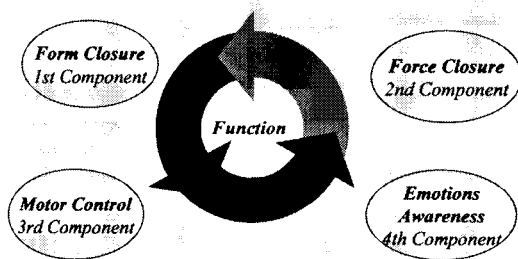


AN INTEGRATED MODEL OF "JOINT" FUNCTION AND ITS CLINICAL APPLICATION

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An Integrated Model of Joint Function Vleeming/Lee



Revelations from recent research, together with the interdisciplinary sharing of ideas facilitated by the past three World Congresses on Low Back and Pelvic Pain, has led to the development of a new model for understanding the lumbopelvic region. This model is an integrated one in that it considers the impact of structure (form or anatomy), function (forces and motor control) and the mind (emotions & awareness) on human performance.

This model evolved from questions which addressed "Why are you in pain?" and "Why are you unable to do the things you want to do?" as opposed to "What structure is causing you pain?" To answer the "WHY" questions we need to understand how forces are controlled and transferred through the body. This functional requirement has been called "effective load sharing", "effective force closure" or "effective load transfer" (Lee & Vleeming 2000). In short, how well can the individual stabilize their bones and joints during both static and dynamic activities. Optimal stabilization requires accommodation to each specific load demand, through adequate, tailored joint compression, by muscles, fascia and ligaments. (Vleeming, Lee, Ostgaard, Sturesson, Mens).

Stability (both to sustained and intermittent loading) can only occur when the passive, active and control systems work together to transfer load safely and efficiently (Panjabi 1992). Adequate approximation of the joint surfaces must be the result of all forces acting across the joint if stability is to be insured. Adequate means not too much, not too little,

but just enough. Consequently, the ability to effectively transfer load through joints is dynamic and requires:

Intact bones, joints and ligaments (form closure (Snijders et al 1993a,b)– first component). optimal function of the muscles which includes the ability of muscles to contract tonically in a sustained manner (*force closure (Snijders et al 1993a,b) - second component*) as well as the ability of the muscles to perform in a co-coordinated manner (*motor control – third component*) such that the resultant force is adequate compression through the articular structures at an optimal point (tailored).

Appropriate neural control, which ultimately orchestrates the pattern of motor control. This requires constant accurate afferent input from the mechanoreceptors in the joint and surrounding soft tissues, appropriate interpretation of the afferent input and a suitable motor response (*emotions and awareness – fourth component*).

For every individual, there are many strategies available to achieve stability. These are based on the individual's anatomical/biomechanical factors (i.e. connective tissue extensibility, muscle strength, body weight, joint surface shape, motor control patterns), psychosocial factors and the loads they need to control.

We have learned that stability is not about amplitude of motion but rather about how well an individual can control the amount of movement they have. When motion control is inadequate, there may be too much or too little compression of the joint surfaces. In both cases, the resultant afferent input is distorted and sustains the ineffective motor control. Too much compression over a long period of time will wear out the joints and lead to osteoarthritis. Too little compression creates episodes of giving way and collapse.

This Integrated Model of “Joint” Function can be applied to every region of the body – the following is an application to the pelvis.

FIRST COMPONENT – FORM CLOSURE

The sacroiliac joint transfers large loads and its shape is adapted to this task. The articular surfaces are relatively flat and this helps to transfer compression forces and bending moments (Snijders et al 1993ab). However, a relatively flat joint is vulnerable to shear forces. The sacroiliac joint is protected from these forces in three ways. Firstly, the sacrum is wedge-shape in both the anteroposterior and vertical planes and thus is stabilized by the innominate. Secondly, in contrast to other synovial joints, the articular cartilage is not smooth but rather irregular, even at birth (Sashin 1930, Bowen & Cassidy 1981). Thirdly, a frontal dissection through the sacroiliac joint reveals cartilage covered bone extensions protruding into the joint (Vleeming et al 1990a,b), the so-called ridges and grooves. They seem irregular, but are in fact complementary and this serves to stabilize the joint when compression is applied. This stable situation with closely fitting joint surfaces where no extra forces are needed to maintain the state of the system, given the actual load situation, is called “*form closure*” (Vleeming et al 1990, Snijders et al 1993 ab).

