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Influences of the Menstrual Cycle on Sacroiliac Joint Dysfunction

Jennifer Hieb
University of North Dakota

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INFLUENCES OF THE MENSTRUAL CYCLE ON SACROILIAC JOINT DYSFUNCTION

by

Jennifer Hieb
Bachelor of Science in Physical Therapy
University of North Dakota, 1997

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
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in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

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This Independent Study, submitted by Jennifer Hieb in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Signatures)

(Faculty Preceptor)
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ABSTRACT

Sacroiliac joint dysfunction is a common but many times untreated contributor to low back pain. The female population in particular is more likely than their male counterparts to injure the sacroiliac joint. A factor that may predispose the female population to injury is the fluctuating levels of hormones a female progresses through during a normal menstrual cycle. The purpose of this pilot study is to review the literature regarding sacroiliac joint anatomy, pathology and dysfunction and to determine whether enough evidence exists correlating sacroiliac joint injuries with a specific time of the menstrual cycle to warrant further investigation. Data was collected from six female patients being treated for sacroiliac joint dysfunction as to the time of their injury in relation to their menstrual cycle timeline. Fifty percent reported that their injury occurred 1 to 2 days prior to menses, while the remaining 50% reported that their injury was not related to menses. The results indicated a need to explore hormonal influence on the prevalence of sacroiliac joint injuries.
CHAPTER I

INTRODUCTION

The specific cause of pain is unknown in 79 to 89 percent of patients experiencing their first attacks of low back pain.\textsuperscript{1} Many times, the sacroiliac (SI) joint is a common but overlooked contributor to this low back pain.\textsuperscript{2} Functioning as a force absorber, the SI joint is subject to shear, torsional, and compressive forces acting across its joint surfaces in response to normal body mechanics.\textsuperscript{3} Improper posturing and abnormal body mechanics have been cited as two possible causes of non-traumatic SI injuries.\textsuperscript{4,5,6}

The female population is more likely than their male counterparts to injure the SI joint.\textsuperscript{7} Anatomical differences between pelvic structure and articulating surfaces predispose the SI joint to wear and set up a propensity for instability.\textsuperscript{8} In particular, the SI joints of pregnant women are affected by hormonal changes during the gestational period.\textsuperscript{7,9,10,11} Ligamentous laxity\textsuperscript{9,10,11} and displaced weight distribution\textsuperscript{3} position the pelvis in a state of vulnerability.

However, SI joint alteration in response to hormonal changes may not be exclusive to the pregnant woman.\textsuperscript{12,9,10,11} In addition to the fluctuating levels of estrogen and progesterone during a normal menstrual cycle, the non-pregnant female is also believed to produce relaxin.\textsuperscript{9} Relaxin targets collagen synthesis at the pubic symphysis\textsuperscript{9,12} and decreases ligamentous tensile strength.\textsuperscript{7} Because the joints of the pelvic girdle are interdependent, a change in the mechanics of one will alter the others.\textsuperscript{13}
Subsequently, the SI joint of non-pregnant females could be compromised during the time relaxin is present in the bloodstream. If such a time period were to exist, women could be taught preventive measures to follow during the time of high risk to avoid injury.

The purpose of this independent study is to review the literature regarding SI joint anatomy and pathology and to determine whether enough evidence exists correlating SI joint injuries with a specific time of the menstrual cycle to warrant full investigation. A pilot study was developed surveying females with SI injuries to test this theory.
CHAPTER II

THE SACROILIAC JOINT

Anatomy and Function

The sacroiliac (SI) joint is normally an area of great controversy; however, its anatomical structure creates a voice of union between opposing theorists. Texts such as *Gray’s Anatomy*¹⁴ concur with numerous medical texts in thoroughly describing the anatomy of the SI joint, however views on function and movement seem to consistently differ. The anatomy of the SI joint will be based on the aforementioned text and expounded upon by various other literature.

Grossly, the pelvic girdle may be divided into an anterior and a posterior arch separated by vertical lines passing through the acetabulum.¹⁴ The anterior arch consists of the pubic bones which articulate in the middle of the arch at the pubic symphysis, while the posterior arch consists of the three upper sacral segments and two iliac portions of the pelvis extending laterally from the SI joints. This posterior arch is primarily concerned with weight transmission from the upper body as well as the dissipation of ground force reactions. However, difficulty exists in eliminating the anterior arch as a weight responsive mechanism during loading of the pelvis. The symphysis pubis of the anterior arch strengthens the effectiveness of the posterior arch by diffusing a portion of the load exerted on the pelvis. Therefore, the two arches work in conjunction to mitigate change in the pelvis during loading.
The SI joint located in the posterior arch connects the auricular surfaces of the sacrum and two ilia. The two auricular surfaces are each lined with cartilage and surrounded by an articular capsule creating a synovial joint. Having cartilage lined surfaces, the SI joint is designed to distribute upper body weight through the pelvis to the lower extremities and dissipate sudden force changes.  

The articular surfaces of the sacrum and ilia have been described as having visible irregularities in both the articulating bony surfaces as well as the surface lining cartilage. More specifically, the sacral surface, lined with thick hyaline cartilage as opposed to the thin fibrocartilage on the iliac surface, is described as having a trough corresponding to a long running crest on the iliac side. In a study conducted by Vleeming et al inspecting SI joint surfaces of 47 embalmed specimens, corresponding ridges and depressions were noted on both articulating surfaces as young as 12 years of age, though less pronounced than older specimens. Not only was the sacral cartilage whiter and smoother but also less coarse than its iliac counterpart. However, with age, differences between iliac and sacral coarseness were less conspicuous. When comparing genders, the SI joints in females were found to be flatter and smoother than in males. These smooth, flat surfaces may facilitate increased motion and subsequent instability of the female SI joint.

The wedged-shaped sacrum, sitting vertically between the two iliac bones, functions to support the weight of the trunk and upper extremities. Entrapped firmly between the two iliac bones, the sacrum responds to weight loading by sinking deeply between the innominates creating tension on its strong supporting ligaments. With increased weight loading, the sacrum locks tightly between the ilia.
Ligaments

The sacrum is suspended between the iliac bones by thick, dense ligaments. Through these ligaments movement of the SI joints can either be induced or counteracted by muscle action occurring around the joint. The following paragraphs will review ligaments attaching to the sacrum and ilia.

Beginning on the anterior surface of the ilium, the iliolumbar ligaments are found connecting the lower lumbar spinal segments to the broad iliac bones. Dividing into two portions, the superior band runs from the transverse process of spinal segment L₄ to the iliac crest, while the inferior band runs from the transverse process of spinal segment L₅ to the iliac crest extending fibers also to the anterior surface of the SI joint and the lateral sacrum. The two bands may work independently or in conjunction according to specific spinal movements. For example, flexion of the lumbar spine will cause the superior band to tighten while the inferior band slackens. Extension of the lumbar spine will create opposite effects. As a description of cooperative function, both bands will tighten during lateral sidebending of the lumbar spine to the contralateral side.

Inferior to the iliolumbar ligaments lies the ventral sacroiliac (SI) ligament. This ligament plays a direct role in connecting the anterior articulating surfaces of the SI joint. Extending thin fibrous bands, the ventral SI ligament runs from the lateral side and base of the sacrum to the auricular surface of the ilium blending with the periosteum of the pelvic surface and reaching the arcuate line. This ligament functions to resist forward movement of the sacral promontory which is a normal reaction to loading of the sacrum.

