

Mechanics and Treatment of the Sacroiliac Joint

Dysfunction of the sacroiliac joint is far more common than has been suspected and may mimic disc disease or give the impression of a multifactorial etiology. Details of the anatomy, biomechanics and pathomechanics are presented enabling clinicians to better understand the function of the sacroiliac joint in different postures and during locomotion. The clinical assessment of sacroiliac dysfunction is presented and suggested treatment techniques are discussed.

THE purpose of this paper is to review and revise the biomechanics and pathomechanics of the sacroiliac joints to accommodate recent research presented at the First Interdisciplinary World Congress on Low Back Pain and Its Relationship to the Sacroiliac Joint (1). A new biomechanical model will be described, the manifestations of the pathomechanics will be presented with suggestions for treatment with manual therapy.

Structurally, the sacrum appears to be suspended from the ilia. The verticality of the neutrally suspended sacroiliac joints precludes significant weight-bearing. Movement is slight, consisting primarily of ventral (nutation) and caudal (contranutation) gliding (2). It has now been demonstrated that weightbearing is increased and movement decreased by a self-bracing mechanism occurring with pelvic flexion (nutations) (3). Pelvic flexion, caused either by a posterior shift in the line of gravity, an increase in anterior pelvic support by the abdominal muscles, or both, causes a tightening of the posterior interosseus ligaments and

the sacrotuberous ligament that markedly increases friction and weightloading capacity of the sacroiliac joint (Fig. 1). This self-bracing mechanism can be maintained in the trunk-forward position with support of the abdominal muscles anteriorly and by the hamstrings and gluteus maximus posteriorly.

Anterior rotation of the innomines on the sacrum decreases tension on the sacrotuberous ligament, releasing the self-bracing mechanism and decreasing friction in the sacroiliac joint (Fig. 2). Standing with the pelvis anteriorly rotated (contranuted) and with the abdominal muscles relaxed appears to release the self-bracing, suspending the sacrum from the ilia, decreasing the capacity for weightloading, and increasing shear.

The sacroiliac joints have an important dynamic function during ambulation. Ambulation is initiated by a controlled fall of the trunk causing an anterior inertial gravitational moment. The ground reaction force of initial impact causes a deceleration moment. Between these two opposing moments is a force couple and a margin of shear at the sacroiliac joints. The deceleration moment arrests and reverses the anterior inertial moment of the trunk. The quadriceps allows some knee flexion with an eccentric contraction that cushions the initial impact. The quadriceps then extends the knee, facilitated by a co-contraction of the ham-

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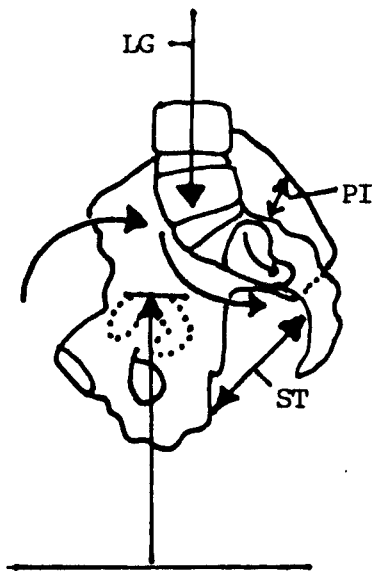


Fig. 1. When the line of gravity (LG) is posterior to the acetabula, the sacrotuberous (ST) and the posterior interosseus (PI) ligaments are tightened and the sacroiliac joint becomes self-braced.

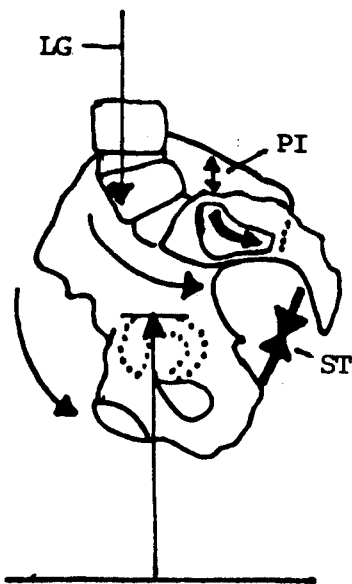


Fig. 2. When the line of gravity (LG) is anterior to the acetabula, the resultant anterior rotation decreases tension in the sacrotuberous (ST) ligament decreasing friction in the joint. Tension on the posterior interosseus ligaments remains as these ligaments carry the superincumbent weight.

strings that pulls the knee posteriorly into extension and, through its lateral insertions, provides lateral stability to the knee. With the knee extended, the pelvis decelerates and is stabilized by the same co-contrac-

tion of the hamstrings. At this two-point support, the innominate on the side of flexion is in slight posterior rotation which facilitates the self-bracing mechanism which, in turn, increases the weight-loading capacity of that sacroiliac joint. The innominate on the side of extension is in slight anterior rotation, releasing the self-bracing mechanism, decreasing friction in that sacroiliac joint and facilitating the weight transfer. The trunk continues to decelerate causing a compensatory caudal excursion of the sacrum and a deceleration of the spine segmentally with a concurrent flattening of the spinal curves. Excessive caudal movement of the sacrum is prevented by the co-contraction of the biceps femoris pulling through its tendinous origin in the sacrotuberous ligament and increasing the self-bracing (Fig. 3). Lateral stability of the sacrum is provided by the sacrospinous ligament and assisted by the piriformis muscle.