For many decades, it was thought that the sacroiliac joint was immobile due to the close fitting nature of the articular surfaces. Research in the last two decades has shown that

mobility of the sacroiliac joint is not only possible (Egund et al 1978, Lavignolle et al 1983, Stuesson et al 1989, 1999), but essential for shock absorption during weight bearing activities. It has also been shown (Vleeming et al 1992b) that the sacroiliac joint retains its mobility with age. The quantity of motion available at this joint has been investigated (Jacob & Kissling 1995, Stuesson 1989, 1997, 1998) with highly sophisticated imaging and motion analysis techniques and the results reflect the wide anatomical variance. It is known that the angular motion available at the sacroiliac joint is very small (no more than 1° - 4° Stuesson 1989, 1997, 1998) and that this motion couples with a very small amount of linear translation (less than 2 mm Stuesson 1989). The direction of motion coupling has been hypothesized by Lee (1999) and recently confirmed by Hungerford et al (2001).

This research addresses the question "How much does the sacroiliac joint move?" The answer – it moves a little bit and the amount varies between individuals. No manual diagnostic tests have shown reliability for determining *how much* an individual's sacroiliac joint is moving in either symptomatic or asymptomatic subjects. What has been shown (Buyruk et al 1997) through Color Doppler Imaging studies is the wide variation in stiffness values of the sacroiliac joint in both symptomatic and asymptomatic subjects. Within the same subject, the asymptomatic individual had similar values of stiffness for both sacroiliac joints, whereas the symptomatic individual had different values for the left and right sacroiliac joint. In keeping with this research, perhaps the focus of manual motion testing should be how resistant the joint is to an applied force rather than *how much* the sacroiliac joint is moving and how symmetric the left and right SIJ's are.

To analyze stiffness we need to consider the zones of motion available to every joint, the neutral zone and the elastic zone. The neutral zone (Panjabi 1992) is a small range of movement near the joint's neutral position where minimal resistance is given by the osteoligamentous structures. The elastic zone is the part of the motion from the end of the neutral zone up to the physiological limit. Panjabi noted (1992) that joints have nonlinear load-displacement curves. The non-linearity results in a high degree of laxity in the neutral zone and a stiffening effect toward the end of the range of motion. He has found that the size of the neutral zone may increase with injury, articular degeneration and/or weakness of the stabilizing musculature and that this is a more sensitive indicator than angular range of motion analysis for detecting instability.

We hypothesized (Lee & Vleeming 1998, 2000) that the neutral zone may also be effected by altering compression across the joint. To explain this further we need to understand the second component of this model – force closure.

SECOND COMPONENT – FORCE CLOSURE

If the articular surfaces of the sacrum and the innominate fit together with perfect form closure, mobility would be practically impossible. However, form closure of the sacroiliac joint is not perfect and mobility is possible, albeit small, and therefore stabilization during loading is required. This is achieved by increasing compression across the joint at the moment of loading. The anatomical structures responsible for this are the ligaments,

muscles and fascia. When the sacroiliac joint is compressed, friction of the joint increases (Vleeming et al 1990 a, b) and consequently augments force closure. The mechanism of compression of the sacroiliac joints due to extra forces is called "force closure" (Vleeming et al 1990, Snijders et al 1993ab). Force closure reduces the size of the neutral zone and thus shear is controlled between the two joint surfaces.

Several ligaments, muscles and fascial systems contribute to force closure of the pelvis. When working efficiently, the shear forces between the innominate and sacrum are adequately controlled and loads can be transferred between the trunk, pelvis and legs.