Ligaments connecting the dorsal aspect of the SI joints include the dorsal SI and interosseous ligaments. The dorsal SI ligament forms a strong posterior attachment
situated in the deep depression between the sacrum and ilia extending numerous fasciculi in various directions. The deeper portion of the dorsal SI ligament is called the short posterior SI ligament. It runs horizontally passing inferiorly and medially from the first and second transverse tubercles of the dorsal sacrum to the ilium. The more superficial of the two portions, the long posterior SI ligament, runs longitudinally from the posterior superior iliac spine to the second, third, and fourth sacral tubercles extending obliquely to become continuous with the sacrotuberous ligament.\textsuperscript{14}

Function of the long posterior SI ligament was studied by Vleeming et al.\textsuperscript{18} Using 12 embalmed cadavers, tension of the long posterior SI ligament was tested by loading the ligament with weight replicating muscle action and SI joint movement. The erector spinae muscle, posterior layer of the thoracolumbar fascia, sacrotuberous ligament and sacrum were all loaded to determine how these structures independently affected the long posterior SI ligament. During forced nutation (forward movement of the sacral promontory), tension on the long dorsal SI ligament diminished while counternutation (backward movement of the sacral promontory) increased tension. Tension also increased during loading of the ipsilateral sacrotuberous ligament and erector spinae muscle. Conversely, tension decreased during loading of the ipsilateral and contralateral posterior layer of the thoracolumbar fascia as well as the gluteus maximus. The function of this ligament, then, is obviously affected by numerous structures that surround the SI joint.

Lying deep to the dorsal SI ligament is the interosseous ligament. The strongest of the SI ligaments, its short fibers connect the irregular and roughened surfaces of the sacrum and ilia filling space behind and above the articulating surfaces to blend with the
short posterior SI ligament lying superficially. The interosseous ligament appears to aid in restricting excessive movement of the SI joints.\textsuperscript{14}

Accessory ligaments that affect SI movement include the sacrotuberous and sacrospinous ligaments. A flat, broad ligament, the sacrotuberous ligament begins superiorly attaching to the posterior superior and posterior inferior iliac spines, fourth and fifth transverse sacral tubercles, and caudal and lateral margin of the sacrum and upper coccyx extending obliquely downward and laterally to the ischial tuberosity. At the ischial tuberosity, its lower fibers blend with the tendon of the biceps femoris. The upper broad fibers also give origin to two muscles, the piriformis and gluteus maximus. The second accessory ligament, the thin, triangular sacrospinous ligament begins on the lateral margins of the sacrum and coccyx extending laterally to the ischial spine. Both of these ligaments are implicated in preventing downward sacral wedging between the two iliac bones.\textsuperscript{14}

Sex Differences in Pelvic Structure

SI joint dysfunction, to be discussed later, is more common in the female versus male pelvis. The first step in understanding why women are predisposed to injury is to review the differences between men and women concerning pelvic anatomical structure. In the adult female, the lateral distance of the pelvic outlet is greater giving rise to greater distance between the iliac crests. The wider outlet is necessary to facilitate childbirth. In addition, the vertical dimension of pelvis is shorter and bone density less than the male pelvis.\textsuperscript{18,19}

Pertaining specifically to the SI joint, the articulating surfaces making up the female joint are smaller, flatter and smoother. A study by Vleeming et al\textsuperscript{20} determined
the amount of friction found between articulating SI joint surfaces in relation to the
degree of visible roughening of the surfaces. Friction coefficients of 47 embalmed and
fresh SI joints were calculated according to weight loading responses. Results showed
that high friction coefficients, indicating increased friction, existed in male SI joints and
at roughened articulating surfaces. The researchers postulated that the higher friction
coefficients signified a more stable joint and that the development of roughened surfaces
was in response to normal weight loading through the upper body. They believed that
most women don’t develop these irregular surfaces because the female upper body center
of gravity does not produce enough weight loading through the SI joints. Without
surface irregularities, more motion is allowed at the joint producing wear on the
ligaments and a propensity for instability.\(^8\)

**Motion of the Sacroiliac Joint**

Historically, controversy has existed in literature as to the nature of movement
occurring at the SI joint. Irregardless of the axes or motion described, researchers have
agreed that motion at the SI joint occurs in both translatory and rotational planes.
According to Saunders\(^17\) this motion is imposed through the stresses of adjacent body
parts and direct muscle action through the piriformis only. Other hip and back
musculature indirectly influence SI movement through expansions to the ligaments
surrounding the joint, but the piriformis is the only muscle with direct attachment to the
sacrum. Additionally, the rectus femoris and sartorius directly produce movement of the
ilia on the sacrum through their attachments to the anterior inferior iliac spine and the
anterior superior iliac spine, respectively.\(^3\)
To create a clearer picture of SI movement, the joint should be imagined as being composed of two joints rather than one. The first joint, called the iliosacral joint, is involved when the ilia are moving on the sacrum. Movement is limited to anterior and posterior rotation as half of the pelvis rotates in relation to the other. Posterior rotation is the most common spanning a range of 3 to 18 millimeters. Any other movement occurring at this joint is termed dysfunctional. The second joint, called the sacroiliac joint, is involved when the sacrum moves between the two ilia. Movements occurring at this joint include nutation (flexion), counternutation (extension), and torsions.\textsuperscript{17,21}

Axes of Motion

Views on axes of motion of the SI joint and movement that occurs around these axes differ from author to author. Weisl\textsuperscript{22} described a single transverse axis located 5 to 10 centimeters below the sacral promontory that tended to vary in position during different movements by the same individual. Motion about this axis was measured as ventral or dorsal translation of the sacral promontory. He recorded a maximum ventral displacement of 5.6±1.4 millimeters taking place during a positional change from recumbancy to standing. Curiously, Weisl noted more marked changes in sacral promontory position immediately following childbirth.

Likewise, Kapandji\textsuperscript{13} also discussed the presence of a single transverse axis located posterior to the sacral tuberosity at the insertion of the SI ligaments. Motion about this axis was termed nutation (sacral flexion) or counternutation (sacral extension). Nutation was described as anterior and inferior displacement of the sacral promontory creating iliac approximation and ischial tuberosity distraction. Counternutation produced motions of the sacrum and pelvic bones reciprocal to those experienced during nutation.
Accordingly, Mitchell et al\textsuperscript{21} described motion occurring about a transverse axis but further distinguished three transverse axes for each sacral and innominate movement. All three sacral axes were located just inferior to the sacral promontory and motion about these axes encompassed both SI and IS movement. Flexion (nutation) and extension (counternutation) described by movement of the sacral promontory was thought to occur around the superior middle axis during respiration and the middle transverse axis during regular sacral flexion/extension in conjunction with normal spinal movements. In contrast, the inferior transverse axis allowed iliac motion in anterior and posterior directions.

Similarly, the respiratory axis for iliac motion was located in the coronal plane passing through the posterior superior iliac spine (PSIS). The second innominate axis delineates movement of the ilia during locomotion. This axis corresponds to the inferior transverse axis of the sacrum and allows rotation. Finally, rotation of the ilia induces motion at the pubic symphysis. This motion takes place around an axis passing transversely through the pubic tubercles allowing the pubes to rotate anteriorly and posteriorly in conjunction with the ilia.

Furthermore, Mitchell et al\textsuperscript{21} described sacral rotations occurring about oblique axes that ran from the superior end of one sacral articular surface to the inferior end of the opposite sacral articular surface. Motion was thought to be initiated by contraction of one of the piriformis muscles. For instance, contraction of the left piriformis muscle pulls the sacrum downward tightly against the left iliac articular surface. Here a pivot point is established creating a right oblique axis (named according to its site of superior origin). Forward motion about this axis is termed right sacral rotation. At the same time,
motion at the right SI joint undergoes inferior linear displacement (left side bending).

Lastly, Mitchell et al\textsuperscript{21} described a transverse pelvic axis running through the pubis about which the pubic bones rotated further allowing anterior/posterior rotation of the ilia.

**Biomechanics of the Sacroiliac Joint**

The SI joints respond to two forces during gait and functional activities. Ground forces act through the lower extremity to impose a posterior rotation on the ilia. Trunk forces acting through the spine counteract the ground forces by producing an anterior and inferior rotation of the sacrum between the two ilia. The combination of these two opposing forces creates a "screw home" of self-locking mechanism to ensure pelvic stability during standing.\textsuperscript{3,17} During various activities and positional changes, these forces change disrupting stability to influence sacral and iliac movements.

