when comparing outcomes.

It should also be noted that fourteen percent (2/14) of the subjects in this study demonstrated increased discomfort, and possible reasons for their increased discomfort were investigated. The first subject with increased discomfort was noted to demonstrate the largest immediate gains in straight leg raising performance bilaterally (left, 28 degrees, and right, 21 degrees) in comparison to other experimental subjects. This same subject also demonstrated an immediate increase of ten degrees in lumbar flexion. Practitioners might expect subjects with large immediate gains in motion to have increased levels of discomfort, due to potential inflammatory processes. Although outside the time frame of this initial study, the end result was a significant reduction in pain. This subject was given a third Oswestry questionnaire four weeks after the initial visit. This final Oswestry score was six raw score points less than his second, or four raw score points below his initial score.

The second subject with increased discomfort had no such increases in motion. While this subject had met criteria for entrance into the study, the physician had initially cautioned both subject and investigator for alternate interpretations of the subject's complaints of pain. (It was thought she might have a hip problem.) The subject agreed to participate in the study having been advised of the precautions.

CONCLUSIONS

This study determined straight leg raising to be an excellent indirect measure of pelvic mobility, while lumbar flexion and pelvic inclination angles were not. Straight leg raising and lumbar flexion were noted to be reliable measures over a two-week period, yet pelvic inclination angles in standing were found to be variable over the same time period.

The Hesch method of pelvic mobilization demonstrated significant pain reduction in forty-three percent of the experimental subjects, following analysis with the Rasch method. Seven of the ten spring tests and twelve of the positional tests demonstrated clinical usefulness. Force delivery during treatment was noted to be reliable prior to the start of any given treatment session.

There are several limitations in this study. One was a small sample population. A second was potentially poor landmark location when determining pelvic inclination angles in standing during the pilot study. A third limitation was the lack of any attempt to correlate the spring test results with interpretations as suggested by Hesch. Any correlational attempts were beyond the scope of this study. The fourth limitation was the lack of more frequent inclinometry measures following pelvic treatment. While it was clear that straight leg raising improved following pelvic mobilization, the exact timing of this change was unclear. Data only supported the change to be non immediate.

Further research is indicated to:

1) Correlate the spring test results with suggested interpretations by Hesch.
2) Determine the exact timing of the straight leg raise change following pelvic mobilization.
3) To assess potential factors related to subject variabity during spring testing; and.
4) To assess the intertester reliability of the spring and positional tests used in the Hesch method.

APPENDIX A

Table 28: Results of tester's ability to deliver forces reliably (in pounds) on 5-26-96

Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10	Trial 11
19	20	18	20	20	20	18	18	20	19	20
19	20	19	20	18	18	19	18	19	19	20
19	22	19	20	19	17	19	19	21	19	20
19	21	18	19	18	19	18	18	20	19	20
18	21	18	20	19	18	18	18	20	18	21
18	20	18	21	20	19	18	17	19	18	18
18	20	17	21	17	20	17	18	20	18	20
19	19	16	21	19	19	17	17	19	19	21
17	20	18	21	20	19	16	18	19	20	21
17	22	17	22	17	20	17	18	19	19	22

There were a total of 11 trials in an attempt to get three consecutive bouts within 10% of the targeted force.
Acceptable scores: 18 - 22 lbs. Range of actual measures: 16 - 22 lbs.

Table 28A: Frequency Table of force delivery attempts on 5-26-96

16 lbs: 11	2
17 lbs: 11111 11111 11	12
18 lbs: 11111 11111 11111 11111 11111 11	27
19 lbs: 11111 11111 11111 11111 11111 11111	20
20 lbs: 11111 11111 11111 11111 11111	25
21 lbs: 11111 11111	10
22 lbs: 1111	4
Total	110

Table 29: Results of Tester's ability to deliver forces reliably (in pounds) on 6-2-96

Trial 1	Trial 2	Trial 3	Trial 4
22	21	22	19
24	20	20	19
23	20	20	20
22	20	20	21
21	21	21	21
22	21	20	21
22	22	19	21
22	22	20	21
22	22	21	22
23	22	21	21

There were four bouts in an attempt to deliver 3 consecutive bouts within 10% of the targeted force.

Table 29A : Frequency Table of force delivery attempts on 6-2-96

19 lbs: 111	3
20 lbs: 11111 1111	9
21 lbs: 11111 11111 111	13
22 lbs: 11111 11111 11	12
23 lbs: 11	2
24 lbs: 1	1
Total	40

Table 30: Results of Tester's ability to deliver forces reliably (in pounds) on 6-9-96

Trial 1	Trial 2	Trial 3
20	21	21
20	21	20
21	21	20
20	20	20
20	20	19
19	19	19
19	21	18
19	21	19
20	19	19
20	20	18

Table 30A: Frequency Distribution of Tester's ability to deliver forces reliably on 6-9-96

18 lbs: 11	2
19 lbs: 11111 1111	9
20 lbs: 11111 11111 11	12
21 lbs: 11111 11	7
Total	30

Table 31: Results of Tester's ability to deliver forces reliably (in pounds) on 6-16-96

Trial 1	Trial 2	Trial 3
19	21	18
19	20	20
19	19	19
18	19	18
19	19	19
18	19	19
18	20	19
19	19	19
19	18	18
19	19	18

Table 31A: Frequency Distribution of Tester's attempts to deliver forces reliably on 6-16-96

18 lbs: 11111 111	8
19 lbs: 11111 11111 11111 111	18
20 lbs: 111	3
21 lbs: 1	1
Total	30