In what position is the pelvic girdle the most stable? Studies have shown (Egund 1978, Lavignolle 1983) that sacral nutation (forward motion of the sacral promontory) occurs bilaterally when moving from sitting to standing and that full nutation occurs during forward (Sturesson 1998) or backward bending of the trunk. This motion tightens the major ligaments of the posterior pelvis (sacrospinous, sacrotuberous, intersosseus) (Vleeming et al 1989a,b, Wingerden et al 1993) and this tension increases the compressive force across the sacroiliac joint. Ligaments can increase articular compression when they are tensed or lengthened by the movement of the bones to which they attach. Alternately, they can increase articular compression when they are tensed by contraction of muscles that insert into them. Tension in the sacrotuberous ligament can be increased by posterior rotation of the innominate relative to the sacrum, nutation of the sacrum relative to the innominate or by the contraction of the muscles that attach to it (biceps femoris, piriformis, gluteus maximus, multifidus). The main ligamentous restraint to counternutation of the sacrum, or anterior rotation of the innominate, is the long dorsal sacroiliac ligament (Vleeming et al 1996, Vleeming 1998). This is a relatively less stable position for the pelvis to resist horizontal and/or vertical loading since the sacroiliac joint is under less compression and is not self-locked.

By themselves, ligaments cannot maintain a stable pelvis. They rely on several muscle systems to assist. There are two important groups of muscles that contribute to stability of the low back and pelvis. Collectively they have been called the inner unit (core) and the outer unit (sling systems). The inner unit consists of the muscles of the pelvic floor, transversus abdominis, multifidus, the diaphragm and the posterior fibers of psoas – the core, also known as the local stabilizers (Gibbons & Comerford 2001). The outer unit consists of several slings or systems of muscles (global stabilizers and mobilizers (Gibbons & Comerford 2001)) that are anatomically connected and functionally related.

THE INNER UNIT – THE CORE

Hodges & Richardson (Hodges & Richardson 1996, 1997a, Richardson & Jull 1995, Richardson et al 1999) have shown that transversus abdominis is a primary muscle for stabilization of the low back and pelvis. It has a large attachment to the middle layer and the deep lamina of the posterior layer of the thoracodorsal fascia (TDF) and is recruited *prior* to the initiation of any movement of the upper or lower extremity (Hodges & Richardson 1996). Its contraction is hypothesized to increase compression across the anterior aspect of the pelvis and thus increase force closure of both the sacroiliac joint in

its anterior aspect and the pubic symphysis in its superior aspect. Its contraction also increases the tension in the thoracodorsal fascia (Hodges & Richardson 1996, Vleeming et al 1997). The secondary effect of this increase in TDF tension is thought to be compression of the sacroiliac joints.

Multifidus is contained between the lamina of the lumbar vertebra and sacrum and the deep layers of the thoracodorsal fascia. When it contracts, it broadens and therefore increases the tension of the TDF. Hides et al (1994) found segmental wasting and local inhibition of the lumbar multifidus muscle in all patients with a first episode of acute/subacute low back pain. In a follow-up study (Hides et al 1996), they found that without therapeutic intervention, multifidus did not regain its original size or function and the recurrence rate of low back pain over an eight-month period was very high. The "pump-up action" and stiffening of the TDF is therefore lost in these patients. Compression of the posterior pelvis would therefore be reduced. Clinically, it appears that co-activation of transversus abdominis and multifidus increases the stiffness value of the sacroiliac joint facilitating the force closure mechanism of the pelvis.

The function of the four parts of the levator ani muscle and the inter-relationship between the pelvic floor and the abdominals has revealed (Sapsford et al 1998) a co-activation pattern between pubococcygeus and transversus abdominis. The pubococcygeus and transversus abdominis help to force close (stiffen) the pubic symphysis (pubococcygeus inferiorly and TA superiorly) and prevent excessive shearing of the symphysis during activation of the adductors (hypothesis).

It is thought that the pelvic floor and sacral multifidus act as a force couple to control the position of the sacrum. When the sacrum is slightly nutated by the proper activation of these two muscles, the pelvis and the lumbosacral junction are more stable.

Bridging the diaphragm and the pelvic floor, it has been suggested (Gibbons & Comerford 2001) that the posterior fibers of psoas act as a local stabilizer of segmental motion in concert with the deep fibers of multifidus. Further research into the timing of activation of psoas under low and high loads is required – the hypothesis is that the posterior fibers are re-anticipatory. Anatomically, it is interesting to note that the fascia which envelopes psoas is directly connected to the fascial origin of both the pelvic floor and the diaphragm (Gibbons & Comerford 2001).