When deceleration of the trunk is complete, the spinal curves recover and the sacrum moves ventrally. This is a rhythmic sacrocranial vertebral oscillation (4) that originates at and moves through the sacroiliac joints with alternate self-bracing on the side of impact loading.

The amount of spinal movement occurring with rhythmic sacrocranial vertebral oscillation was measured by Thorstensson and his associates and found to be about 2.5 cm at L3 (5). The wave form of the spine appears to damp the oscillation so that the movement is about 1.5 cm at C7. The complimentary movement of the sacrum was described and measured by Pierrynowski and his colleagues (6). The spinal ligaments store and release energy with this oscillation and the discs appear to undergo an intermittent compression that may have pumping action to circulate spinal fluid and assist in nutrition of the discs.

With the posterior recovery of the trunk at two-point support, the hip flexors raise the trailing leg slightly, releasing the energy stored in the tightened fascia which then propels the leg forward for the next step. This serves to decrease the energy demands of ambulation.

After heel strike, to facilitate the forward swing of the trailing leg and to lengthen the step, the pelvis swings anteriorly in the horizontal plane in response to previously tightened fascia. This pelvic swing is decelerated by an eccentric contraction of the gluteus maximus on the side of the stabilizing leg to decrease the impact loading of the next step (Fig. 4). The counterrotation of the trunk, acting through the sacroiliac joint, also serves to decrease impact loading on the side of the posterior swing of the upper trunk and tightens pelvic fascia on the side of the anterior swing (4).

The gluteus medius and other hip abductors function in a harmonic sequence with the gluteus maximus

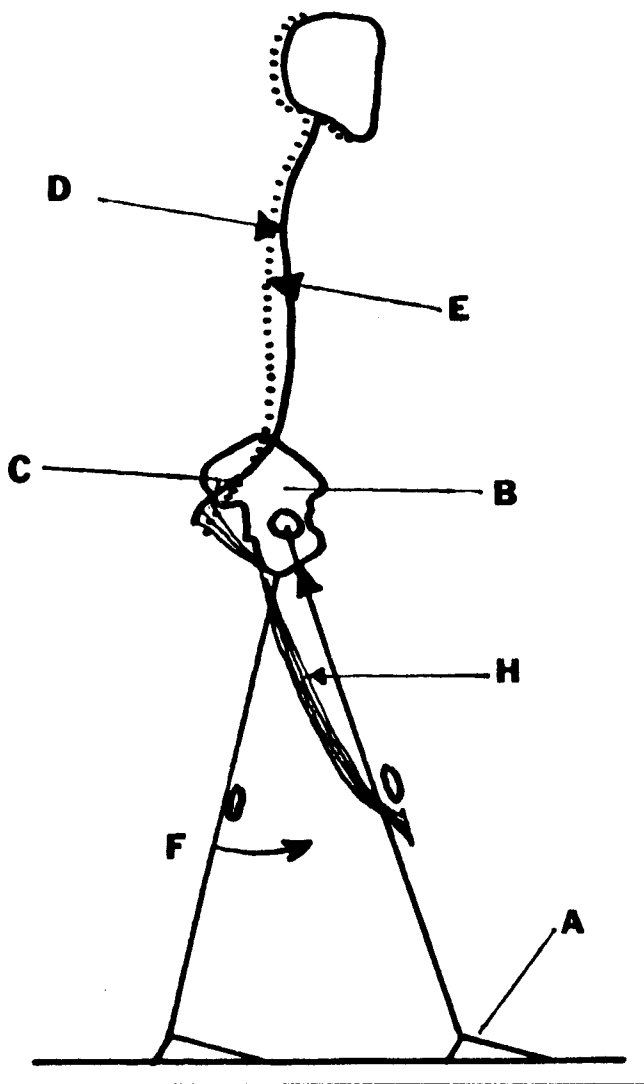


Fig. 3. After initial impact (A), the pelvis (B) decelerates in the sagittal plane followed by weight-loading of the upper trunk, onto the ipsilateral innominate bone. The ipsilateral sacroiliac joint (C) is self-braced, increasing its weight-loading capacity while self-bracing is released in the contralateral sacroiliac joint, probably releasing shear forces. The pelvic deceleration slows the anterior inertial movement of the trunk (D) causing a sequential rhythmic flattening of the spinal curves from the sacrum cephalad. A posterior recovery motion (E) helps to control the anterior inertial movement and assists the hip flexors in the initiation of the next step (F). The hamstrings (H) both stabilize the pelvis and help to maintain self-bracing through their origin in the sacrotuberous ligament.

to stabilize the pelvis in the horizontal plane as the swing leg is lifted and carried anteriorly. At heel strike of the contralateral leg, the iliopsoas, the tensor fascia lata, the abdominal obliques and the associated pelvic fascia of the trailing leg are stretched and store energy for the next step.

