The Effect of Foot Function on the Sacroiliac Joint

Robert D. Phillips, D.P.M.

Every year, millions of dollars are spent in treating sacroiliac joint pain syndromes. The sacroiliac joint has been the subject of much argument over the years between physicians, some claiming that sacroiliac joint function exists and some claiming that it does not. The following discussion is an a priori approach to the function of the sacroiliac joint based on the author's readings in both the manipulative medicine and orthopedic medicine journals about the SIJ, his own knowledge about the gait cycle, and the logic that would connect these. Unfortunately there is no a posteriori documentation of the actual relationship between the function of the foot and the function of the SIJ. It is the author's contention, though, that podiatrists will integrate themselves with those who do treat the SIJ disorders, and significantly improve the results that are obtained.

I. Sacroiliac Joint Anatomy

A. The pelvic ring is responsible for the transition for force between the torso and the legs. Through this structure, a disymmetric bipedal gait is transformed into a biphasic harmonic motion of the center of mass up and down and a uniphasic harmonic motion side to side of the center of mass. The pelvic ring is responsible for bearing complete body weight coming from the floor upward, as well as the weight of the torso pressing downward. The ring shape makes it possible for it to bear the greatest amount of stress with the least amount of mass. The ring is made up of three bones, the left os innominate, the right os innominate and the sacrum. The left and right os innominate are mirror images. They form one junction at the pubic symphysis and are joined together posteriorly by the intervening sacrum.

1. The right structure distributes weight, coming from the leg, anteriorly to the symphysis pubis, and posteriorly to the sacroiliac joints. Loss of the ring structure of the pelvic ring, results in the inability to bear weight. Likewise the bowl shape allows direct weight of the internal organs to rest on the pelvis. In this way, the spinal disks do not have to bear the entire vertical load of the trunk. They do, however, have to resist a forward bending torque being placed on them by the chest and abdominal organs. The lordotic curve in the lumbar spine, helps to naturally resist this forward bending force.
2. The sacrum itself is wedge shaped. It is wider superiorly than inferiorly. This means that as it moves backward, it becomes wedged between the two innominate bones, while as it moves forward it becomes mobile. Likewise as the sacrum moves downward it becomes wedged between the two innominate bones, while as it move upward it becomes more mobile.

B. The shape of the SIJ surfaces - the synovial portion of the SIJ is an L-shaped surface, with the short arm pointing cranially and the longer arm pointing posteriorly.

1. The joint surface is not flat, in one plane, but has been described as having a surface that is twisted like a propeller. This gives the joint a twisting action as it moves.
2. The joint surface starts in childhood very flat. During puberty the joint surfaces develop their adult morphology. As adulthood progresses, though, the joint usually becomes more roughened and irregular. Many have hypothesized that this is not normal joint, but is reflective of a disease process. Unfortunately most men over the age of 50 show signs of this disease process.

II. The two motions of the sacroiliac joint are called *Nutation* and *Countermutation*. Nutation is characterized by the sacrum rotating forward. In so doing the top of the sacrum moves anteriorly

while the caudal end moves posteriorly. Various authors have measured the axis of the SIJ in a little different area. Some have maintained that the sacrum in moving forward, also moves downward, whereas some have maintained that the sacrum might move upward a little when it nutates. It is my belief that it probably has very little upward or downward movement.

A. When the SIJ moves, the sacrum may move, or the ilium may move. When the SIJ nutates, the ilium slides backward and medially behind the sacrum. The ischium is rotating just the opposite direction, moving laterally. This lateral movement of the lower part of the ischium has the effect of adducting the hip (provided the femur didn't move in space.)
B. On the other hand when the SIJ counternutates, the ilium moves forward and also more laterally to the side of the sacrum. This forces the ischial tuberosities more medially. The medial movement of the ischium has the effect of mildly abducting the hip (provided the femur did not move in its spatial orientation).
C. When both SIJs nutate, the effect is the posterior superior iliac spines moving posteriorly and rotating backward. They also move closer together. The ischiae on the other hand move further apart. Counternutation of the SIJs on the other hand causes the posterior superior iliac spines to rotate forward and to separate. As they move apart, the sacrum can move posteriorly. The ischiae move closer together, which is an abductory force on the hip joint.
D. Disymmetrical motion of the SIJ occurs when one SIJ nutates and the opposite one counternutates. This type of motion of the two SIJs together, produces the greatest degree of sacral movement against the two os inominates. There are several reasons for this.
    1. The first reason being that the total motion of the center of mass of the sacrum remains almost nil.
    2. When both SIJs nutate together, the net movement of the sacrum is anteriorly. While movement anteriorly of the sacrum will give more freedom of the sacrum to move due to it being wedged between the innominates to a less degree, as will be discussed below, the ligaments of the SIJ will try to prevent this net anterior movement. When both SIJs counternutate together, the sacrum is driven posteriorly and becomes more wedged between the os innominates, and this decreases the total movement.
    3. The third and most important reason is that the propeller shape of the SIJ articular surface dictates that sagittal plane movement of the SIJ also produces transverse plane motion. Nutation causes the anterior surface to rotate away from the SIJ while counternutation rotates the anterior surface of the sacrum toward that SIJ. If both SIJs try to nutate together, each side is trying to rotate the sacrum away from its particular side, thus the two sides of the sacrum are being driven in opposite directions. Likewise when both SIJs try to counternutate at the same time, the left SIJ is trying to rotate the anterior surface toward the left side and the right SIJ is trying to rotate the anterior surface toward the right side. However if the left SIJ nutates while the right side counternutates, both SIJs are producing a rotation of the sacrum to face more toward the right side. Likewise when the right SIJ nutates while the left side counternutates, both SIJs are producing a rotation of the sacrum to face more toward the left side.