THE OUTER UNIT – THE INTEGRATED SLING SYSTEM

In the past, four systems have been described that comprise the outer unit of muscles – the posterior oblique, the anterior oblique, the longitudinal and the lateral (Table 1). Although these muscles can be trained individually (topographically), effective force closure requires specific co-activation and release for optimal function.

SYSTEM	MUSCLES
Posterior Oblique	Latissimus dorsi, gluteus maximus and the intervening thoracodorsal fascia
Anterior Oblique	External Oblique and contralateral Internal Oblique and the intervening anterior abdominal fascia, contralateral adductors of the thigh (contralateral to the external oblique)
Longitudinal	Erector spinae, deep laminae of the thoracodorsal fascia, sacrotuberous ligament, biceps femoris
Lateral	Gluteus medius and minimus, tensor fascia lata and contralateral adductors of the thigh

Table 1. A topographic description of outer unit muscle systems.

Recognizing that individual muscles are important for stabilization as well as for mobility, it is critical to understand how they connect and work together in functional systems. When muscles contract, they produce a force that spreads beyond the origin and insertion of the active muscle. This force is transmitted to the muscles, tendons, fascia, ligaments, capsules and bones that lie both in series and in parallel to the active muscle. In this manner, forces are produced quite distant from the origin of the initial muscle contraction. These integrated muscle systems produce slings of forces that assist in the transfer of load through 'tension sharing' or tensegrity.

Tensegrity is a term popularized by Buckminster Fuller when he built the first geodesic dome. These buildings transfer loads through tension beams which are connected in triangles. The integrity of this tension system is crucial to the stability of the structure (tension integrity = tensegrity). When a force pulling in one direction is equally opposed by a force pulling in the opposite direction, stability is achieved *for that direction of force only*. For complete *rigidity* of a structure the various lines of force form a series of isosceles triangles. These are called tensegrity structures. Our bodies do not require this amount of rigidity; in fact our function would be limited because of it. However, the linking together of muscles through their connective tissue bonds (fascia, ligaments and bones) can create momentary tensegrity systems that assist in the transference of force without too much compression through the joints. Exercises, which connect muscles both individually and collectively, provide tensegrity for the direction of load being imposed.

The integrated sling system represents forces and is comprised of several muscles. A muscle may participate in more than one sling and the slings may overlap and interconnect depending on the task being demanded. There are several slings of myofascial systems in the outer unit. These include, but are probably not limited to, a coronal sling (has medial and lateral components) a sagittal sling (has anterior and posterior components) and an oblique spiral sling. The hypothesis is that the slings have no beginning or end but rather connect as necessary to assist in the transference of forces. It is possible that the slings are all part of one interconnected myofascial system and the sling (coronal, sagittal or oblique), which is identified during any particular motion, is merely due to the activation of selective parts of the whole sling.

The identification and treatment of a specific muscle dysfunction (weakness, inappropriate recruitment, tightness) is important when restoring force closure (second component) and for understanding why parts of a sling may be restricted in motion or lacking in support. Exercises, which restore specific muscle length and strength, are second component exercises in this model. Exercises that integrate the muscles together in tensegrity sling systems retrain the third component - motor control.

THIRD COMPONENT – MOTOR CONTROL

Motor control pertains to the patterning of muscle activation, in other words the timing of specific muscle action and release and is not a birthright. Superb motor skills require coordination of muscle action such that stability is ensured and loads are transferred effortlessly.

Integrated exercises, which focus on sequenced muscle activation, are necessary for restoring motor control. Some of these methods include Pilates, Feldenkrais, Somatics and some forms of Yoga and Tai Chi. Janda, Sahrmann, Hodges, Richardson, O'Sullivan and Comerford approaches to muscle balance and exercise also fit into this model at the 3rd component.

FOURTH COMPONENT – EMOTIONS & AWARENESS

Recently, more focus is being given to the effect of emotions on motor control and muscle activation. As a clinician, it is imperative to understand the powerful effect thoughts and motivation can have on outcome and to seek professional assistance when necessary. In addition, it is understood that awareness of both the emotional state and awareness when exercising can have a dramatic impact on functional outcomes.