Since rhythmic sacrocranial vertebral oscillation

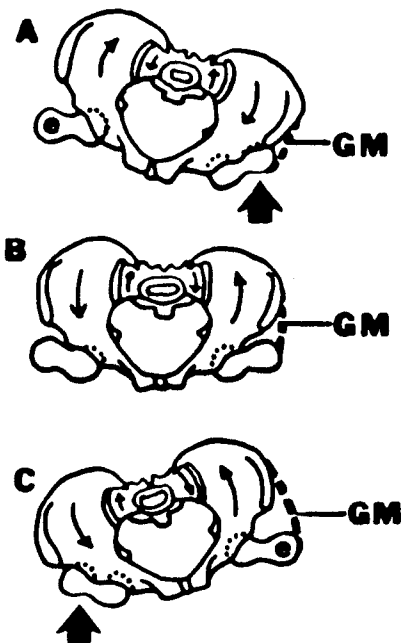


Fig. 4. With heel strike on the left (A) the trochanter is posterior toward the innominate, while the right leg is in extension (e) and the right trochanter is more anterior toward the innominate (two-point support). During mid-swing with weight-bearing left (B), the gluteus maximus (GM) is decelerating and elongating. With heel strike on the right side (C) the right trochanter is posterior toward the innominate, the left leg is in extension (e), and the gluteus maximus (GM) completes deceleration. This deceleration controls pelvic swing in the horizontal plane to decrease contralateral impact loading, aided by the counter-rotation of the upper trunk. (Courtesy of Forum Medicum, Inc).

occurs with one innominate in slight anterior rotation and the other in slight posterior rotation, it must move on an oblique axis. This is in addition to the three axes of rotation through the symphysis pubis described by Lavignolle and his colleagues (7). These movements at two-point support are made somewhat more complex at the sacroiliac joints when the torque of the counterrotation of the upper trunk is considered.

Dysfunction

Most dysfunction occurs when leaning forward to perform some task such as lifting, bending or lowering which causes the line of gravity to move anteriorly to the acetabula. This causes a force in anterior rotation of the innominate bones around the femoral heads. If the abdominal muscles are active and support the anterior pelvis, stabilizing the trunk to maintain a constant relationship of the trunk to the pelvis during anterior rotation, the self-bracing mechanism is maintained and no dysfunction occurs.

Dysfunction occurs with anterior rotation of the

innominates in the absence of adequate anterior pelvic support which decreases tension in the posterior interosseus ligaments and the sacrotuberous ligaments resulting in a release of the self-bracing mechanism. This allows a concurrent ventral gliding (contranutation) of the sacrum on the innominates. This may occur while leaning forward, if the pelvis rotates downward anteriorly slightly before the trunk comes forward, or in lifting, if the trunk extends before the pelvis rotates posteriorly. With anterior rotation of the innominates on the ventrally rotated sacrum, the posterior superior iliac spines rise and diverge on the sacrum where they appear to wedge and become partially fixed. This slight shifting probably occurs at the most caudal aspect of the sacroiliac joint and appears to prevent the re-establishment of the self-bracing mechanism. Vleeming suggests that this anterior dysfunction of the sacroiliac joints would be better grasped if it was labeled "sustained unilateral or bilateral contranutation of the SI-joints" (8).

If the dysfunction is unilateral, the crest on the affected side will be higher when standing and the leg on that side will appear to be longer when supine (Fig. 5, 6). The posterior superior iliac spine will be higher on the painful side when standing and the sacral plateau will tilt away from the side of pain. Any resultant lateral shift will be away from the side of pain and a compensatory scoliosis may occur toward the painful side when standing. Even though the posterior superior iliac spine will be noticeably higher on the side of anterior dysfunction, the level of the iliac crests (CL) may appear to be nearly the same. Note how

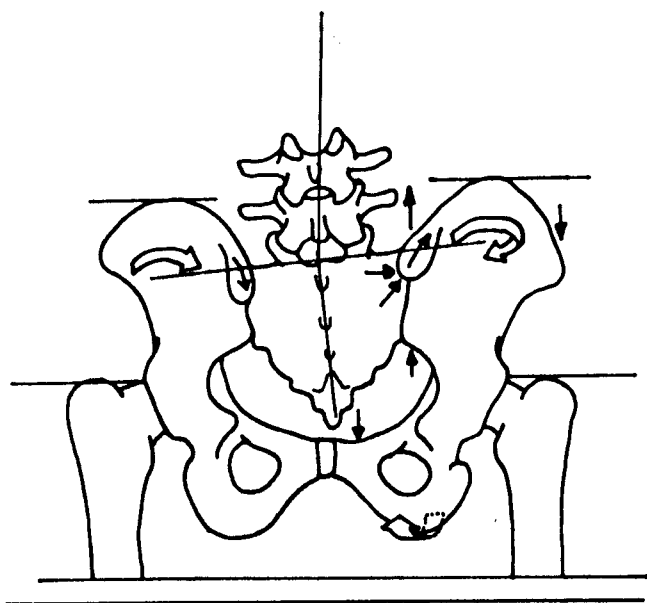


Fig. 5. Posterior view of a right anterior dysfunction standing.

the acetabulum (K) moves posteriorly with reference to the sacroiliac joint (S) causing the leg on that side to appear shorter in the long-sitting position (Fig. 7).

Both legs will appear to be of equal length with

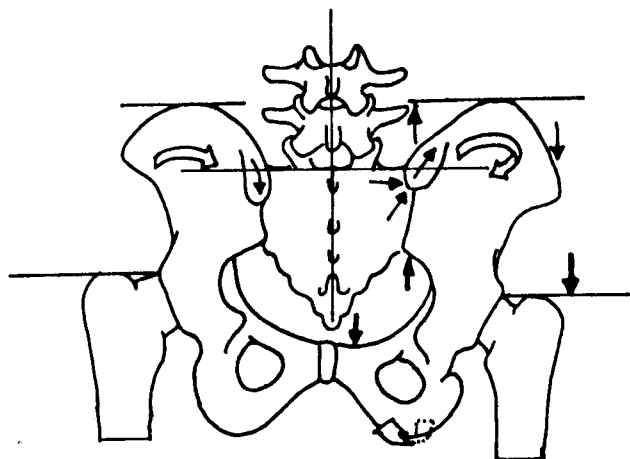


Fig. 6. Posterior view of a right anterior dysfunction supine.