Although the SI joint is affected largely by external forces through the spine, its orientation in relation to space can have a profound effect on spinal posture. A more vertical sacrum can modify normal spinal posture by decreasing dynamic curves. Conversely, a more horizontal sacrum can promote accentuated spinal curves.\textsuperscript{17}

The pelvis and lumbar spine interact during forward trunk bending to counterbalance the forward progression of the body's center of gravity. As the trunk flexes forward from a standing position, the sacrum experiences an extension moment produced by contractions of the gluteus maximus and hamstring muscles. On the other hand, when returning from the flexed to the erect position, the sacrum is influenced by a flexion moment.\textsuperscript{3}

Mitchell et al\textsuperscript{21} further stated that the sacrum follows the lumbar spine during forward flexion but undergoes a contradictory counternutation at the extreme of flexion.
in standing and sitting. Upon returning from the flexed to erect position, the sacrum again follows the lumbar spine counternutating during normal lumbar extension but converting to a nutated position as the spine hyperextends. These contradictory movements of the sacrum, however, have yet to be proven experimentally.

In addition, Mitchel and associates defined SI motion during normal respiration. The sacral apex moves anteriorly during inhalation and posteriorly during exhalation about a transverse axis located at S₂. As well, the ilia move with the same type of motion about a transverse axis running through the posterior superior iliac spine. Sacral excursion should exceed iliac movement by approximately 3 millimeters.

As previously noted, the subject of SI joint motion evokes heavy controversy from current literature. As expected, the study of SI joint motion during gait elicits the same controversy. However, Saunders and Porterfield and DeRosa concurred on SI functional movement during gait with the following description.

During heel strike of the gait cycle, the ipsilateral ilium rotates posteriorly in reciprocal action to the opposite ilium. Advancing through the gait cycle, the ilium continues to posteriorly rotate experiencing its greatest degree of posterior rotation at loading response. As the limb proceeds to the midstance phase, rotation of the ilium converts anteriorly. This anterior rotation continues until the limb moves into swing phase. At this point of the gait cycle, the extreme anterior rotation is converted to posterior rotation initiated by hip flexion.

Sacral motion during ambulation occurs about an oblique axis. Forward rotation begins during loading response, reaches its maximum position at midstance and reverses during terminal stance. For example, during loading response of the right lower
extremity, the sacrum performs a right-on-right forward torsion, achieves its maximum rotation at midstance and slowly reverses to its neutral position shortly before beginning a left-on-left forward torsion during loading response of the left lower extremity.  

Running accelerates this sequence of movements experienced by both the sacrum and ilia. However, higher impact forces cause increased stress on the SI joints imparting near pathological movement. During heel strike the ipsilateral ilium experiences upslip while the unsupported extremity experiences increased rotation and inflaring.
CHAPTER III
THE MENSTRUAL CYCLE

The menstrual cycle involves a complex interaction of the brain, pituitary gland, ovaries and endometrium designed for the purpose of procreation. Over the years, clinical researchers have defined measurable steps of the cycle while theorists have attempted to explain mysteries yet to be solved. An overview of the integration of the two views as presented by Barbieri and Ryan from *Kistner’s Gynecology* will follow with elaboration from various other literature.

The menstrual cycle is one of the human body’s many elaborate feedback systems. Beginning in the brain, the hypothalamus receives environmental cues (nutrition, stress, emotion, light, smell, sound) via the central nervous system. These neural signals in turn trigger the release of gonadotropin releasing hormone (GnRH) from the hypothalamus which further stimulates the pituitary gland to release luteinizing hormone (LH) and follicular stimulating hormone (FSH). The target organs of these two gonadotropins are the ovaries. Influenced by LH and FSH, the ovaries select and develop one oocyte for ovulation and secrete steroid hormones. These steroid hormones, estrogen and progesterone, in turn stimulate the endometrial lining to prepare for pregnancy and complete the feedback system by regulating secretions from both the hypothalamus and pituitary. If the ovum is not fertilized, the endometrium is shed and the cycle repeats itself.
The normal cyclic shedding of the endometrium in response to steroid hormone withdrawal spans an “ideal” time frame of 28 days; however, less than 50% of women have a cycle length falling within a 26 to 30 day range. Not only does duration vary between women, but variation is also seen within an individual woman’s reproductive life. However, for the sake of simplicity, a description of hormonal and uterine changes evident during the menstrual cycle will be based on the 28-day interval during which pregnancy does not occur.

Ovarian Cycle

During the 28-day cycle, hormone levels surge and plummet in exact synchronization to prepare the uterus for pregnancy. The follicular phase or Day 1 of the cycle (the first day of menses) is marked by selection and maturation of the follicle containing the oocyte in response to rising levels of FSH and LH. LH stimulates the follicular cells to divide and produce androgens which can be converted into estrogen. At the same time, FSH stimulates additional cells of the follicle to divide and produce enzymes to aid in the conversion of androgens to estrogens. As this stage of follicular maturation continues, enough estrogen is produced to cause a surge of LH through positive feedback to the pituitary gland on Day 14 of the cycle. This two-week ripening period is then completed by ovulation of the mature ovum 36 hours later.

Collapse of the follicle following ovulation marks the beginning of the luteal phase. After reorganization of the follicular cells, the structure is referred to as the corpus luteum. In addition to producing estrogen, the corpus luteum also releases progesterone. Secretion of both hormones is dependent upon continued stimulation by pituitary LH.
If fertilization of the ovum should occur, the life of the corpus luteum would be extended by fetal human chorionic gonadotropin (hCG) stimulation through 7 to 8 weeks of pregnancy. However, if fertilization does not occur, the corpus luteum regresses four days before the next menses causing steroid hormone levels to drop giving feedback to the pituitary to increase LH and FSH release once again marking the beginning of follicular development.

Uterine Cycle

Changes in the endometrium during the aforementioned phases are in response to fluctuating levels of hormones. Days 1 to 14 of the cycle are termed the proliferative phase during which the endometrium grows and matures in preparation for pregnancy. During the first four days of this phase, menses occurs in response to steroid hormone withdrawal; however, by Day 5, rising levels of estrogen from the follicle signal the endometrium to grow thick with blood supply. Under the continued influence of estrogen, uterine glands in the endometrium also lengthen but are not stimulated to secrete.

Ovulation on Day 14 marks the end of the proliferative phase and the beginning of the secretory phase. Through stimulation by estrogen and now progesterone from the corpus luteum, the endometrium becomes thick, highly vascularized and slightly edematous. As well, uterine glands continue to lengthen but begin secreting a thick, clear fluid.

When pregnancy does not occur, effects of corpus luteum regression and steroid hormone withdraw begin to become evident in the endometrium on Day 24. As a response, the endometrium thins, coiling its arteries and developing areas of necrosis. In
addition, arteries spasm in response to locally released prostaglandins, further progressing necrosis of the endometrium. Subsequently, hemorrhaging occurs on Day 28 and endometrial sloughing on Day 1 indicating a new cycle has begun.24

Systemic Response to Hormonal Changes

During the normal menstrual cycle, the uterus and ovaries undergo changes in response to fluctuating levels of hormone. Actions of these hormones, however, are not limited to reproductive tissues alone. Although, receptor sites for these hormones have been located outside the reproductive structures, limited scientific research exists citing structural changes that can occur in non-reproductive tissues; however, researchers tend to agree that hormonal effects are far reaching and do include other body systems.25 The following discussion will outline changes that occur in tissues outside the reproductive system in response to estrogen and relaxin that may ultimately affect the musculoskeletal system.

Estrogens

Estrogens are secreted into the blood stream by the ovaries and metabolized by the liver.24 Receptor sites have been located on the anterior cruciate ligament of the knee, although their function is not yet known.25 The significance that lies in that statement is not the exact location of receptors but rather that receptors were found in connective tissue of a peripheral joint. The marvel exists in how many other structures receptors are waiting to be discovered.