When an exercise is taught emphasizing learning (focused and attentive), motor control patterns can be changed. Conversely, when the exercise environment is noisy, attention is lacking and exercises are often done without considering how the motion is occurring (i.e. 10 repetitions at 10 kilos no matter what) and faulty patterns are often reinforced. This is when exercise can actually be harmful and the patient's symptoms made worse. The reader is referred to the article by Vleeming in these proceedings for further information on the role of emotions and awareness on motor control.

CLINICAL APPLICATION OF THE INTEGRATED MODEL OF "JOINT" FUNCTION

Impaired pelvic function can be defined as an inability to effectively transfer forces through the pelvis. To reach this diagnosis, specific clinical tests that analyze form closure, force closure, motor control and emotional states are required. Since pain on movement is not a criteria from which a biomechanical diagnosis can be made (Bogduk 1997), pain provocation tests do not assist in reaching this diagnosis. Pain provocation tests look for nociceptive generating structures and belong to the "WHAT" question and not the "WHY". To reach a biomechanical diagnosis (WHY) we need to evaluate pelvic function with simple tests that have the potential to meet scientific scrutiny for reliability and validity.

The following clinical tests were initially described in the proceedings of the 3rd World Interdisciplinary Congress on Low Back and Pelvic Pain and only the relevant updated information will be presented in this article.

QUEBEC BACK PAIN DISABILITY SCALE

This functional questionnaire has been used at the Spine and Joint Center in Rotterdam for several years now and research has been conducted (Mens et al submitted) on its efficacy to evaluate the course of recovery in peripartum pelvic pain patients. Each participant in the program completed this questionnaire at their initial visit and then again after 8 weeks of treatment. The test scores have been co-related with hip abduction/adduction strength as well as the findings of the Active Straight Leg Raise Test (ASLR) (see Mens 2001). The QBPDS rating scale is from 0 – 100. Mens found that sensitivity for pelvic impairment was greatest when the results from this test were greater than 45. All patients who scored greater than 45 on this test had a positive Active Straight Leg Raise meaning they had difficulty (increased effort or pain) while performing the ASLR. The scale is a useful way to measure the impact of disability and the impact of treatment programs.

GAIT

Greenman (1997) has described the biomechanics of the pelvis necessary to achieve a smooth efficient gait. When pelvic impairment is present, marked deviations in the coronal plane (waddling gait) occur (Lee 1997). Part of Mens' (2001) doctoral study investigated the validity and reliability of reduced hip abduction and adduction strength as a diagnostic instrument in posterior pelvic pain as a consequence of pregnancy. He found a significant reduction in the strength of both hip abduction and adduction in the pelvic pain group compared to controls and suggests "Weakness of the abduction strength explains why patients with severe PPPP (peripartum pelvic pain) have a waddling gait. When abduction strength decreases and body weight increases it is no longer possible to keep the pelvis horizontal during one-leg stance. To avoid this problem, the patient places the center of gravity of the trunk above the hip of the weight-bearing leg."

SAGITTAL PLANE MOTION – FORWARD AND BACKWARD BENDING

This test examines the ability of the low back and pelvis to control both vertical and horizontal shear forces during segmental sagittal rotation while forward or backward bending the trunk. When the leg lengths are equal, the pelvic girdle flexes symmetrically at the hip joints and the sacrum remains nutated bilaterally throughout the forward bending motion (Sturesson 1989, 1999). No intrapelvic torsion should occur, in other words the PSIS's should remain level. In backward bending, the pelvic girdle extends symmetrically at the hip joints and the sacrum remains nutated bilaterally. Asymmetry of motion of the innominates during forward or backward bending is NOT indicative of any specific dysfunction since many articular and myofascial problems can produce this finding. When unstable, loads are not easily transferred through the low back or pelvis when the trunk moves in the sagittal plane.

ONE LEG STANDING WITH CONTRALATERAL HIP FLEXION

The clinical relevance of any motion analysis between the innominate and the sacrum on the non-weight bearing side during this test has been challenged by Sturesson (1998). In his RSA studies of women with suspected hypermobility of the sacroiliac joint, he found that minimal (0.2°) motion actually occurred on the non-weight bearing side. He concluded that this movement too small to be reliably palpated and that this test should not be used to determine *mobility* of the sacroiliac joint.