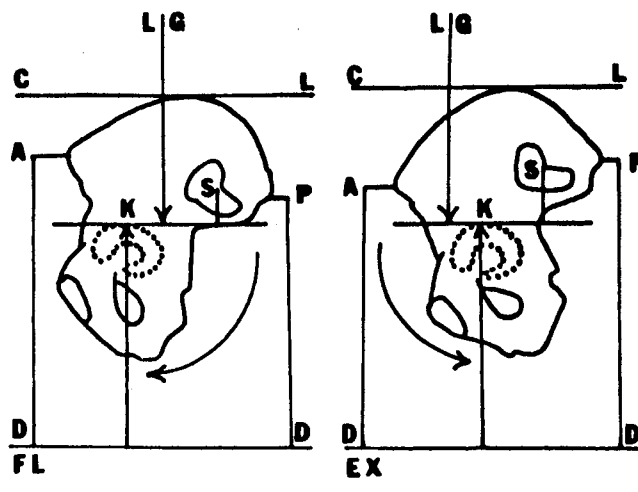


Fig. 7. In the flexion position (FL), the line of gravity (LG) is posterior to the acetabula and causes a posterior rotational force around the acetabula. As the line of gravity moves anteriorly to the acetabula in the extension position (EX), the pelvis rotates anteriorly around the acetabula. The top of the acetabula (K) to the base (DD) remains constant. Although the height of the posterior superior iliac spine (PD) and of the anterior superior iliac spine (AD) changes considerably, the level of the crests of the ilia (CL) may not change much. As the level of the sacroiliac joint (S) rises, apparent leg length is increased in both supine and standing positions. The horizontal distance from K to S becomes shorter, thus, in the patient with sacroiliac joint dysfunction, leg length may be shorter during sitting, but longer when positioned supine. (Courtesy of Forum Medicum Inc.).

the bilateral anterior dysfunction, but the pelvis will be inclined anteriorly, stretching the iliopsoas and giving the impression of tight hip flexors (Fig. 8). Any attempt to stretch the hip flexors with the sacroiliac joints in anterior dysfunction will increase the dysfunction and increase the pain. This bilateral dysfunction also tends to flair the iliac crest, which then approximate with correction. A bilateral anterior oblique dysfunction may also occur that is similar to the unilateral dysfunction, but both sides are involved.

The cephalad and lateral movement of the posterior superior iliac spines on the sacrum opens the sacroiliac joints slightly, decreasing contiguity and friction in the anterior aspect of the joint which then may allow the anterior aspect of the innominate portion of the sacroiliac joint to slip vertically upward on the anterior aspect of the sacral portion of the sacroiliac joint if the innominate rotates posteriorly in an attempt to re-establish self-bracing. This is frequently referred to as an upslip or as a posterior innominate and is frequently mistaken for an anterior dysfunction on one side and a posterior dysfunction on the other. The iliac crest on the more painful side will be slightly lower than the other when standing and the leg on that side will appear to be shorter when the patient is supine (Fig. 9, 10). The posterior superior iliac spine will be lower on the more painful side when standing and the sacral plateau will tilt toward the side of pain. Any resultant lateral shift will be toward the more painful side when standing and a compensatory scoliosis may develop away from the painful side. The acetabulum will move anteriorly with reference to the sacroiliac joint causing the leg on that side to appear longer than the other in the long-sitting position. All of these variations of anterior dysfunction can be corrected with the same basic mobilization. I find no true posterior dysfunction of the sacroiliac joints, probably because the self-bracing mechanism prevents dysfunction posteriorly.

Where the Pain is Coming From

Pain arises from many adjacent tissues and may mimic disc disease or give the impression of a multifactorial etiology. The divergence of the innominates on the sacrum opens the joint and stretches the nociceptor-rich anterior capsule. Vertical shearing at the caudal horn may disrupt tissue and cause pain deep to the conjoint origin of the gluteus maximus muscle. The separation of the conjoint origin of the gluteus maximus

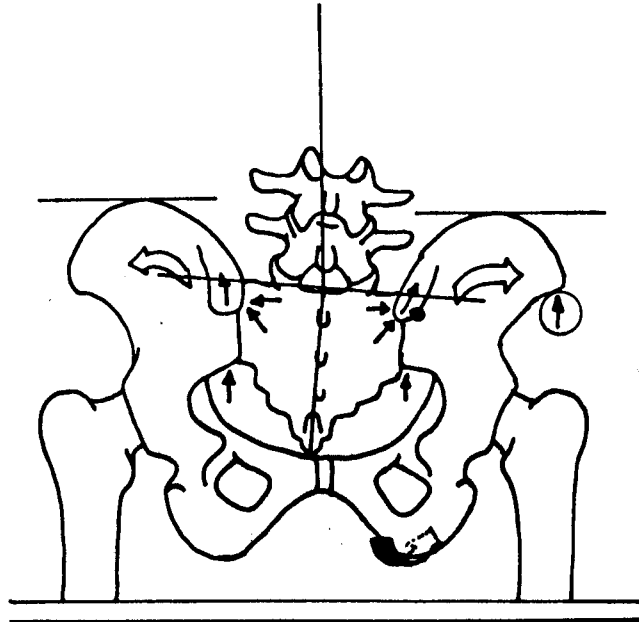


Fig. 9. Posterior view of a bilateral anterior dysfunction compromised right, standing.