More importantly, estrogens and aldosterone elevation during the mid-luteal phase have been implicated in salt and water retention as well as weight gain experienced by women prior to menstruation.24 Additionally, effects of estrogens on other endocrine
systems (i.e. renin-angiotensin) may also increase water retention and aldosterone secretion.\textsuperscript{23} This excess fluid retained through various mechanisms is stored in the interstitial space between cells. If a chronic state of retention would persist, it could lead to eventual fibrosis of interstitial tissue and subsequent restricted function of joints and muscles.

Relaxin

Relaxin is mainly thought of as a hormone of pregnancy, however, MacLennan\textsuperscript{9} suggested evidence exists that the non-pregnant corpus luteum does produce relaxin. Unfortunately, relaxin’s role in the non-pregnant female is not clear but actions in the pregnant female have been well defined within the last twenty years through clinical research by MacLennan.\textsuperscript{9,10,11}

Production sites for relaxin are the corpus luteum, decidua and chorion with postulated receptor sites and target organs including the pubic symphysis, myometrium, cervix, placenta, breasts and skin fibroblasts.\textsuperscript{9,10,11} Of the widespread effects relaxin can cause, this paper’s primary focus will be on the influences relaxin has on the pubic symphysis.

Relaxin is believed to have a profound affect on collagen metabolism at the pubic symphysis. By stimulating collagen biosynthesis, relaxin causes, as the name implies, relaxation of this connective tissue. Relaxation is achieved through activation of the collagenolytic system, regulation of new collagen formation and alteration of ground substance by decreasing viscosity and increasing water content. Through these three mechanisms, the intrinsic strength of connective tissue is decreased allowing tissue expansion and ultimate loss of rigidity.\textsuperscript{9}
A study by Weib\textsuperscript{12} and associates testing the influence of relaxin on the pubic symphyses of mice confirmed the above results. After exposure to relaxin, collagen was found to have increased water content, dry weight and relative amount of soluble collagen, however, total collagen in relation to dry weight was slightly decreased. Interestingly, more profound results were found when the symphyses were primed with estrogens prior to relaxin exposure. Overall, both studies are supporting the fact that relaxin plays an integral role in collagen degradation at the pubic symphysis.

Reduction in connective tissue strength at the pubic symphysis may predispose this joint to instability or under normal stress loads, allow movement that it would usually restrict. As stated in the previous chapter, movement of the pubic symphysis or in this case possible excess movement will have an affect on the SI joints.

Another study by MacLennan et al\textsuperscript{26,27} correlated the level of relaxin in the bloodstream during late pregnancy with the presence of severe pelvic pain and pelvic joint instability. This study found that the most incapacitated patients demonstrated the highest levels of relaxin. Additionally, the women with the highest levels of relaxin took the longest to recover postnatally. MacLennan\textsuperscript{9} further stated that anecdotal evidence exists of women with persistent pelvic joint syndrome after pregnancy who experience exacerbations of symptoms near ovulation and the time during which the corpus luteum is present.
CHAPTER IV

SACROILIAC JOINT DYSFUNCTION

Dysfunctions

Because the SI joint is a synovial joint lined with cartilage and supported by ligaments, it is subject to the same types of pathologies that occur in the peripheral joints. Dysfunction is a general term that encompasses any type of lesion that interrupts normal biomechanics of this joint or is the cause of pain and discomfort. Vast research exists defining the different types of lesions that can occur at the SI joint, however, Cyriax continues to disagree stating “Lesions of the SI joint are as rare as pain at the medial aspect of the buttock and the side of the sacrum is common”. Clearly controversy still exists in establishing the SI joint as a source of pain and dysfunction. However, Dillane et al demonstrated that a specific cause of pain was unknown in 79 to 89 percent of patients experiencing their first attacks of low back pain. This creates a large population of patients struggling to find reasons for their pain. In addition, Kirkaldy-Wills and Hill further stated that the SI joint is a commonly overlooked cause of low back pain.

Porterfield and DeRosa defined specific SI lesions by classifying them according to their mechanisms of injury. The first cause they identified is direct trauma. Direct trauma usually results in forces applied to the ischial tuberosity that induce posterior rotation of the innominate thereby stressing the anterior structures of the joint. Secondly,
indirect trauma includes injuries caused by skeletal asymmetry or stress to the SI joint at its extreme ranges of motion. Combined movements such as flexion and sidebending or extension and sidebending leave the joint vulnerable to injury by placing undue amounts of stress on the supporting structures. A force imparted through the lower extremities at these extremes could elicit a strain or sprain of the joint. Thirdly, pregnancy not only stresses the lumbopelvic tissues by anteriorly displacing the body’s normal center of gravity but also increases joint laxity through the influence of the hormone relaxin. Decreasing the tensile strength of the SI joint’s supporting structures subjects the female pelvis to higher rates of injury in response to normal stress loads.7

Saunders17 defined direct trauma further by associating certain actions with specific injuries. For example, a posterior iliac rotation lesion is caused by falling backward onto the ischial tuberosities or by forward bending with the knees locked during lifting. Similarly, an anterior iliac rotation lesion is caused by tripping, stumbling forward, or twisting. All motions could produce a strain, inflammation or subluxation that may present as hypomobility as the joint tissues heal.

Williams29 disregarded traumatic causes and focused on degenerative changes, mechanical instability through congenital malformation, and relaxation during parturition. Degenerative changes included hypertrophic and atrophic alterations in response to the arthritis disease process. Destruction of articular cartilage and underlying bony cortices with fibrous and bony bridging of the joint were noticed upon x-ray of the SI joints.

Finally, Mitchell et al21 described specific SI injuries caused by imbalances of muscle, fascia and ligaments crossing the pelvic girdle. Moreover, these authors have
further subdivided SI lesions into sacroiliac (SI) and iliosacral (IS) abnormalities, similar to the way in which they defined normal motion at the joint. Abnormal SI motion pertains to sacral lesions which include sacral torsions (forward and backward) and sacral flexion lesions.

Sacral torsion is the most prevalent of the sacral lesions with left on left forward comprising 90 percent of the torsion injuries. This dysfunction involves movement about the oblique axes in the presence of postural strain. Four possible injuries exist: left on left forward, right on right forward, left on right backward and right on left backward. Those patients exhibiting a forward torsion tend to walk stiffly erect and list toward the axis of involvement, while those patients exhibiting a backward torsion tend to stoop and list away from the axis of involvement.

Sacral flexion lesions are rare and may occur as left, right or bilateral injuries with left being the most common. The cause of this lesion is usually trauma, however, it can often be associated with a pre-existing accentuated lumbar lordosis. In other words, this lesion can be thought of as an exaggeration of normal mechanics in which the focal of rotation actually changes from the inferior to the superior transverse axis.

The lumbar spine seems to adapt to lesions of the sacrum. For instance, sacral flexion, unilateral or bilateral, promotes increased lumbar lordosis, however, backward sacral torsions flatten lordosis producing a rigid lumbar spine. In addition, extension of the lumbar spine will accentuate positional changes of a backward torsion lesion and vice versa for a forward lesion.

Regarding IS lesions, abnormal motions are defined as rotations, subluxation or flares of either iliac bone. Of all the IS injures listed above, iliac rotations are most
frequently encountered. This dysfunction can occur unilaterally or bilaterally as well as anteriorly or posteriorly. Authors differ as to which rotation occurs most often, however, it is the opinion of Mitchell et al that the right anterior followed by the left posterior iliac rotations constitute the majority of rotational lesions. To create controversy, DonTigny\textsuperscript{4} stated that the existence of a posterior innominate rotation lesion is highly unlikely. To this date, no mechanism of injury has been documented to elicit a posterior iliac rotation lesion. He refuted that the SI joint functions well to absorb compressive forces as the innominates rotate posteriorly preventing possible abnormal motion. In addition, the dense posterior SI ligaments are too strong to allow wedging of the sacrum between the ilium.