Table 32: Results of Tester's ability to deliver forces reliably (in pounds) on 8-13-96

Trial 1	Trial 2	Trial 3
18	19	19
19	21	19
19	21	20
21	21	21
19	20	19
19	21	19
19	21	20
20	21	20
21	22	18
20	19	19

Table 32A: Frequency Distribution of tester's ability to deliver forces reliably on 8-13-96

18 lbs: 11	2
19 lbs: 11111 11111 11	12
20 lbs: 11111 1	6
21 lbs: 11111 1111	9
22 lbs: 1	1
Total	30

Table 33: Results of Tester's ability to deliver forces reliably (in pounds) on 8-20-96

Trial 1	Trial 2	Trail 3
21	20	21
20	19	21
21	19	21
19	19	21
19	19	21
19	19	21
20	19	21
19	21	22
19	19	19
20	19	19

Table 33A: Frequency Distribution of tester's ability to deliver forces reliably on 8-20-96

19 lbs: 11111 11111 11111	15
20 lbs: 1111	4
21 lbs: 11111 11111	10
22 lbs: 1	1
Total	30

Table 34 Pilot Straight Leg Raise results.

	Time 1		Time 2 (2 weeks later)		Differences	
Subject	Left	Right	Left	Right	Left	Right
01	81.3	83.7	81.3	83	0	-0.7
02	95	91	90.6	91.6	-4.4	0.6
03	82.3	77	79.6	78.6	-2.7	1.6
04	81.6	72.3	82.3	80.6	0.7	8.3
05	85.0	80.0	78.3	77.6	-6.7	-2.4
06	100.6	102.6	105.6	104.6	5	2
07	93	99.3	90.6	91.6	-2.4	-7.7
08	92	86.	90	88	-2	2
09	100.0	99.3	100.6	94.6	0.6	-4.7
10	108.6	106.0	95.6	95	-13	-11
Means	**91.94**	**89.72**	**89.45**	**88.52**	**-2.49**	**-1.2**
ST Dev	**9.36**	**11.67**	**9.21**	**8.61**	**4.87**	**5.51**

Table 35: Pilot Pelvic Inclination Angles

	Time 1		Time 2 (2 weeks later)		Differences	
Subject	Left	Right	Left	Right	Left	Right
01	3	2	12.3	12.3	9.3	10.3
02	5	8.6	1	10.6	-4	2
03	2.3	7	11.3	15	9	8
04	3	6.6	11.6	12	8.6	5.4
05	3.6	2.6	11	13.6	7.4	11
06	2.3	1	11.6	11.6	9.3	10.6
07	13	20	9.3	5.3	-3.7	-14.7
08	7.3	14	6	7.6	-1.3	-6.4
09	3.3	6.3	6.6	9.0	3.3	2.7
10	7.6	7.6	10	12.3	2.4	4.7
Means	**5.04**	**7.57**	**9.07**	**10.93**	**4.03**	**3.36**
ST Devs	**3.39**	**5.76**	**3.55**	**2.89**	**5.46**	**8.23**

Table 36: Pilot Schoeber Results

Subject	Time 1	Time 2 (2 weeks later)	Differences
01	19.0	21.6	2.6
02	20.1	20.1	0
03	23	21.5	-1.5
04	24.8	20.8	-4
05	20.2	21	0.8
06	20.2	20	-0.2
07	22	21	-1
08	19.6	21.5	1.9
09	21.2	22.6	1.4
10	18.5	20.6	2.1
Means	**20.86**	**21.07**	**0.21**
St Dev	**1.93**	**0.77**	**2.00**

Table 37: Pilot Results for Lumbar Flexion using Double Inclinometry

	Time 1		Time 2 (2 weeks later)		Differences	
Subject	S_2	T_{12}	S_2	T_{12}	S_2	T_{12}
01	65	85	62.6	90.6	-2.4	5.6
02	40	81.6	61	94.3	21	12.7
03	45	71.3	49.6	73.3	4.6	2
04	57.6	87.6	62.6	94.3	5	6.7
05	22	59.6	50.0	77.0	28	17.4
06	48.6	75	59	61.6	10.4	-13.4
07	45	66.3	52.6	71.6	7.6	5.3
08	54.3	81.6	65.6	71.3	11.3	-10.3
09	52	80.3	68	91.6	16	11.3
10	67.3	67.3	70.6	73.6	3.3	6.3
Means	**49.68**	**75.56**	**60.16**	**79.92**	**10.48**	**4.36**
ST Devs	**13.07**	**9.169**	**7.34**	**11.71**	**9.06**	**9.63**

Table 9- Subject Demographics for the **Control Group** (sham treatment)

Subject #	Location of pain	Pain duration	Gender (M/F)	Age (years)	Height (inches)	Weight (pounds)
4	low back	38 years	M	64	72	198
6	low back	10 years	F	55	69	170
7	low back	20 years	F	53	63	150
8	low back & hips	2 years	F	44	60	185
9	low back & hips	2.5 years	M	31	73	180
11	low back	2 years	M	49	70	235
13	low back	10 years	M	67	67	200
14	low back	10 years	M	34	70	190
16	low back	1 year	M	53	70.5	280
18	low back	0.5 year	M	36	71	200
19	low back	2 years	M	31	62	130
24	low back	20 years	F	38	61	108
25	low back	25 years	M	45	70	155
27	low back	0.5 years	M	61	69	170
	MEAN	10.25 years		47.21	67.67	182.2
	STD DEV			12.15	4.33	42.6