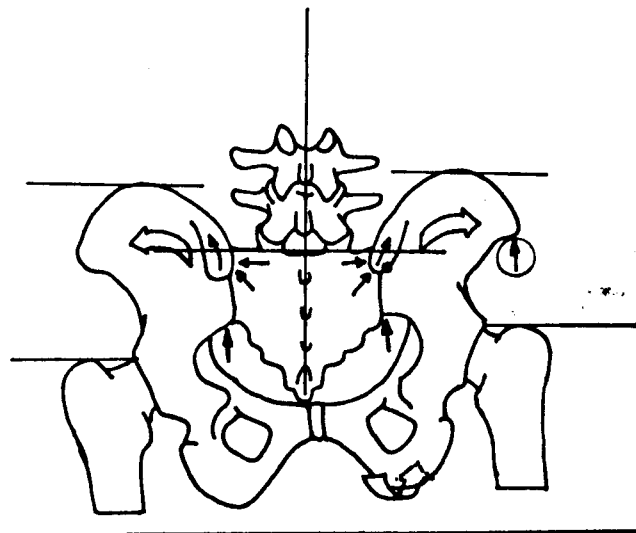


Fig. 10. Posterior view of a bilateral anterior dysfunction, compromised right, supine.

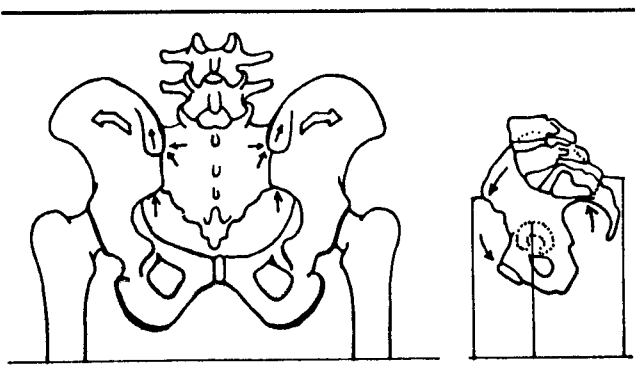


Fig. 8. Posterior view of a bilateral anterior dysfunction.

may cause pain from there, on a line, to the greater trochanter. The long posterior sacroiliac ligament will be stretched and may be disrupted resulting in joint instability. An associated release of chemical irritants will increase local tissue congestion and sensitivity to pain. Pain in the posterior thigh may occur as the hamstrings contract in an attempt to reestablish the self-bracing mechanism. This may also cause tightness in the associated fascia of the posterior thigh. The patient may also experience pain in the lower abdomen over Baer's sacroiliac point, described as being on a line from the umbilicus to the anterior superior iliac spine, two inches from the umbilicus (9). This may be falsely interpreted as ovarian pain or appendicitis pain. Pain may also be referred into the groin and testicles and cause a pseudo-epididymitis.

Leaning forward when standing will increase the pain of an anterior dysfunction, although standing erect may ease the pain as the line of gravity is posterior to the acetabula and the resultant posterior rotation, aided by the buttressing action of the femoral heads tends to approximate the innominates at the posterior superior iliac spines and increase self-bracing. Sitting may cause pain if the innominates lose the buttressing action of the femoral heads and rotate anteriorly on a fixed ischial tuberosity decreasing self-bracing (Fig. 11, 12).

The increase of intra-abdominal pressure associated with coughing or straining can be expected to spread the innominate bones on the sacrum and may precipitate or exacerbate sacroiliac joint dysfunction. Stabilization of the sacroiliac joints by manual compression of the iliac crests will usually allow the patient to cough in comfort and implicates the sacroiliac joints as the pain source rather than an associated increase in intradiscal pressure.

Passive Straight Leg Raising

Passive straight leg raising can alter tension on the sacroiliac joint and this test is very useful in assessment of dysfunction of the sacroiliac joint, but it must be interpreted properly. Bohannon, Gajdosik and LeVeau found a constant relationship between passive straight leg raising, pelvic rotation and the pelvic angle (10). Pelvic rotation occurred in every subject by nine degrees of passive straight leg raising and usually before four degrees. Any alteration in pelvic rotation caused by a dysfunction of the sacroiliac joints may affect the passive straight leg raising test.

The pull of the hamstrings on the ischial tuberosity with passive straight leg raising causes a force in posterior rotation that increases self-bracing and may ease the pain of an anterior dysfunction. As the examiner lowers the leg at the conclusion of the passive straight leg raising test, if the patient attempts to assist the

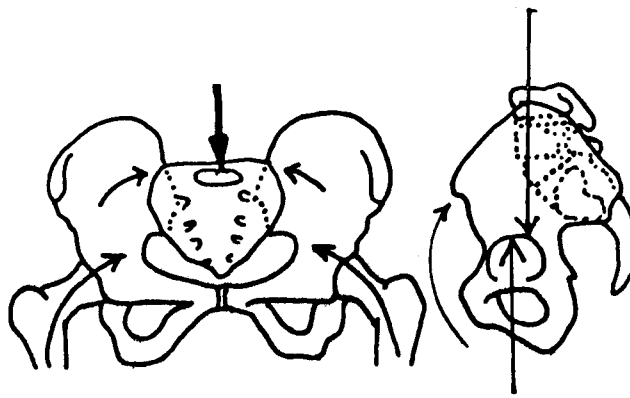


Fig. 11. Standing erect facilitates self-bracing.