The second and third most prevalent IS lesions involve subluxations of the pubic bones and ischial tuberosities respectively. Pubic subluxations occur unilaterally and are described as superior or inferior displacements in relation to the other pubic bone. This lesion is often associated with a hip adductor or abdominal-thigh muscle imbalance. Presentation of this dysfunction may be confused with cystitis symptoms. Ischial tuberosity subluxations occur only in a superior direction. This injury is caused by a traumatic force that pushes the ischial tuberosity cephalad in relation to the other side. The resultant displacement reduces tension on the sacrotuberous ligament that should remain taut in normal alignment.

The final lesion classified as an IS injury is the iliac flare. This dysfunction is described as an inflare or outflare depending on the positions of the anterior superior iliac spines (ASIS) and posterior superior iliac spines (PSIS). The iliac bone can be thought of
as externally rotating (outflare) or internally rotating (inflare) about a vertical axis passing through the middle of the iliac bone.

Assessment

Kapandji\textsuperscript{13} stated that because movement, though minimal, of all three pelvic joints is interdependent, an impairment at any level will affect the structure as a whole and decrease its mechanical resistance. Therefore, injury to one pelvic element may induce subsequent changes to all other pelvic structures blurring a true clinical presentation. As a result, assessing for SI dysfunction (referring to both SI and IS lesions) involves the integration of observation and palpation skills as well as active and passive movements of the joints themselves.

SI assessments should always be combined with evaluations of the lumbar spine, the hip joint, and soft tissue flexibility. When other possible orthopedic diagnoses are ruled out, the therapist can then begin evaluating the SI joint. Mitchell et al\textsuperscript{21} defined several tests the therapist can use to determine the type of lesion creating SI joint pain and dysfunction. The tests can grossly be subdivided into three categories: palpation, active movements and passive movements. The following is a sample of the myriad of assessment tools used to screen the SI joint.

\textit{Palpation-} Iliac crest height can be used to estimate relative anatomical leg length. In standing, the iliac crests are palpated and observed for possible asymmetry. Pelvic obliquity may indicate a leg length discrepancy, however, further testing is necessary to reach a definitive diagnosis.

ASIS palpation is conducted in supine. Placing a finger upon the highest point of each ASIS, one again observes for asymmetries. This test is used to detect iliac rotations
and flares. Anterior/posterior and superior/inferior displacement is noted in relation to
the opposite ASIS, however, medial/lateral displacement is measured relative to the
umbilicus or xiphoid. The clinical picture of a right anterior rotation would present with
an inferior right ASIS when compared with the left ASIS.

PSIS height adds to the effectiveness of detecting ASIS position. The PSIS is
once again simply palpated for asymmetries in relation to the other side and the sacrum.
Anterior displacement could indicate tightness present in the ipsilateral hip external
rotators or contralateral hip internal rotators while posterior displacement would
obviously indicate the opposite. Continuing with the above example, right superior
displacement would indicate a right anterior iliac rotation, but may also implicate
tightness of the contralateral hamstrings or right inferior pubic subluxation. The endless
possible answers for a displacement deem this test non-definitive.

Pubic tubercle height is used to detect superior or inferior pubic subluxations.
However, with this test, only a subluxation can be diagnosed. The direction is dependent
upon the result of the standing flexion test to be described later in the active movement
section.

Ischial tuberosity height should be thought of as a two-part test. First, the ischial
tuberosities are palpated for asymmetry. If one ischial tuberosity is located superiorly to
the other, then tension of the sacrotuberous ligament is established to either confirm or
dispute diagnosis of the lesion. If a true superior subluxation exists, the ipsilateral
ligament should slacken. Once again, this test’s results must agree with those of the
standing flexion test to determine the side of lesion.
The final palpation test is used to determine sacral lesions. Testing sacral sulci depths and positions of the sacral inferior lateral angles is used to detect sacral flexion and torsion lesions. The distance from the peak of the PSIS to the adjacent sacral sulcus is observed by palpating the PSIS with the thumb and curling the thumb into the sulcus. The sacral inferior lateral angle (ILA) is palpated at the caudal end of the sacrum and asymmetry is noted. Results of these tests are definitive for sacral flexion lesions and present with one sacral sulcus deeper and ipsilateral ILA more inferior and posterior. A sacral torsion lesion would again present with one sacral sulcus deeper but with the opposite ILA more posterior and inferior. Lumbar spring testing would need to be conducted to establish the direction of the torsion.

Active Movements- Functional limb shortness is measured in supine by comparing distal medial malleolar positions. If a difference is noticed, a true leg length discrepancy should first be ruled out. With SI joint dysfunction, one will often find that true leg length measurements will be equal even though limbs present with an apparent difference in length. Mitchel et al.\textsuperscript{21} then suggested that the patient bridge multiple times, allow the examiner to passively extend the patient’s legs, internally rotate them slightly and once again compare the length. A number of SI and IS causes are believed to create an apparent limb shortness.

1. Posterior iliac rotation of the same side
2. Anterior iliac rotation of the opposite side
3. Superior pubic subluxation of the opposite side
4. Inferior pubic subluxation of the same side
5. Superior iliac subluxation of the same side
6. Forward sacral torsion to the same side
7. Backward sacral torsion to the same side
8. Sacral flexion lesion of the opposite side
DonTigny\textsuperscript{4,5}, however, stated that apparent leg length discrepancy is the definitive test for an anterior iliac rotation. Comparing length again at the medial malleolar level, he suggested that the leg on the affected side would appear to be 1 to 1.5 cm longer. Upon sitting, the acetabulum rotates posteriorly in relation to the SI joint and the limb will then appear to shorten. He then suggested placing the patient once again supine and manually rotating the affected side posteriorly. In doing so, the acetabulum moves posteriorly to shorten its apparent length. This mobilization confirms the already positive test results.

The standing flexion test is used to determine the side of lesion for IS dysfunctions. As the patient flexes forward at the trunk, the examiner palpated PSIS excursion. The point with greatest or longest superior movement is considered the abnormal or "positive" side. In actuality, the ilium locks against the sacrum and follows the sacrum's path of flexion. False positive results may be exhibited by individuals demonstrating hamstring tightness.

The seated flexion test eliminates the effects of possible hamstring tightness and stabilizes the innominates by weight bearing on the ischial tuberosities. This test is used to grossly rule out sacral lesions by once again noting PSIS movement symmetry. A positive result is exhibited by the PSIS that moves the greatest distance superiorly.

The final active test Mitchel et al\textsuperscript{21} identified evaluates PSIS excursion during deep respiration. Pathology exists on the side that exhibits exaggerated sacral motion. During inhalation, the sacrum should travel no more than three millimeters inferiorly to the adjacent PSIS.
Passive Movements- Mitchel and associates described only two passive movement tests to assess SI joint dysfunction. The FABERE (Patrick’s) test involves flexion, abduction, external rotation and extension of the hip. Pain in the hip would indicated hip pathology rather than SI joint involvement. Lumbar spring testing proposes to determine the direction of a sacral torsion lesion. A quick anterior pressure is applied to the lumbar spine to assess its relative flexibility. “Springiness” defines spinal segments that readily move anteriorly thus indicating a forward sacral lesion. In contrast, “non-springiness” presents as a resistance to movement and confirms a backward torsion lesion. For example, a proposed right sacral torsion (sacral face turned right) could define either a right on right forward or a right on left backward lesion. If the lumbar spring test assessed “springiness”, the examiner would be led to believe that a right on right forward lesion existed.

Finally, a commonly used assessment tool is the Gillet test as described by Gemmell. This test assesses iliac movement on the sacrum. In standing, the patient flexes both the hip and knee while the examiner palpates movement of the PSIS in respect to the second sacral tubercle. Normally, the PSIS should move postero-inferiorly in relation to the second sacral tubercle as posterior rotation of the iliac is induced by lower extremity motion. A positive test result could present as an absence of PSIS movement or its movement superiorly during hip and knee flexion.