Table 10 - Subject Demographics for the **Experimental Group**

Subject #	Location of pain	Pain Duration	Gender (M/F)	Age (years)	Height (inches)	Weight (pounds)
1	low back	2 years	F	25	58	104
2	low back	29 years	M	46	71	198
3	low back	2 years	F	44	62	159
5	low back	6 years	F	65	64	170
10	low back	9 years	M	39	73	207
12	low back & legs	10 years	F	43	61	140
15	low back	10 years	F	26	68	250
17	low back	10 years	F	55	66	120
20	low back	6 years	F	30	68	200
21	low back	13 years	M	47	73	240
22	low back	7 weeks	M	53	71	170
23	low back	25 years	M	42	64	140
26	low back	13 years	M	25	70	165
28	low back	3 years	F	29	67	160
	MEAN	9.86 years		40.64	66.85	173.07
	STD DEV			12.38	4.6	42.17

Table 38: Raw Scores for the Control Group's Straight Leg Raising. Each value represents the average of three measures in degrees.

Subject #	Pre-Treatment		Immediately Post Rx		Final Measure (2 wks)	
	Left	Right	Left	Right	Left	Right
04	65.6	65.3	65.0	67.3	72.0	73.0
06	78.3	75.6	75.6	74.6	92.6	82.3
07	77.6	72.3	85.0	82.0	83.6	83.0
08	80.3	79.3	78.6	79.3	81.6	77.6
09	72.3	78.6	74.0	81.6	60.6	65.0
11	62.6	63.3	61.0	63.3	70.0	69.0
13	58.0	55.6	57.6	58.6	60.6	66.3
14	75.0	74.6	79.6	79.0	86.3	87.6
16	69.0	62.3	66.0	63.0	70.6	61.3
18	65.0	69.6	67.3	71.0	68.0	77.3
19	69.6	74.6	74.0	75.3	90.0	90.0
24	107.6	102.3	105.0	108.0	110.3	104.6
25	90.6	90.0	88.0	89.3	90.6	89.3
27	53.0	50.3	58.3	60.6	60.6	62.0
MEANS	**73.17**	**72.40**	**73.92**	**75.20**	**78.38**	**77.73**
ST DEVS	**13.84**	**13.36**	**13.03**	**13.16**	**14.76**	**12.59**

Table 39: Raw Scores for the Experimental Group's Straight Leg Raising. Each value represents the average of three measures in degrees.

Subject #	Pre-Treatment		Immediately Post Rx		Final Measure (2 wks)	
	Left	Right	Left	Right	Left	Right
01	99.6	96.0	103.3	102.3	117.6	114.6
02	50.0	52.0	78.0	73.0	76.6	76.0
03	88.6	85.3	76.0	82.0	88.0	88.3
05	63.3	77.0	74.3	64.6	63.0	90.0
10	59.5	61.3	57.6	61.0	71.0	65.0
12	71.3	72.3	73.3	73.0	94.0	87.0
15	75.3	85.0	79.3	91.3	99.3	110.0
17	96.0	95.3	96.0	97.0	105.0	105.3
20	91.6	89.0	88.6	87.0	99.0	95.6
21	80.0	75.0	78.3	72.0	90.0	89.3
22	71.3	79.6	77.6	80.0	76.0	84.0
23	82.3	82.0	84.3	80.6	80.3	81.6
26	86.6	85.0	89.0	90.0	84.3	89.3
28	105.0	104.6	114.0	108.6	112.0	112.0
MEANS	**80.02**	**81.38**	**83.54**	**83.02**	**89.72**	**92.00**
ST DEVS	**15.92**	**13.75**	**14.03**	**13.91**	**15.80**	**14.24**

Table 40: Raw Data for the Control Group's Lumbar Flexion. Each value represents the average of three measures in degrees.

Subject #	Pre-treatment	Immediately Post-Rx	Final Measure (2 weeks later)
04	30.6	22.3	18.3
06	22.3	16.3	20.3
07	15.6	22.0	20.6
08	38.3	32.3	36.0
09	25.6	22.6	20.0
11	18.0	13.6	11.6
13	16.3	5.0	19.6
14	24.6	28.0	21.3
16	16.3	18.3	23.0
18	16.6	17.0	32.6
19	30.3	18.6	37.0
24	-12.6	-12.7	-7.7
25	-9.7	4.0	21.0
27	6.0	4.3	6.3
MEANS	**17.01**	**15.11**	**19.99**
ST DEVS	**14.38**	**11.64**	**11.58**

(-) numbers indicate lumbar extension

Table 41: Raw Data for the Experimental Group's Lumbar Flexion. Each value represents the average of three measures in degrees.

Subject #	Pre-treatment	Immediately Post-Rx	Final Measure (2 weeks later)
01	24.0	29.0	27.3
02	10.3	12.3	22.3
03	7.0	12.0	7.6
05	34.3	41.6	37.0
10	7.0	7.0	4.6
12	20.0	3.6	18.6
15	22.0	36.3	17.0
17	21.6	21.6	22.6
20	2.3	12.0	-1.66
21	10.6	4.6	19.0
22	14.3	14.0	8.6
23	23.6	30.6	30.3
26	-5.7	-14.3	-3.7
28	15.7	-16.7	-14.9
MEAN	**14.78**	**13.82**	**13.90**
ST DEVS	**10.39**	**17.13**	**14.46**

(-) numbers indicate lumbar extension

Table 42: Raw Data for the Control Group's Pelvic Inclination Angles. Each value represents the average of three measures in degrees.