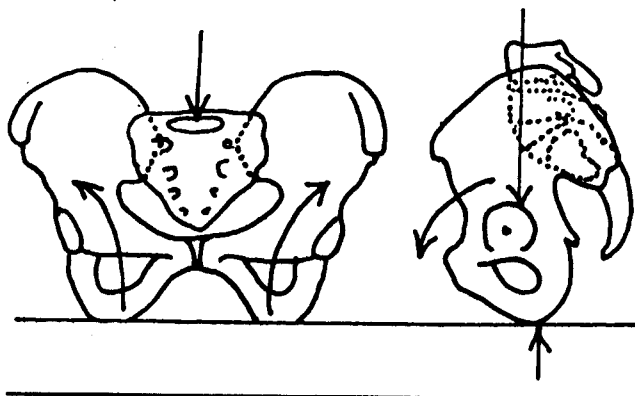


Fig. 12. Sitting may release self-bracing.

examiner and actively holds back or lowers his or her own leg with the hip flexors, ipsilateral pain in the low back may be increased as the eccentric contraction of the iliacus tends to pull the ipsilateral innominate anteriorly on the sacrum, decreasing self-bracing and increasing the pain of an anterior dysfunction. James Mennell (9) noted that as the ipsilateral innominate bone moves posteriorly with passive straight leg raising, the sacrum is carried posteriorly on the contralateral innominate, decreasing self-bracing on the contralateral side and indicating an anterior dysfunction on that side. An increase of ipsilateral pain in the low back with passive straight leg raising is indicative of the compromised vertical slipping that occurs with bilateral anterior dysfunction of the sacroiliac joints. The pain with PSLR in this pathologically braced joint is immediately relieved with correction and normal self-bracing.

Confirmation and Correction

Because the leg appears to lengthen when the innominate rotates downward anteriorly and upward poste-

riorly on the sacrum, it can be expected to appear to become shorter when the innominate is rotated upward anteriorly and downward posteriorly to its resting position. The key here is downward posteriorly where fixation appears to occur. The apparent shortening of the leg is a measurable, objective, positive and frequently predictable sign occurring with correction that relieves pain in and restores function to the sacroiliac joint. This apparent shortening will occur with correction of the unilateral dysfunction, with long leg on the painful side, with bilateral dysfunction when both legs appear to be of equal length, with bilateral oblique dysfunction when both sides are anterior, one more than the other, and with the compromised bilateral dysfunction with an apparent short leg on the more painful side. This apparent change in leg length is accompanied by a movement of the posterior superior iliac spines caudad and medially on the sacrum. It is not a difference in leg length that cause dysfunction in the sacroiliac joints, but rather the dysfunction that causes the changes in leg length. As this is easily corrected with mobilization, heel lifts are unnecessary.

The test to correct and confirm anterior dysfunction is performed with the patient supine on a plinth. The examiner stands at the foot of the plinth, grasps each ankle, approximates the malleoli in the midline and notes the comparative length of each leg. The relative position of each medial malleolus is an extension of the position of each ipsilateral acetabulum and indicative of the relative position of that acetabulum to the sacrum.

Any of several methods may be used to rotate the innominate bones posteriorly on the sacrum; either by using the leg as a lever; grasping the innominate directly and rotating; or by using a strong isometric hip extension (Fig. 13) (4). After mobilizing one side in this manner, reexamine the apparent leg length at the malleoli to see if the leg on that side now appears to be shorter than it was. Mobilize the other side in the same manner and check the leg length again. Keep mobilizing each side posteriorly until the leg length no longer changes.

Occasionally correction may be somewhat difficult, especially in the case of a bilateral dysfunction that is compromised on one side. Pulling down in the long axis on the shorter leg on the more painful side may cause that leg to become longer and the leg length to appear equal, but only corrects the compromise and leaves both innominates in anterior dysfunction. Pulling on that leg with the hip in 40 degrees (or more) of flexion and about 15–20 degrees of abduction will cause that shortened leg to become even more short as the posterior superior iliac spines move caudally and medially on the sacrum with restored self-bracing. Pull on the other leg in the same manner and that