It remains useful for testing the ability of the patient to transfer load through one lower extremity while flexing the contralateral hip. During this maneuver the sacrum should nutate on the weight bearing side (Sturesson 1998, Hungerford et al 2001a, b) facilitating the transference of load to one leg. This should occur smoothly with minimal adjustments of the lower extremity and the pelvis should remain in its original coronal plane.

ACTIVE STRAIGHT LEG RAISE

This test was developed by Mens & Vleeming (1997, 1999, 2001) to evaluate load transfer through the pelvic girdle in the non-weight bearing position. While supine, the patient is asked to lift one leg with the knee extended. Their ability to do so without bulging their abdomen, rotating or side bending their trunk and pelvic girdle is observed and their effort to perform the task is noted. Force closure of the pelvic girdle is then augmented by applying a gentle compression force through the pelvis. The active straight leg raise test is repeated and any change in the motor pattern (ability to stabilize the pelvis in a neutral position) and in their effort is noted.

Variations of the test have been developed (Lee 2001) to facilitate exercise prescription for core stabilization. The action of the inner unit core muscles (local stabilizers) can be simulated by varying the location of the compression force prior to the ASLR. Approximation of the ASIS's (anterior compression) simulates the action of transversus abdominis, approximation of the PSIS's (posterior compression) simulates the action of multifidus and approximation of the pelvis at the level of the pubic symphysis simulates

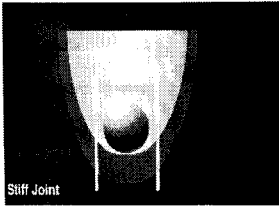
the action of the pelvic floor. Improvement in the ASLR during specific pelvic compression assists in the development of individual exercise programs (Lee 2001).

NEUTRAL ZONE ANALYSIS WITH AND WITHOUT ACTIVATION OF THE FORCE CLOSURE MECHANISM

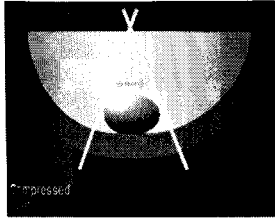
These tests examine the ability of the sacroiliac joint to resist vertical and horizontal translation forces (shear) that are applied passively to the non-weight bearing joint and have been described in detail elsewhere (Lee 1997, 1998, 1999). When analyzing the results from these tests it is important to remember that stability is NOT about *how much* movement there is or isn't but rather about the stiffness value the system has. Buyruk et al (1997) found that unstable sacroiliac joints had lower stiffness values and that symptomatic individuals demonstrated asymmetry in the values between their left and right sides. The force displacement curve (stiffness value) or rather the response of the innominate to the pressure (sense of resistance or sense of easily giving way) is noted and then compared to the patient's opposite side. We cannot make any judgements regarding *amplitude of motion* (stiff, loose, normal) with this test since it has been shown that the range of motion at this joint is highly variable and making a statement regarding the amplitude implies knowledge of what is "normal". It is not possible to know what the patient's normal should be. We can only compare the left to the right side of the pelvis and look for symmetry of stiffness values. Echo Doppler studies of the effect of both the local stabilizers (inner unit muscles) and the global mobilizers (outer unit sling systems) on stiffness of the SIJ (force closure) will be presented at this congress (see proceeding articles by Richardson & Hides, Wingerden & Vleeming). Resting muscle tone as well as subtle activation of muscles can effect force closure of the pelvis and thus stiffness of the SIJ. This must be taken into consideration when interpreting the results of these tests. This fact is also significant when inter-tester reliability studies are considered for motion analysis of the SIJ, either passive, as in joint play testing, or active.

These studies support the clinical hypothesis (Lee 1999) that when force closure is effective, it will reduce the size of the neutral zone, increase the friction of the joint surfaces and thus increase the resistance to shear forces at the SIJ. Alternately, sustained, overactivation of these same muscles (too much compression) can restrict any motion of the SIJ. Optimal function requires adequate, and appropriately timed, compression and release of the sacroiliac joint.