Subject #	Pre-Treatment		Immediately Post Rx		Final Measure (2 wks)	
	Left	Right	Left	Right	Left	Right
04	2.3	0.6	4.6	0.6	3.0	1.3
06	13.6	13.3	12.3	13.6	10.0	10.0
07	1.3	3.6	0.6	4.6	7.0	2.3
08	-0.3	8.3	2.3	8.6	8.0	2.6
09	2.6	4.3	5.0	3.0	3.3	1.6
11	0.0	5.6	1.6	7.3	7.6	8.6
13	0.6	3.6	0.3	4.3	6.0	3.6
14	3.6	1.0	1.6	0.3	5.3	5.3
16	10.0	10.0	9.6	8.0	5.6	5.6
18	8.3	8.0	6.0	4.6	4.0	4.3
19	10.0	9.3	8.3	8.3	5.0	6.0
24	2.0	7.6	3.6	1.6	8.0	6.3
25	5.0	5.0	2.6	2.3	5.0	5.0
27	6.0	3.6	3.6	5.3	5.0	2.0
MEAN	**4.64**	**5.98**	**4.42**	**5.17**	**5.91**	**4.60**
ST DEVS	**4.33**	**3.58**	**3.54**	**3.68**	**1.98**	**2.61**

Table 43: Raw Scores for the Experimental Group's Pelvic Inclination Angles. Each value represents the average of three measures in degrees.

Subject #	Pre-Treatment		Immediately Post Rx		Final Measure (2 wks)	
	Left	Right	Left	Right	Left	Right
01	4.3	4.0	5.0	3.0	5.0	3.0
02	1.6	4.0	1.6	6.6	3.6	5.6
03	9.0	13.3	10.6	14.0	5.0	3.6
05	9.6	13.0	10.0	10.6	8.0	2.6
10	2.3	2.6	1.0	2.6	10.3	9.0
12	2.6	6.3	2.3	2.3	2.0	5.3
15	7.6	8.6	4.0	8.6	6.3	9.6
17	4.3	0.3	0.3	1.0	2.6	2.6
20	6.0	5.0	5.6	7.6	1.0	1.3
21	9.3	8.6	8.6	5.6	8.0	7.0
22	4.3	2.0	4.3	2.6	9.0	8.0
23	7.6	8.0	6.6	6.6	0.0	3.0
26	5.0	5.3	4.3	3.6	8.0	8.6
28	4.0	5.0	5.3	3.6	5.0	8.0
MEAN	**5.54**	**6.14**	**4.96**	**5.59**	**5.27**	**5.51**
ST DEVS	**2.67**	**3.82**	**3.17**	**3.67**	**3.15**	**2.82**

Table 44: Original Oswestry Scores for the **Control Group**. Scores indicate original values on a 1 - 50 pt scale.

Exp. ID #	Initial Oswestry Item Total	Final Oswestry Item Total	Difference
04	14	11	-3
06	3	4	+1
07	8	8	0
08	19	16	-3
09	8	10	+2
11	9	9	0
13	8	8	0
14	14	16	+2
16	3	2	-1
18	4	4	0
19	1	7	+5
24	13	11	-2
25	7	4	-3
27	0	0	0

Table 45: Original Oswestry Scores for the **Experimental Group**. Scores indicate original values on a 1 - 50 pt scale.

Subj. ID #	Initial Oswestry Item total	Final Oswestry Item total	Difference
01	3	3	0
02	25	27	+2
03	2	2	0
05	11	16	+5
10	6	5	-1
12	11	11	0
15	3	2	-1
17	7	2	-5
20	10	6	-4
21	20	3	-17
22	14	2	-12
23	8	5	-3
26	3	2	-1
28	10	6	-4

Table 46: Oswestry conversions for the **Control Group**

Subject ID#	Initial Oswestry (in Logits)	Final Oswestry (in Logits)	Difference
04	-0.61	-0.97	-0.36
06	-2.65	-2.31	0.34
07	-1.42	-1.42	0
08	-0.07	-0.38	-0.31
09	-0.84	-1.11	-0.27
11	-1.26	-1.26	0
13	-1.42	-1.42	0
14	-0.61	-0.49	0.12
16	-2.65	-3.12	-0.47
18	-2.31	-2.31	0
19	-3.87	-1.60	2.27
24	-0.72	-0.97	-0.25
25	-1.60	-2.31	-0.71
27	Bottom	Bottom	0

Table 47: Oswestry conversions for the **Experimental Group**

Subject ID#	Initial Oswestry (in Logits)	Final Oswestry (in Logits)	Difference
01	-2.65	-2.65	0
02	0.56	0.78	0.22
03	-3.12	-3.12	0
05	-0.84	-0.26	0.58
10	-1.8	-2.03	-0.23
12	-0.97	-0.97	0
15	-2.65	-3.12	-0.47
17	-1.60	-3.12	-1.52
20	-1.11	-1.8	-0.59
21	0.14	-2.31	-2.44
22	-0.49	-3.05	-2.56
23	-1.42	-2.03	-0.61
26	-2.65	-3.12	-0.47
28	-1.02	-1.72	-0.7

Table 48: Spring Test # 1 Results: Posterior Rotation of Ilium with subject in supine