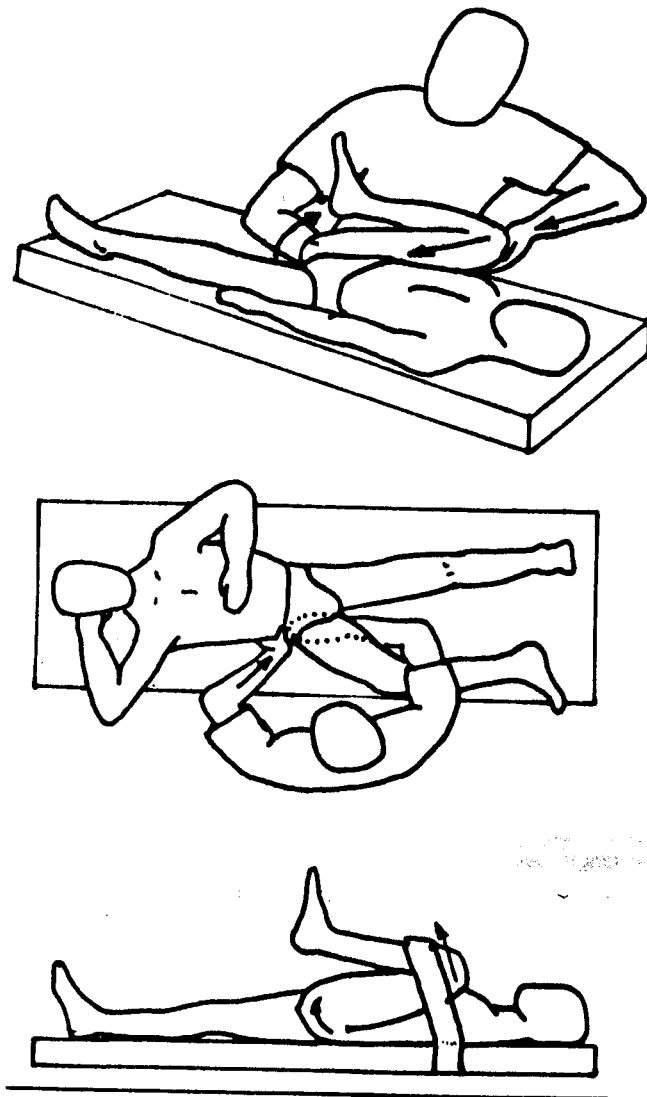


Fig. 13. Sacroiliac dysfunction can be corrected and self-bracing restored by mobilizing the innominate bones posteriorly and downward on the sacrum either by using the leg as a lever (top), by grasping the innominate directly and rotating (Middle), or by using a strong isometric hip extension against a strap.

leg will also appear to shorten. Now rotate each innominate on the sacrum as previously described and continue to check any change in leg length to make sure the correction is complete. It is very interesting to be able to pull down on a short leg and watch it become even more short (Fig. 14).

The point of fixation appears to function as a pathological axis of rotation and the anterior aspect of the innominates may be mobilized anteriorly or posteriorly, making the leg length appear to change, without getting a correction. You must direct the mobilization to cause the posterior superior iliac spines

to move caudally and medially on the sacrum to get a correction and restore self-bracing.

Corrective Exercises

The patient must begin self-mobilization exercises as soon as possible after onset to correct the dysfunction. This can be done with a direct stretch (Fig. 15) or with a strong isometric hip extension (Fig. 16). Any of these exercises may be used depending upon individual efficacy of response. The selected exercise should be performed alternately on each side at least three times

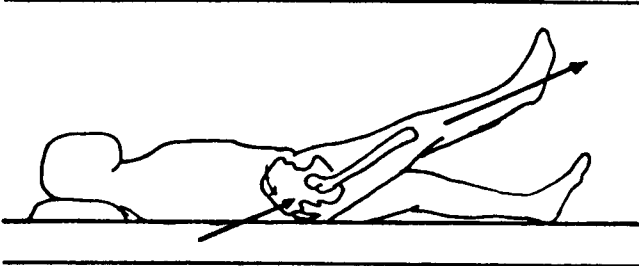


Fig. 14. Pulling on the leg in the long axis in hip flexion will correct the dysfunction and cause the leg to become shorter. Repeat at least three times with each leg, alternating. Check the leg length each time.

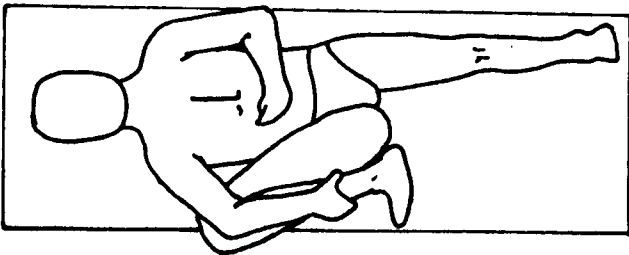
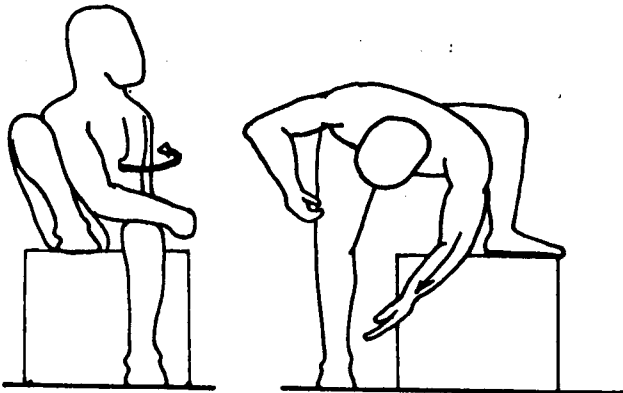


Fig. 15. The patient should correct his or her own dysfunction many times during the day with a direct stretch while either sitting, standing or lying. After the acute phase, correct only when necessary.

and repeated many times throughout the day. Self-correction at bedtime allows the joints to stay relatively unstressed for several hours. Prevention of onset or recurrence of dysfunction is by actively supporting the anterior pelvis when standing and especially prior to leaning forward to perform any task to maintain the self-bracing mechanism (Fig. 17). Depending upon individual fitness, muscles most involved in the self-bracing mechanism may have to be strengthened. These include the abdominal musculature (including the obliques), the gluteus maximus and the hamstrings.

Pain on sitting can be minimized by placing a pad about 40 cm long by 20 cm wide by 3–4 cm thick under the upper thighs, just anterior to the ischial tuberosities. This unweights the ischial tuberosities, relieving any ischemic pain there, shunts that weight to the femoral heads, restoring some buttressing, and

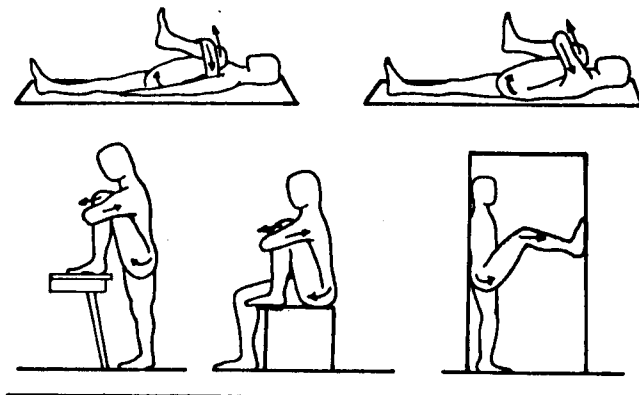


Fig. 16. The patient may also use a strong isometric hip extension in any convenient position. Alternate on each side at least three times.