III. The soft tissues of the SIJ.
    A. The ligaments of the SIJ

1. The dorsal sacroiliac ligaments are extremely strong, and have led to the assumption that was prevalent during the first half of the century that the SIJ is an amphiarthrodial joint, with virtually no motion. These ligaments are very important for supporting the sacrum from a nutating force when a person is standing.
2. The sacrotuberous ligament arises from the lower half of the dorsal sacrum and inserts into the ischial tuberosity. It also becomes tight when the sacrum moves forward relative to the innominate. It also tightens up when the two ischiae move away from each other, such as occurs with symmetrical nutation of both SIJs.
3. The sacrospinous ligament completes the bottom of the greater sciatic foramen. This ligament also limits nutation of the SIJ by limiting the posterior motion of the inferior sacrum.

B. The muscles that cross the SIJ
1. The pyriformis arises from the anterior aspect of the sacrum bodies 2, 3 & 4. It passes through the greater sciatic foramen, just superior to the sciatic nerve. It then proceeds downward to insert into the superior internal side of the greater trochanter.
   a. The pyriformis is normally thought to be an external rotator of the hip. It is normally a midstance phase muscle, which assists in helping the hip externally rotate during midstance.
   b. More important than the function on the hip is the action of the pyriformis on the SIJ. It's direction of pull is such that it pulls the anterior surface of the sacrum downward and backward. Thus the muscle is a counternutation of the SIJ.
2. The erector spinae inserts into the dorsal surface of the sacrum. It lifts the posterior surface upward, which is a nutating force on the SIJ.
3. The iliopsoas, while not inserting on the sacrum, provides a strong external rotation force on the hip. This external rotation force on the hip and also, its ability to pull the lumbar vertebrae anteriorly. The action it produces on the sacrum is to also pull it forward, however, the forward movement of the lumbar vertebrae will at the same time push the sacrum posteriorly, which would be a counternutation force on the SIJ.

IV. The dynamics of the SIJ in weightbearing

A. One of the major functions of the SIJ is to allow for asymmetrical rotations of the two sides of the pelvis, especially in the sagittal plane. Without mobility of the sacrum, then the left and right halves of the pelvic ring would have to perform exactly the same degree of sagittal, transverse and frontal plane motions. However with the ability of the SIJ to move, small differences in the motion of the two innominates may exist during the gait cycle. This small degree of asymmetry may become very important when trying to ensure that the lower spine moves as smoothly as possible though the gait cycle.
1. As the foot strikes the ground, there is a sudden backward rotation placed on the side of the pelvis that is striking the ground. The motion in the two SIJs makes it possible that the striking side os innominate may rotate backward without making the opposite os innominate rotate backward the same amount. The opposite os innominate should not rotate backward as much as the striking innominate, in order that propulsion on that side may continue.
2. The pelvis starts it's forward rotation at the end of contact period and continues its forward rotation until the heel is off the ground. During this midstance period, the opposite leg and pelvis are in swing phase, however it is not rotating forward as much as the stance leg side.