Subject #	Time 1	Time 2	Agreement *
1	Left hypo	Right hyper	*
2	Normal	Left hypo	
3	Normal	Right hypo	
4	Left hypo	Right hypo	
5	Normal	Normal	*
6	Normal	Normal	*
7	Right hyper	Left hyper	
8	Left hyper	Normal	
9	Normal	Normal	*
10	Normal	Right hypo	
11	Normal	Normal	*
12	Normal	Left hypo	
13	Right hypo	Normal	
14	Normal	Normal	*
15	Normal	Normal	*
16	Normal	Normal	*
17	Right hypo	Normal	
18	Normal	Normal	*
19	Normal	Normal	*
20	Normal	Normal	*
21	Normal	Normal	*
22	Normal	Normal	*
23	Normal	Normal	*
24	Normal	Right hypo	
25	Right hypo	Right hypo	*
26	Left hyper	Left hyper	*
27	Right hypo	Right hypo	*
28	Right hypo	Right hypo	*
		# of Agreements	**18/28**

Table 49: Spring Test # 2 Results: Inferior Stress of Ilium with subject in supine

Subject #	Time 1	Time 2	Agreement *
1	Left hypo	Right hypo	
2	Right hypo	Left hypo	
3	Right hypo	Right hypo	*
4	Left hypo	Right hypo	
5	Normal	Normal	*
6	Left hypo	Left hypo	*
7	Left hypo	Left hypo	*
8	Left hypo	Left hypo	*
9	Left hypo	Left hypo	*
10	Left hypo	Left hypo	*
11	Left hypo	Left hypo	*
12	Normal	Normal	*
13	Left hypo	Left hypo	*
14	Right hyper	Left hypo	*
15	Left hypo	Left hypo	*
16	Left hypo	Right hypo	
17	Normal	Left hypo	
18	Right hypo	Left hypo	
19	Right hypo	Right hypo	*
20	Right hypo	Left hypo	
21	Left hypo	Left hypo	*
22	Left hypo	Right hypo	
23	Left hypo	Left hypo	*
24	Right hypo	Right hypo	*
25	Right hypo	Left hypo	
26	Left hypo	Right hypo	
27	Right hypo	Right hypo	*
28	Right hypo	Right hypo	*
		# of Agreements	**18/28**

Table 50: Spring Test # 3 Results: Anterior Rotation of Ilium with subject prone

Subject #	Time 1	Time 2	Agreement *
1	Right hyper	Normal	
2	Normal	Normal	*
3	Normal	Normal	*
4	Right hypo	Right hypo	*
5	Normal	Normal	*
6	Normal	Normal	*
7	Normal	Normal	*
8	Normal	Normal	*
9	Right hypo	Right hypo	*
10	Normal	Normal	*
11	Right hypo	Right hypo	*
12	Left hyper	Left hyper	*
13	Normal	Right hypo	
14	Normal	Normal	*
15	Left hyper	Normal	
16	Normal	Normal	*
17	Right hypo	Right hypo	*
18	Normal	Normal	*
19	Normal	Normal	*
20	Normal	Normal	*
21	Left hypo	Normal	
22	Normal	Normal	*
23	Right hypo	Right hypo	*
24	Right hypo	Right hypo	*
25	Right hypo	Right hypo	*
26	Left hypo	Right hypo	
27	Right hypo	Right hypo	*
28	Normal	Normal	*
		# of Agreements	**23/28**

Table 51: Spring Test # 4 Results: Sacral Rotation with subject prone

Subject #	Time 1	Time 2	Agreement *
1	Normal	Right hypo	
2	Normal	Right hypo	
3	Right hypo	Right hypo	*
4	Normal	Normal	*
5	Normal	Normal	*
6	Normal	Normal	*
7	Normal	Normal	*
8	Normal	Normal	*
9	Right hypo	Right hypo	*
10	Normal	Right hypo	*
11	Right hypo	Right hypo	*
12	Right hypo	Right hypo	*
13	Normal	Normal	*
14	Normal	Normal	*
15	Right hypo	Right hypo	*
16	Normal	Normal	*
17	Right hypo	Right hypo	*
18	Left hypo	Normal	
19	Left hypo	Normal	
20	Normal	Normal	*
21	Normal	Normal	*
22	Left hypo	Left hypo	*
23	Right hypo	Right hypo	*
24	Right hypo	Right hypo	*
25	Normal	Normal	*
26	Left hypo	Right hypo	
27	both sides	both sides	*
28	Normal	Normal	*
		# of Agreements	**21/28**

Table 52: Spring Test # 5 Results: Sacral Sidebending with subject prone

Subject #	Time 1	Time 2	Agreement *
1	Right hypo	Normal	
2	Right hypo	Right hypo	*
3	Normal	Normal	*
4	Normal	Normal	*
5	Normal	Normal	*
6	Normal	Normal	*
7	Normal	Right hypo	
8	Normal	Normal	*
9	Right hypo	Right hypo	*
10	Normal	Normal	*
11	Normal	Normal	*
12	Left hypo	Right hypo	
13	Normal	Normal	*
14	Normal	Normal	*
15	Normal	Normal	*
16	Normal	Normal	*
17	Normal	Right hypo	
18	Normal	Normal	*
19	Left hypo	Normal	
20	Normal	Normal	*
21	Normal	Normal	*
22	Normal	Normal	*
23	Normal	Normal	*
24	Right hyper	Right hypo	
25	Right hypo	Right hypo	*
26	Normal	Normal	*
27	Right hypo	Right hypo	*
28	Right hypo	Right hypo	*
		# of Agreements	**22/28**