Research by Dreyfuss and colleagues studied the prevalence of positive SI screening tests in asymptomatic adults. The standing flexion test, seated flexion test and Gillet test were evaluated for their validity. In a sample of 101 subjects, false positives
were found for all three tests at relatively high rates regardless of sex or age (standing flexion test 13%; seated flexion test 8%; and Gillet test 16%).

This study demonstrates the need for more than one diagnostic tool when evaluating the SI joint. If therapists understand tissue orientation and how to produce movements that stress these tissues appropriately, they can develop an evaluation that is easy to interpret. A good understanding of SI joint anatomy and function can de-emphasize the need to prepare a battery of standardized tests.

Pathomechanics

As stated before, SI joint function is influenced directly by ground reaction and trunk forces as well as indirectly by muscles crossing the joint and motions of the connected limbs. These forces set up a delicate balance that is easily disrupted and can readily produce dysfunction in not only the compromised joint but also the normal, healthy joint. Some motions generated around the joint create forces greater than the joint can absorb. Researchers are attempting to explain how such motions can be pathologic.

Cibulka\(^6\) reported a case study in which a muscle imbalance was implicated as the cause of a right posterior iliac rotation. The subject habitually slept in a prone position with the right hip and knee flexed and externally rotated. As well, the subject sat with a slumped posture weight bearing on the posterior surfaces of the ischial tuberosities and crossing the right leg over the left leg creating the same type of flexed and externally rotated position. Cibulka postulated that this continued posturing caused shortening of the hip external rotators and lengthening of the internal rotators creating an imbalance and subsequently fixating the right iliac posteriorly. As expected, this subject responded
well to attempts at rotating the right iliac anteriorly, in addition to stretching the hip external rotators and deterring old postural habits.

Also implicated as a cause of SI joint dysfunction is an imbalance between hip flexors and extensors by means of lengthened, shortened, strengthened or weakened musculature. In each instance, the strengthened or shortened musculature is allowed to exude greater forces over the joint governing its motion. For example, via their attachments to the pelvis, short hip flexors would rotate the innominates forward creating an anterior pelvic tilt. In response, the sacrum adopts a more horizontal position and accentuates lordosis of the lumbar spine. In this position, the SI ligaments experience greater amounts of strain even though axial loading remains constant.

DonTigny further described a posture that attributed to SI joint dysfunction. The most common onset of dysfunction occurred during an anterior shift of the line of gravity in forward leaning to perform a task such as ironing, washing dishes or brushing the teeth. Standing in this lordotic position created an anterior rotational force on the pelvis. With insufficient abdominal support, the pelvis rotated anteriorly and downward around the acetabula to promote a tendency for fixation. In addition, little ligamentous support was offered by the thin anterior SI ligaments and slackened posterior SI ligaments to prevent this rotation. Because the sacrum is wider anteriorly, the forward movement by the innominates spread them and favored their wedging or binding against the sacrum. Locked against the sacrum in a rotated position, the iliac articular surfaces were altered and allowed to slip vertically upward (or sacrum slip vertically downward) further fixating the joint.
Acute pain begins as the innominates move anteriorly and stretch the anterior joint capsule. Furthermore, the subject may notice an increase in pain upon sitting. Since the ischial tuberosities are positioned posteriorly by the anterior rotation, weight bearing on them only promotes more anterior rotation and stretches the anterior capsule to a greater degree. 4,29

Two mechanisms of injury incorporate this faulty movement pattern. The first involves leaning forward to lift an object in the absence of anterior pelvic support, which allows the anterior and downward pelvic rotation described above. Upon returning to standing, the added weight of the object facilitates the vertical downward movement of the sacrum, locking the joint. The second mechanism involves a subject with a pre-existing anterior dysfunction who steps down forcefully from a step of falls directly on the buttocks. The sudden deceleration combined with normal joint mechanics again caused the sacrum to wedge vertically downward on the ilium. 4,29

Pelvic Deformation During Parturition

During the gestational period, the pelvic girdle undergoes many changes in preparation for delivery. MacLennan 10 postulated that high levels of the hormone relaxin prior to parturition may target pelvic ligaments to increase pelvic mobility. Furthermore, Kapandji 13 described pelvic motion with emphasis on SI joint motion induced by the stress of labor and delivery. During labor, pelvic movement facilitates the descent of the fetus into a wider pelvic brim. The hips are slightly extended promoting an anterior pelvic tilt accompanied by counternutation of the sacrum. During the delivery process, the hips are flexed, abducted and externally rotated causing posterior rotation of the pelvis through tension of the hamstrings. As a result, the sacrum adopts a nutated
position enhancing delivery by creating a wider pelvic outlet. Furthermore, Farbrot estimated that a mean increase of 7 millimeters vertical stretching and 3 millimeters lateral stretching takes place at the pubic symphysis during pregnancy.

In response to pelvic changes during labor and delivery, some women have developed pelvic girdle relaxation. This term describes a condition in which the SI joints and pubic symphysis are highly unstable and vulnerable to injury. Symptoms of the disorder begin earlier and increase in intensity with subsequent pregnancies. In a study following 23 patients who presented with pelvic girdle relaxation post-partum, an average of six years later, patients still exhibited pelvic pain and instability. Furthermore, a study by Golightly found that 14% of a 2400-person sample of pregnant women met diagnostic criteria for an SI subluxation.

Applying DonTigny's rotational-locking theory to the pregnant woman's posture clarifies this picture of instability. The weight of the fetus carried anteriorly displaces the woman's line of gravity forward simulating the flexed posture previously described. Furthermore, lack of ligamentous support in this position is accentuated by the hormone induced relaxation occurring around the pelvic girdle. In this constant rotated and unsupported position, the pelvis is vulnerable to injury.

Similarly, the hormone relaxin is believed to target the pubic symphysis and SI ligaments of non-pregnant females as well. Compromising the ligamentous support of the pelvis would allow greater iliac anterior rotational excursion via the aforementioned mechanism of dysfunction. Therefore, the non-pregnant female could likewise be subject to pelvic instability during the time relaxin is present in the bloodstream.
Prevention

The best form of treatment for SI injuries is to prevent them from happening. Abnormal body mechanics and improper posturing have been cited as two possible causes of non-traumatic SI injuries. Understanding the basic postures that predispose the joint to injury is the first step in prevention. However, little research is available documenting preventive methods for individuals who have not sustained SI injuries. Positions to avoid are dependent upon the type of lesion and mechanical alignment of the subject. However, general guidelines can accommodate these differences.

DonTigny stated that flexion postures of the spine induce forces on the SI joint. He suggested when working in such a position, one should place a foot on a low stool to minimize anterior rotational forces on the pelvis. In addition, support of the anterior joint capsule should be reinforced by strengthening the abdominal musculature. Abdominal muscles need to be “set” prior to forward flexing the spine to offer support to the anterior joint. One may perform sit-ups with bent knees to mitigate hip flexor substitution but should definitely incorporate isometric abdominal contractions throughout the day.

The improper sit-up would be performed in a supine position with knees and hips flexed. Such a position would produce traction on the hip flexors and cause further anterior strain and anterior innominate rotation. All leg-raising exercises create a similar type of strain and thus should also be avoided. Likewise, any type of leg or upper extremity motion independent of spinal movement should be strictly prohibited. Such movements increase torsional, shear tensile and compressive forces on the SI joint.
Porterfield and DeRosa\textsuperscript{3} listed four preventive measures to follow to avoid SI injury. First, stair climbing covering two at a time is strictly prohibited. In addition, while carrying a basket or other load up stairs, one step should be taken at a time leading with the unaffected lower extremity. Secondly, when getting up from a sitting position, the affected lower extremity should be unloaded and weight shifted over the unaffected leg. Once upright, the body should continue to lean over the unaffected leg to reduce weight bearing on the side of pelvic lesion. Thirdly, squatting down or full hip flexion in weight bearing on the affected side should be avoided. Lastly, femoral flexion, abduction, and external rotation in the nondominant sexual position should be avoided. In this position, external forces would be transmitted through the femur to the pelvis and finally result on the SI joint.