B. Normal phasic movements of the SIJ

1. Heel strike the pelvis is internally rotating, though not as much as the femur internally rotates. The striking of the foot against the ground, produces an external rotation torque on the pelvic ring. Again, the internal rotation of the spine during this phase of gait transverse plane rotation
2. At heel strike, the force of the ground pushing upward into the acetabulum of the hip, produces a backward rotation on the pelvis. This is a jarring type of motion, and would normally put a backward shock on the spine. However this backward force on the spine is cushioned by the sacrum continuing to move forward a little bit by the SIJ nutating. The greater the impact, the greater will be the nutation motion in the joint. Without nutation during contact, a greater jarring action is applied to the 5th lumbar disc between the sacrum and the 5th lumbar vertebrae. Thus, SIJ motion is a major contributor to protecting the 5th lumbar disk from becoming exposed to excessive shock at heel strike.
3. During midstance, the subtalar joint is recovering from its pronated position and the pelvis starts rotating forward. The sacroiliac joint responds by counternutating through the midstance period and as the heel lifts from the floor. This counternutation is assisted by the contraction of the pyriformis, and is accelerated by the contraction of the iliopsoas as it slows down the hip extension and starts the flexion action. The counternutation reaches its maximum as the opposite foot is hitting the ground and that SIJ is reaching maximum nutation.

C. As can be seen from the above discussion, during normal gait, the two SIJs are always showing disymmetrical motion. Whenever one side is nutating, the contralateral side is counternutating. In this way, then, the distance between the two iliae may stay constant, and the ligaments are neither stretched, nor are the two iliae being forced apart by the sacrum becoming wedged posteriorly and downward. On the other hand, if both SIJs are being forced into a symmetrical motion pattern, then jamming of the SIJ is likely to occur, or stretching of the SIJ ligaments may occur. Both of these scenarios can produce SIJ symptoms.

V. Relationship between foot movements and SIJ movements

A. Pronation of the foot in static stance has a knee flexing action and also a hip flexing action. It also produces an internal rotation on the femur.
1. Hip flexion, if in static stance will produce an anterior rotation on the ilium. An anterior rotation on the ilium will produce a posterior movement of the sacrum, pushing it backward between the two iliae, creating SIJ jamming..
2. The internal rotation of the femur also produces a pull on the pyriformis and also on the psoas major. The pull on psoas major may create symptoms of low back strain as the lower erector spinae muscles must increase their activity to prevent the lumbar spine from moving forward excessively. The pull on the pyriformis may cause the SIJs to both counternutate, pushing backward and downward, increasing the rate at which DJD symptoms may begin to appear.
3. It is noted that there is a basic difference between men and women in the alignment of the center of the hip joint and the location of the center of mass falling downward. In men, the upward force on the acetabulum placed by the head of the femur, lines up very closely with the center of force falling downward. In women, however, the upward force placed on the os innominate by the head of the femur falls anteriorly to the center of mass falling downward. This misalignment places a backward rotatory force on the iliae, which places a nutation moment on the SIJ. In other words, passive forces tends to keep the sacrum more

mobile in women than in men. This may be one reason why men suffer much more from SIJ degeneration than women.

B. Double heel support produces joint jamming. The only way for the trailing heel to stay on the ground when the lead heel is striking the ground is for the hip to be excessively flexed on the trailing side. Thus at heel strike, you have both the leading and trailing hips in a flexed position, which blocks disymmetrical motion of the SIJ. Now both hips will be flexed, which creates an anterior rotation of the pelvis, and a counternutation motion will occur in both SIJs at the same time, causing the SIJ to jam downward between the os inominates. The patient develops a forward stooping posture. This may also be the suspected mechanism for a high degree of SIJ degenerative disease in elderly men.

C. Pyriformis syndrome or SIJ jamming occurs produced when the hip is internally rotating during the last half of the stance phase. During the last half of midstance, the SIJ should be very mildly counternutating because the femur is externally rotating. If, however pronation of the foot occurs during this time, the external rotation of the femur is blocked. When the femur is blocked from externally rotating, then a contraction of the pyriformis will produce an increased counter-nutation movement of the SIJ. It may cause jamming of the SIJ, or it may also produce symptoms of tenosynovitis of the pyriformis.

D. Short leg syndrome may produce changes in SIJ function. When the person has a short limb in order to keep the eyes level the spine bends toward the long side. Now side bending of the spine always causes the shoulder on the side that bends to move posteriorly. This rotates the pelvis on the long side to rotate anteriorly. The foot on the long side corresponds by pronating. The anterior rotation of the pelvis causes a counternutation of the SIJ on the long side and a nutation of the SIJ on the short side. This may cause a problem with heel strike when the long side hits the ground, as there will be a tendency for the SIJ not to be able to nutate enough and you may get some jamming of the SIJ during contact. Also, during static stance, the patient may develop symptoms in the lower back. There may develop some ligament strain across the SIJ on the short side. On the long side the patient may have some jamming symptoms or may also develop strain of the psoas and/or pyriformis muscles.