Table 53: Spring Test # 6 Results: Lateral Ilium Stress with subject prone

Subject #	Time 1	Time 2	Agreement *
1	Right hypo	Right hypo	*
2	Right hypo	Right hypo	*
3	Normal	Right hypo	
4	Left hypo	Right hypo	
5	Normal	Normal	*
6	Left hypo	Right hypo	
7	Right hypo	Right hypo	*
8	Normal	Normal	*
9	Right hypo	Right hypo	*
10	Right hypo	Right hypo	*
11	Left hyper	Right hypo	*
12	Right hypo	Right hypo	*
13	Normal	Normal	*
14	Right hypo	Normal	
15	Normal	Normal	*
16	Normal	Normal	*
17	Right hypo	Normal	
18	Normal	Left hyper	
19	Left hyper	Left hypo	
20	Normal	Normal	*
21	Normal	Normal	*
22	Normal	Normal	*
23	Normal	Normal	*
24	Right hyper	Right hypo	
25	Right hypo	Right hypo	*
26	Left hypo	Right hypo	
27	Right hypo	Right hypo	*
28	Right hypo	Right hypo	*
		# of Agreements	**19/28**

Table 54: Spring Test # 7 Results: Superior Stress to Ischial Tuberosity with subject prone

Subject #	Time 1	Time 2	Agreement *
1	Right hypo	Normal	
2	Right hypo	Right hypo	*
3	Right hyper	Right hypo	
4	Normal	Normal	*
5	Normal	Normal	*
6	Normal	Normal	*
7	Right hypo	Right hypo	*
8	Normal	Normal	*
9	Right hypo	Right hypo	*
10	Right hypo	Right hypo	*
11	Normal	Normal	*
12	Normal	Right hypo	
13	Right hypo	Normal	
14	Normal	Normal	*
15	Normal	Normal	*
16	Right hypo	Right hypo	*
17	Right hypo	Right hypo	*
18	Normal	Left hypo	
19	Normal	Normal	*
20	Normal	Normal	*
21	Normal	Normal	*
22	Normal	Left hypo	
23	Right hypo	Normal	
24	Normal	Right hypo	
25	Normal	Normal	*
26	Right hypo	Right hypo	*
27	Right hypo	Right hypo	*
28	Normal	Normal	*
		# of Agreements	**20/28**

Table 55: Spring Test # 8 Results: Inferior stress to the Ilium with subject prone

Subject #	Time 1	Time 2	Agreement *
1	Right hypo	Normal	
2	Right hypo	Right hypo	*
3	Right hypo	Right hypo	*
4	Normal	Right hypo	
5	Right hypo	Right hjypo	*
6	Right hypo	Right hypo	*
7	Right hypo	Normal	
8	Normal	Normal	*
9	Right hypo	Right hypo	*
10	Right hypo	Right hypo	*
11	Right hypo	Right hypo	*
12	Normal	Left hyper	
13	Right hypo	Right hypo	*
14	Right hypo	Left hypo	
15	Right hypo	Right hypo	*
16	Right hypo	Right hypo	*
17	Right hypo	Right hypo	*
18	Left hypo	Left hypo	*
19	Normal	Left hypo	
20	Normal	Right hypo	
21	Right hypo	Right hypo	*
22	Left hypo	Left hypo	*
23	Right hypo	Right hypo	*
24	Right hypo	Right hypo	*
25	Right hypo	Right hypo	*
26	Right hypo	Right hypo	*
27	Right hypo	Right hypo	*
28	Right hypo	Right hypo	*
		# of Agreements	**21/28**

Table 56: Spring Test # 9 Results: Inferior Sacral Glide Test with subject prone

Subject #	Time 1	Time 2	Agreement *
1	hypo	Normal	
2	Normal	Normal	*
3	Normal	Normal	*
4	Normal	hypo	
5	Normal	Normal	*
6	Normal	hypo	
7	Normal	hypo	
8	hypo	Normal	
9	Normal	Normal	*
10	hypo	hypo	*
11	Normal	Normal	*
12	Normal	Normal	*
13	hypo	hypo	*
14	Normal	Normal	*
15	hypo	hypo	*
16	hypo	hypo	*
17	hypo	Normal	
18	hypo	hypo	*
19	Normal	Normal	*
20	Normal	Normal	*
21	Normal	Normal	*
22	Normal	Normal	*
23	Normal	Normal	*
24	Normal	Normal	*
25	Normal	Normal	*
26	hypo	Normal	
27	Normal	Normal	*
28	hypo	Normal	
		# of Agreements	**20/28**

Table 57: Spring Test # 10 Results: Sacral Backward Bending with subject prone

Subject #	Time 1	Time 2	Agreement *
1	hypo	Normal	
2	Normal	Normal	*
3	Normal	hypo	
4	Normal	Normal	*
5	Normal	Normal	*
6	Normal	hypo	
7	hypo	normal	
8	hypo	hypo	*
9	hypo	hypo	*
10	Normal	Normal	*
11	hypo	Normal	
12	hypo	hypo	*
13	Normal	hypo	
14	Normal	Normal	*
15	Normal	Normal	*
16	Normal	Normal	*
17	Normal	Normal	*
18	Normal	Normal	*
19	Normal	Normal	*
20	Normal	Normal	*
21	Normal	hypo	
22	Normal	Normal	*
23	hypo	hypo	*
24	hypo	hypo	*
25	Normal	Normal	*
26	Normal	Normal	*
27	Normal	Normal	*
28	hypo	hypo	*
		# of Agreements	**21/28**