Porterfield and DeRosa\textsuperscript{32} also noted that static postures can alter supporting structures of the SI joint. For example, one-legged standing increases rotary and upward shear forces imparted on the ilium. If such a posture produced pain, it should be avoided along with other activities that mimicked upward and rotary forces. Importance lies in establishing what postures elicit pain or discomfort for each individual. All daily activities, therefore, that reproduce those symptoms should be avoided.

Cibulka\textsuperscript{6} also noted that habitual postures can set up muscle imbalances across the pelvis and predispose the joint to injury. Continuous posturing that favors the lengthening or shortening of a single muscle group on one side of the joint can eventually lead to alterations at the tissue level. Avoiding changes at the muscle level demands that the individual be knowledgeable of pelvic girdle anatomy and function.
Finally, combined movements of the spine such as flexion and sidebending or extension and sidebending place the SI joint in a position of vulnerability. In these postures, the SI joint is positioned at its extreme ranges of motion placing abnormal amounts of stress on its supporting joint structures. These postures should obviously be avoided.³

Needless to say, much of the following information presented in current literature is tailored to prevent the recurrence of SI injury. On the other hand, it is the opinion of this researcher that the possible compromised or unstable joint exhibited in the presence of relaxin would benefit greatly from these postural guidelines to prevent the onset of an initial injury.
CHAPTER V
PILOT STUDY

Female subjects for this pilot study were selected from the populations of North Dakota and South Dakota. Criteria for inclusion consisted of SI injury diagnosis through a licensed, practicing physical therapist who worked in women’s health areas. Six female subjects ranging in age from 18 to 42 years participated by completing a survey. One subject was a practicing physical therapist and the remaining five were patients of physical therapists. Signed consent was obtained from all subjects before they were allowed to participate in this pilot study.

The method of data collection consisted of an original survey and consent form designed by this researcher with assistance from the faculty of the University of North Dakota Physical Therapy Department (Appendix). Questions for this survey were created to obtain information regarding the subjects’ histories of SI joint dysfunctions and menstrual cycles. In the question regarding injury history, the term low back pain was substituted for SI joint dysfunction with hope that it would be a more recognizable term to lay people.

Four copies of both the consent form and survey were sent to eight licensed, practicing physical therapists for a total of 32 surveys and consent forms distributed. Two physical therapists in each Bismarck, ND and Fargo, ND, three physical therapists in Grand Forks, ND and one physical therapist in Aberdeen, SD administered the surveys.
and consent forms to only female patients they or another physical therapist in their facility had diagnosed with some type of SI joint dysfunction. Information from completed surveys and signed consent forms was analyzed using descriptive statistics.

Responses to completed surveys are listed in Tables 1, 2, and 3. Of the six surveys returned, 50% answered that their time of SI injury was not related to menses. However, the remaining three subjects reported that their SI injuries occurred 1 to 2 days before menses. These three subjects answering 1 to 2 days before menses also recorded histories of recurrent SI injuries. One subject with a history of recurrent SI injury stated that two of her four injuries occurred during menses.

Three of the six subjects answered that low back pain was experienced both during and after pregnancies. All three subjects were multiparous. Two of these three subjects also stated that the onset of their SI injuries occurred 1 to 2 days before menses.
<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Menstrual Cycle Length</th>
<th>Bleeding Length</th>
<th>Irritable Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33</td>
<td>BC^a regulated</td>
<td>Light for 1-3 Days</td>
<td>NR^b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Off BC: 28-40 Days</td>
<td>Heavy for 4-5 Days</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>26-28 Days</td>
<td>5 Days</td>
<td>Sometimes low back pain-nothing severe-referred to hip/leg at times. Recurrent pain at femur stress fracture site</td>
</tr>
<tr>
<td>3</td>
<td>39</td>
<td>28 Days – Length is variable since birth of last child</td>
<td>5-8 Days</td>
<td>NR</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>28-30 Days</td>
<td>4-5 Days</td>
<td>Less severe when exercising regularly</td>
</tr>
<tr>
<td>5</td>
<td>18</td>
<td>NR</td>
<td>3-4 Days</td>
<td>Low back pain, crankiness, headache</td>
</tr>
<tr>
<td>6</td>
<td>35</td>
<td>NR</td>
<td>5 Days</td>
<td>Mild to moderate cramps the first day only; bloating prior to first two days</td>
</tr>
</tbody>
</table>

^aBC=birth control  
^bNR=not reported
## Table 2-Pregnancy History

<table>
<thead>
<tr>
<th>Subject</th>
<th>Number of Times Pregnant</th>
<th>Low Back Pain During Pregnancy</th>
<th>Low Back Pain After Pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>Yes</td>
<td>Some</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>NA(^a)</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

\(^a\)NA = not applicable
<table>
<thead>
<tr>
<th>Subject</th>
<th>Description of Injury</th>
<th>Time of Menstrual Cycle</th>
</tr>
</thead>
</table>
| 1       | 1. During second pregnancy, radiating pain into buttock/hip/leg area  
          2. Low back injury Jan. 1996 while playing volleyball; possible disc bulge  
          4. Low back injury Oct. 1997 playing volleyball bent to side and forward causing pain in buttock/hip/leg area - same as during second pregnancy | NA<sup>a</sup>  
During menses  
1-2 days before menses  
During menses |
| 2       | Episodes of back pain during pre-menstrual period; pain/ache at old femur stress fracture site 2-3 days prior to menses; low back pain during entire childbearing period; 3-4 years back was susceptible to injury; 3-4 episodes of back/leg pain | 1-2 days before menses |
| 3       | Twinge when injury occurred 15-20 minutes prior to onset of pain in lower left back | Not related to menses |
| 4       | SI<sup>b</sup> displacement (originally thought to be trochanteric bursitis) | Not related to menses |
| 5       | MVA from driver's side; left with persistent hip and low back pain | Not related to menses |
| 6       | Initial injury at 19 years of age- backpacking – SI pain primarily; several recurrent episodes each progressively worse; right SI pain greater than left SI pain; pain down leg occasionally; trouble bending forward and pain with sitting | 1-2 days before menses |

<sup>a</sup>NA = not applicable  
<sup>b</sup>SI = sacroiliac
CHAPTER VI
DISCUSSION

Controversy is not limited to the anatomy and function of the SI joint but also encompasses the joint's capability of exhibiting dysfunction. Cyriax\textsuperscript{28} believed that movement of the joint is so slight that displacement was highly unlikely; however, strain of its ligaments could be a possible source of pain. In contrast, other authors believed that every motion of the body induces movement of the SI joint and thus jeopardizes the joint's stability.\textsuperscript{3,5,13,17,18,21} Particularly, researchers pursue theories to explain why the female and pregnant female exhibit greater amounts of motion and are predisposed to dysfunction. Regardless of the rationale, researchers continue to battle over the existence of this disorder.

Tying in the possible existence of an injury with the largely unexplainable events of the menstrual cycle only creates another area of controversy. Limited research regarding menstrual and pregnancy hormonal influences on tissues outside the reproductive system exists in current literature. Receptor sites for menstrual hormones have been located outside the reproductive tissues.\textsuperscript{25} Research has yet to discover whether these sites are active or furthermore, if their location outside the reproductive system is of importance to musculoskeletal performance. Subsequently, very little is known regarding hormonal predisposition to injury.
The results obtained in this pilot study may cloud these issues even further. Subjects reporting the onset of SI injury as 1 to 2 days before menses could have been experiencing exacerbations of old injuries. During this time of the menstrual cycle, estrogen levels are tapering and relaxin released by the dying corpus luteum lingers in the bloodstream. Weib and associates noted that priming the pubic symphysis with estrogens prior to relaxin exposure produced greater amounts of relaxation than influence through relaxin alone. Thus, women could develop a more compromised joint during the time when both estrogen and relaxin are present. MacLennan, however, documented anecdotal evidence of women experiencing re-injury shortly after the time of ovulation. The specific time periods in relation to the menstrual cycle are obviously not the same, but MacLennan does support the possible connection of SI injuries under hormonal influences.