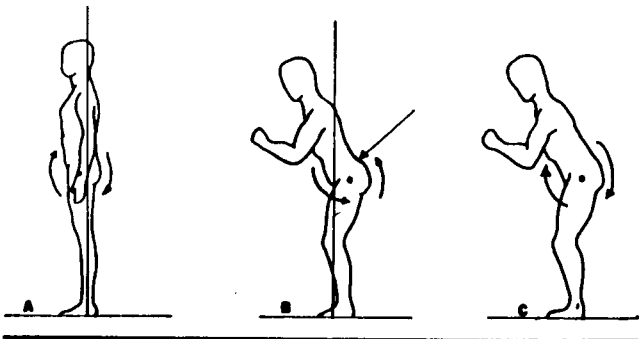


Fig. 17. A. Standing with a posterior pelvic tilt (nutation) maintains self-bracing. B. Dysfunction occurs with anterior rotation and a loss of self-bracing. C. Dysfunction can be prevented by maintaining self-bracing with support of the anterior pelvis by the abdominal muscles while leaning forward.

causing a posterior rotation force on the innominates to restore self-bracing. If a lumbar pad is used, it should be placed higher than the ilia to stabilize the vertebra anteriorly and not interfere with the corrective posterior rotation of the innominate bones (Fig. 18). If a lumbar pad is used without the seat pad and placed too low, it may cause the innominates to rotate anteriorly, decreasing self-bracing and increasing pain.

A good lumbosacral support can be helpful to stabilize the unstable joint, but it should be put on when the patient is supine and after a correction has been made. If the support is put on without correcting the dysfunction, it may increase pain by increasing pressure on the uncorrected sacroiliac joints. Not only can the support be worn during the day to stabilize the pelvis and maintain self-bracing, but it is frequently helpful when worn at rest when the muscles and ligaments are at rest and the pelvis is less stable.

Comfortable sleeping positions are supine with a pillow under the upper thighs, sidelying with the hips and knees flexed and a pillow between the legs, and prone with the hip and knee of the painful side well flexed. Silk or acetate pajamas decrease torsional pelvic stress when turning in bed by decreasing friction with the sheets.

The importance of good posture cannot be over-emphasized. A forward head posture will allow the chest to flatten which decreases anterior pelvic support and decreases self-bracing. The anteriorly inclined pelvis impairs the hip flexor mechanism leading to ambulating with an externally rotated thigh and a substitution of hip adduction for hip flexion. This leads to a valgus deformity of the knee, improper patellar tracking, a flattening of the longitudinal arch and a rolling over the hallux with eventual hallux valgus. The anteriorly inclined pelvis may also impair venous return from the lower extremities, increasing back-pressure in the veins and leading to varicosities.

Stabilization of the unstable joint remains a problem although even transient restoration of self-bracing offers relief. The use of proliferant therapy in appropriate ligaments, especially the long posterior sacroiliac ligament, holds much promise (11).

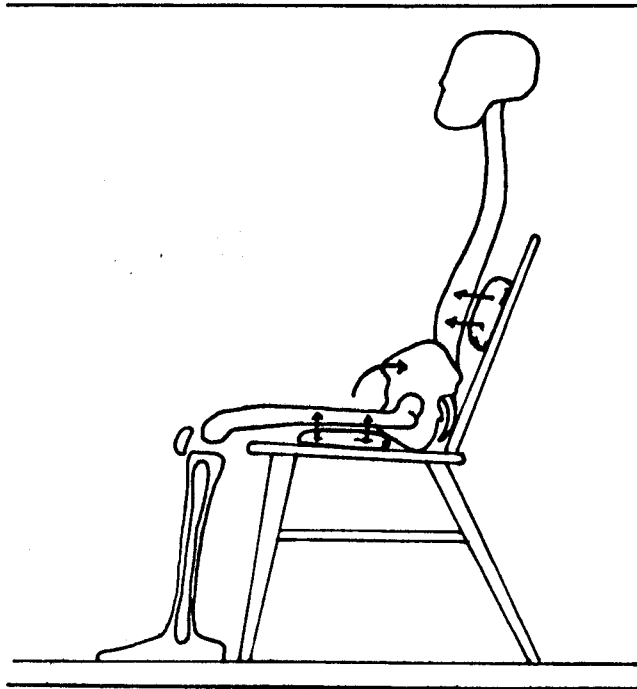


Fig. 18. Use of appropriate support will maintain self-bracing while seated.

Incidence

Dysfunction of the sacroiliac joint is far more common than has been suspected and may mimic disc disease or give the impression of a multifactorial etiology. After careful examination of 1000 consecutive cases of low back pain, Shaw found that 98% had some component in the sacroiliac joints (12).

Conclusion

The sacroiliac joints are prominent dynamic structures in the low back with a unique action and important functions. Dysfunction as an impairment of the self-bracing mechanism is a common source of low back pain. Effective treatment lies in the restoration and maintenance of the self-bracing mechanism.

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