Table 26 : Spring Test Results by Subject. An asterisk (*) indicates agreement

Subject #	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	Total # of agreements
1	*					*					2
2			*		*	*	*	*	*	*	7
3		*	*	*	*			*	*		6
4			*	*	*		*			*	5
5	*	*	*	*	*	*	*	*	*	*	10
6	*	*	*	*	*		*	*			7
7		*	*	*		*	*				5
8		*	*	*	*	*	*	*		*	8
9	*	*	*	*	*	*	*	*	*	*	10
10		*	*	*	*	*	*	*	*	*	9
11	*	*	*	*	*	*	*	*	*		9
12		*	*	*		*			*	*	6
13		*		*	*	*		*	*		6
14	*	*	*	*	*		*		*	*	8
15	*	*		*	*	*	*	*	*	*	9
16	*		*	*	*	*	*	*	*	*	9
17			*	*			*	*		*	5
18	*		*		*			*	*	*	6
19	*	*	*				*		*	*	6
20	*		*	*	*	*	*		*	*	8
21	*	*		*	*	*	*	*	*		8
22	*		*	*	*	*		*	*	*	8
23	*	*	*	*	*	*		*	*	*	9
24		*	*	*				*	*	*	6
25	*		*	*	*	*	*	*	*	*	9
26	*				*		*	*		*	5
27	*	*	*	*	*	*	*	*	*	*	10
28	*	*	*	*	*	*	*	*		*	9

Table 27: Positional Test Agreement by Subject (*) denote agreement.

subject	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	Test 11	Test 12	Test 13	Test 14	Test 15	Total
1				*		*	*	*		*	*	*	*	*	*	10
2				*		*	*	*		*	*		*	*	*	9
3		*		*		*	*	*	*	*		*	*	*	*	11
4		*	*	*	*		*	*	*	*			*	*		10
5	*	*	*	*		*	*	*	*	*	*	*	*	*	*	14
6	*	*	*	*	*	*	*	*			*	*	*	*	*	13
7		*	*	*	*	*	*	*	*	*	*	*	*	*	*	14
8		*	*	*		*	*	*	*	*	*	*	*	*		12
9	*	*			*	*	*	*	*	*	*	*	*	*		12
10	*	*			*	*	*	*			*	*	*	*	*	11
11	*	*	*	*	*	*	*	*			*	*	*	*	*	13
12	*	*	*	*		*	*	*	*	*	*	*	*	*	*	14
13	*	*		*		*	*	*	*	*	*	*	*	*	*	13
14	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	15
15		*	*	*		*	*	*	*	*	*	*	*	*	*	13
16	*	*		*	*	*	*	*	*	*	*	*	*	*	*	14
17	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	15
18	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	15
19	*	*		*	*	*	*	*		*	*	*	*	*	*	13
20	*	*	*	*		*	*	*			*	*	*		*	11
21	*	*	*	*		*	*	*	*	*	*	*	*	*	*	14
22	*		*	*	*	*	*	*	*		*	*	*	*	*	13
23		*	*	*	*	*	*	*			*	*	*	*	*	12
24	*		*	*	*	*	*	*	*	*	*	*	*	*	*	14
25		*	*	*	*	*	*	*	*	*	*	*	*	*	*	14
26	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	15
27		*	*	*	*	*	*	*	*	*	*	*	*	*	*	14
28	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	15

Appendix B

Hesch Treatments

Specific treatments, as described by Hesch, will follow.[9] Terminology regarding pelvic dysfunction may often be confusing, therefore a few comments are warranted here. Pelvic dysfunctions may be described either positionally or in the direction of motion restriction. The osteopathic literature refers to dysfunctions positionally.[5] We see this exemplified with an anteriorly rotated ilium. Positionally, the ASIS should have moved inferiorly and medially while the PSIS moved superiorly and laterally. The direction of restricted motion, in this example, would be in a posterior rotation. Hesch uses both terminologies to describe dysfunction. With terminologies in opposite directions, readers must take care to maintain clear understandings.

1. *Positional Dysfunction:* Sacral Rotation

   Movement Dysfunction: The prominent side will have decreased anterior mobility, while the deep side will have increased anterior mobility

   Treatment: Patient Position: Prone.

   Therapist Position: Therapist places the heel of treating hand onto the prominent side of sacrum at S_1 - S_3. The mobilizing force is directed anteriorly for 2 - 5 minutes. Hesch states that if the patient perceives discomfort, treatment for ilial dysfunctions (inflares/outflares) may also be given. No reason for this clinical conclusion was offered.

2. *Positional Dysfunction:* Sacral Side Bent

Movement Dysfunction: Inability of the sacrum to glide superiorly on the side of the lower inferior lateral angle.

Treatment: Patient Position: Prone with patient's spine side bent opposite to the direction of sacral side bending.

Therapist Position: Ulnar border of treating hand is placed on the most inferior aspect of the inferior lateral angle. A gentle superior pressure is applied directed towards the patient's same side PSIS.

3. *Positional Dysfunction:* Anterior Ilium

Movement Dysfunction: Reduced posterior rotation on the side of the dysfunction. Has increased anterior mobility.

Treatment: Patient position: Supine with hip flexed and foot flat on the table. Side to be treated has hip in slight external rotation and abduction.

Therapist position: Therapist stands on the side of dysfunction. One hand is placed on the ischial tuberosity while the other is placed on the patient's anterior ilium.

Treatment: A gentle rotary force is applied until the slack in the joint has been taken up. The position is maintained anywhere from 2 - 5 minutes.