Pain at the SI joint may also implicate mechanisms other than the musculoskeletal system. Disorders of the reproductive tissues or other internal organs could similarly be responding to hormonal influence or ongoing disease that produces pain radiating to the SI joint. Dysmenorrhea or bleeding outside the uterus could be two possible pathologies that refer pain to the low back as well. Such diagnoses should be ruled out before labeling pain at the pelvic region as SI dysfunction.

Of the subjects reporting that their SI injuries were not related to menses, one subject’s injury was caused by trauma during a motor vehicle accident. The injury may not be attributed to possible hormonal influence considering that the great amounts of force generated in an auto collision accident would damage even the healthy joint.
However, since no other structures exhibited lingering effects, the SI joint may have been presenting as the weakest link in the chain of force distribution.

The remaining two subjects who felt their injuries were not related to menses may have chosen this item based on their understanding of the mechanism of injury. However, Cyriax\textsuperscript{28} agreed that very little evidence supports the possibility of pregnancy or hormonally induced SI dysfunction. The subjects did not report the mechanism of injury, and thus, difficulty is created in establishing possible causes of SI injury.

All three subjects who did not associate their SI injuries to menses relayed vague histories of injury that could be related to how the survey was presented to the subject. In contrast, subjects who believed their injuries were related to menses reported long histories of recurrent injuries. These subjects even included extraneous injuries they obviously felt were influenced by the menstrual cycle. Both occurrences could be attributed to bias of the presenter or subject.

The report of low back pain during and after pregnancy was relayed by subjects who experienced multiple births. The pelvic deformation occurring at labor and delivery\textsuperscript{10,13,35} may contribute to post-partum SI dysfunction.\textsuperscript{7} In a study by Berg and colleagues\textsuperscript{38} following 862 women who had experienced low back pain during pregnancy, 19\% were unable to return to work because of severe post-partum low back pain. The most common cause of this pain was found to be SI dysfunction. Multiple births may only accentuate the deformation and create more permanent change.

Furthermore, two of these subjects associated their present SI injuries with a time period prior to menses. These injuries could be lingering effects of labor and delivery.
A limitation encountered during this pilot study revolved around the methods chosen to collect data. Considering the low rate of intertester reliability for SI assessment\textsuperscript{28}, the results obtained during this study may include injuries not of a true SI origin. In addition, physical therapists were asked to administer the survey and add any commentary they felt would assist the subject in answering the survey. The researcher could develop a standard presentation to limit any bias the presenter may have created. Furthermore, the subjects were not screened for possible additional causes contributing to their symptoms.

The instrument used to gather information contained limitations as well. For example, using the term “low back pain” as a substitution for SI injury may have misled individuals to convey information regarding a back injury rather than SI involvement. In addition, when asked to date their onset of injury according to a menstrual timeline, subjects were given three specific choices and one very vague option. The “not relate to menses” answer spanned at least twenty days of the ideal cycle length while the other three answers covered only eight days. In order to establish a definite time period of risk, the researcher needs to know what hormonal changes are occurring at each day of the cycle. However, with the high variability that exists between women and within one woman’s own cycle, a scale with precision would be difficult to create. An ideal research project would require obtaining exact measurements of hormonal levels by drawing blood samples from its subjects.

Continued research spanning a longer time period and involving more subjects needs to be conducted to either dispute or support possible hormonal influences on SI injuries. Criteria for selecting subjects for such a study should include either an exact
diagnosis recorded on the survey or diagnosis by physical therapists who have obtained a certain level of education regarding SI assessment techniques. As well, the instrument for data collection should be more precise in covering the menstrual cycle timeline. MacLennan\textsuperscript{9} noted anecdotal evidence of SI pain shortly after ovulation and during the presence of the corpus luteum. Only by charting a subject’s cycle to establish “normalcy” with step by step increments can a pattern of injury be detected.

In conclusion, the information collected during this pilot study indicates a greater need for exploration into the power the menstrual cycle can exude over musculoskeletal tissues. Research establishing a connection between hormonal changes and biomechanical performance yearns to be clarified. It is the opinion of this researcher that hormonal influence on musculoskeletal tissues can create a state of vulnerability at the SI joint predisposing the individual to injury. The hormones responsible for compromising the SI joint supporting structures need to be tracked through long-term studies to establish a time of risk. Only then can women incorporate preventive measures to counteract instability.

Accordingly, mechanisms of injury to the SI joints are of vital importance in preventing subsequent or initial injuries. Research should begin by investigating the efficacy of incorporating a preventive program into SI dysfunction treatment protocols. The inquiry can then proceed by establishing those individuals that are predisposed to injury and incorporate measures to prevent the initial injury. Ultimately creating a clearer understanding of SI joint anatomy and biomechanics as well as its causes of dysfunction is the first step in preventing its injury.
APPENDIX
INFORMATION AND CONSENT FORM

TITLE: Influences of the Menstrual Cycle on Sacroiliac Injuries

You are being invited to participate in a study conducted by Jennifer Hieb, a graduate student in physical therapy at the University of North Dakota. I am investigating sacroiliac injuries and possible ways to prevent further injuries from occurring in the female population.

The purpose of this study is to determine whether a correlation exists between sacroiliac injuries and the time they occur in relation to the menstrual cycle timeline. I am attempting to define a certain time period during which women are more prone to develop musculoskeletal injuries. If such a time should exist, it would be possible to teach women precautions to follow during this high risk time to avoid future sacroiliac injuries.

If you choose to participate in this pilot study, you will be asked to fill out a survey taking approximately 5 minutes of your time and return it to me. You will not be asked to reveal any identifying information that could connect your face or name to the survey you fill out. The data obtained will be identified by a number known only to me, the investigator. Any information obtained that could be identified with you will be kept completely confidential and only disclosed with your permission.

Your decision whether or not to participate in this pilot study will not prejudice your future relationship with the Physical Therapy Department or the University of North Dakota. You also have the right to withdraw from this study at any time, and in no way are you obligated to participate in this study.

By signing this consent form, you are agreeing to participate in this pilot study. If you have any further questions, feel free to contact me at (701)795-7043 or my advisor, Bev Johnson at (701)777-2831.

I have read the above information and willingly agree to participate in the study as described to me by Jennifer Hieb.

_________________________________________  _______________________
Signature Date
Influences of the Menstrual Cycle on Sacroiliac Injuries

Please answer the following questions to the best of your ability and return the survey as soon as possible in the envelope provided for you. Thank you for taking the time to fill out this survey and participate in my study.

Date of birth: _______________________________
Mo./day/year

Briefly describe your normal menstrual cycle: (i.e. length of cycle, length of bleeding, irritable symptoms, etc.)

Briefly describe your low back pain: (i.e. when injury occurred, mechanism of injury, type of injury, etc.)

At what time of your menstrual cycle did your injury occur?

_____ 1-2 days before menses*
_____ During menses
_____ 1-2 days after menses
_____ Not related to menses

Have you ever been pregnant? _____ If so, how many times? _____ Did you experience any low back pain during your pregnancy? _____ After your pregnancy? _____

*Menses refers to the time of the menstrual cycle during which you are bleeding.
REFERENCES


5. DonTigny RL. Anterior dysfunction of the sacroiliac joint as a major factor in the etiology of idiopathic low back pain syndrome. Physical Therapy. 1990;70(4):250-263.