4. *Positional Dysfunction:* Inflare Type I, (Special note is made here to differentiate this definition of Inflare from the osteopathic definition. Type I inflare has a smaller

degree of positional dysfunction than a Type II inflare (which is the same as the osteopathic definition). Each of these two definitions of inflares, as described by Hesch, respond differently to spring tests. This type I definition has a very subtle movement dysfunction, and responds to an anterolateral spring test, whereas the type II inflare responds to spring tests given in sidelying only. (The type II inflare will not be described by this study). The ASIS is medial and anterior. The PSIS is lateral and deep.

Movement Dysfunction: Increased anterolateral mobility when subject is tested in prone.

Treatment: Patient Position: Supine with hips and knees flexed. Feet should be elevated with external support to maintain thighs in a purely vertical position.

Therapist Position: Therapist will guide both legs in a lower trunk rotation to the side of inflare. (Legs may be off the table.) Treatment to the opposite ilium outflare occurs concommitantly. No other manual treatment is required.

5. *Positional Dysfunction:* Outflare Type I (Please see explanation under inflare (type I) The ASIS is lateral and deep (posterior), the PSIS is posterior and medial.

Movement Dysfunction: Decreased anterolateral mobility of the ilium with the patient in prone.

Treatment: Patient Position: Same as for the inflare.

Therapists Position: Will be the same as in inflare. Both of the patients legs will be lowered, as before, to the side of the

inflare. This treatment will concurrently correct the opposite side of inflare.

6. *Positional Dysfunction:* Upslip - ASIS, Iliac crest and ischial tuberosity on the same side have all moved superior.

   Movement Dysfunction: Definite decreased mobility of the ilium to move inferiorly as tested at either the anterior or posterior iliac crests.

   Treatment: Patient position: Supine with leg, on the side to be treated, in neutral or slight adduction.

   Therapists position: Seated at the end of the table while applying a gentle prolonged inferior stretch to the involved side through the leg.

7. *Position Dysfunction:* Anterior Ilium with Upslip, which may be extremely subtle. Clinicians should look for asymmetries at the anterior iliac crests.

   Movement Dysfunction: Signs of movement restrictions from both dysfunctions should be evident. Therefore, the ilium will have movement restricted inferiorly from both the anterior and posterior crests (upslip). The ilium will also have movement restricted in the direction of posterior rotation while demonstrating increased mobility anteriorly.

8. *Positional Dysfunction:* Posterior Ilium. ASIS landmark moves superior and lateral, PSIS moves posterior and inferior, the ischium moves inferior.

   Movement Dysfunction: Decreased ability of ilium to rotate anteriorly.

Treatment: Patient Position: Sidelying with the affected side on top. Hip on top leg should be flexed to 90 degrees. A folded pillow may be placed under the flexed knee to avoid hip adduction.

Therapist Position: Therapist support patient's uppermost knee by placing his/her abdomen against the patient's knee. Palmar contact is made at the patients ischial tuberosity and the posterior ilium. The therapist should gently move the ilium into end range anterior rotation by fixing the position of the upper posterior ilium and gently leaning into the patient's thigh with the abdomen.

9. *Positional Dysfunction:* Posterior Rotation with Upslip. Positionally, the landmarks may look very similar to a posteriorly rotated ilium.

   Movement Dysfunction: Combined movement dysfunction from both the posterior ilium and upslip. Or in other words, the ilium will not be able to anteriorly rotate nor will it be able to move inferiorly.

   Treatment: With treatment, the vertical component should be addressed prior to treatment for the posterior positional component.

10. *Positional Dysfunction:* Superior Pubic Bone. In this dysfunction, the pubic crest has moved superior, as determined by palpation.

    Movement Dysfunction: Spring tests unnecessary, yet if performed a limited inferior mobility would be noted. Superior mobility would be increased. When this area is difficult to resolve, the

clinician should treat the opposite pubis for a relative inferior position.

Treatment: Patient Position*:* Supine with the involved side extended and abducted.

Therapists position: On the side being treated. One hand is to support the lower thigh, while the other hand stabilizes the opposite anterior ilium The side to be treated is passively held at end range for 2 - 5 minutes.

11. *Positional Dysfunction:* Inferior Pubic Bone. Positionally, the pubic crest has moved inferiorly as determined by palpation.

Movement Dysfunction: Spring tests not necessary since the positional tests are reliable, but would reveal decreased superior mobility with increased inferior mobility.

Treatment: Patient Position: Supine with leg slightly abducted.

Therapists Position: Ulnar border of the treating hand on the inferior pubic bone. Due to the increased tenderness at this joint, treatment consists of a lesser force of 5 - 10 lbs. vertically for 2 minutes through the pubic bone, after taking up the slack.

12. *Positional Dysfunction:* Sacrum with inferior glide fixation. There are no distinguishing positional landmarks associated with this.

Movement Dysfunction: Sacrum has decreased ability to glide superiorly with an increased ability to glide inferiorly.

Treatment: Patient Position: Prone with a pillow under the chest.

Therapist Position: Near the foot of the table with firm contact on the inferior sacrum. A small amount of anterior pressure is required to maintain friction. A superior glide hold is applied for up to 2 minutes.

13. *Positional Dysfunction:* Backward bent sacrum. Sacral base may appear posterior and the apex anterior.

Movement Dysfunction: Increased backward bending with decreased forward bending.

Treatment: Patient Position: Prone with a pillow under chest, if desired.

Therapist Position: Heel of treating hand on sacral base. Prolonged hold anteriorly for up to 2 minutes.