To test the efficacy of force closure of the pelvic girdle, the patient is first instructed to recruit their inner unit (Richardson et al 1999) while maintaining a normal breathing pattern. This instruction may take a few sessions to master. Once the patient is able to sustain an isolated contraction of the inner unit, the effect of this contraction on the neutral zone is assessed by repeating the anteroposterior and vertical shear tests after the patient has force closed the pelvis. The stiffness value should increase and no relative motion between the innominate and sacrum should be felt.



A biomechanical diagnosis can now be made regarding the stability of the pelvic girdle and the ability of the system to transfer and sustain a load.



IMPAIRED PELVIC FUNCTION

Optimal stabilization of the pelvis requires accommodation to each specific load demand, through adequate, tailored joint compression, by muscles and ligaments. (Vleeming, Lee, Ostgaard, Sturesson, Mens). Biomechanically, there are only two things that can go wrong with the sacroiliac joint – its ability to move can become restricted or its mobility can be poorly controlled. In this model, we (Lee & Vleeming 1998, 2000) prefer to call this too much or too little compression which results in inappropriate force closure and subsequently ineffective load transfer.

Panjabi's concept of the ball in the bowl (1992) and the broadening of this concept has been previously described (Lee & Vleeming 1998, 2000). What follows is the clinical application of this concept into the "Integrated Model of "Joint" Function". Hopefully, the following will clarify how essential *all* of the different clinical approaches (manual therapy, exercise, education) are in the management of patients with pelvic impairment. It is illogical to attempt to "prove" that one approach is better than another since each will have relevant clinical application for specific impairments.

EXCESSIVE ARTICULAR COMPRESSION

Excessive compression across the sacroiliac joint can result from true articular pathology such as ankylosing spondylitis or fibrosis of the capsule secondary to trauma. While a fused SIJ cannot be mobilized with manual therapy techniques, a fibrosed joint is easily mobilized in one or two treatment sessions when specific, localized, passive techniques are used (Lee 1998, 1999). This is an impairment of the first component of this Integrated Model of "Joint" Function – form closure. Manual therapy is an essential part of the treatment of this impairment.

Excessive compression of the joints of the pelvis can also be caused by inappropriate muscle forces. When an individual develops a stabilization strategy that uses predominantly the posterior pelvic floor and the deep external rotators of the hip joint, the constant activation of these muscles overly compresses the inferior aspect of the sacroiliac joint (Lee 2001).

This is an impairment of the second component of this Integrated Model of "Joint" Function – force closure. While manual therapy (passive SIJ mobilization or manipulation, muscle energy technique, pressure-stretch techniques, strain/counterstrain) may assist in

relieving the inferior pelvic compression, unless the motor control strategy for stabilization is addressed, the dysfunctional pattern is likely to recur.



The specific muscles that are weak must be strengthened; those, which are tight, must be lengthened. Addressing individual muscle function is treatment of the second component of this model – force closure. However, once the individual is able to isolate and activate the local stabilizers they must learn to sequence the timing of this muscle activation prior to any loading through the trunk, arms and/or legs. This is treatment of the third component of this model – motor control. Exercises need to be prescribed according to individual impairments and the reader is referred to the references for further information on this (Richardson et al 1999, Lee 1999, 2001). The Active Straight Leg Raise Test can help direct the selection of exercises by noting which part of the system requires more compression and which requires less. Recently, we have been using imagery (Lee 2001, Franklin 1996) to facilitate the learning process – a longstanding technique of dancers and athletes.

Impairments of this component require more exercise and education than manual therapy for long-term results.

EXCESSIVE ARTICULAR COMPRESSION WITH AN UNDERLYING INSTABILITY

When a force is applied to the sacroiliac joint sufficient to attenuate the articular ligaments (fall on the buttocks or a lift/twist injury), the muscles will respond to prevent dislocation and further trauma to the joint. The resulting spasm fixes the joint in an abnormal resting position and marked asymmetry of the pelvic girdle (innominate and/or sacrum) is present. This is an unstable joint under excessive compression and commonly occurs unilaterally. This is an impairment of both form and force closure in that the relationship between the articular surfaces has been disturbed and the muscle response is excessive. Treatment of this individual which focuses on exercise without first addressing the “posture”, “position”, alignment” of the pelvis tends to be ineffective and commonly increases symptoms. Conversely, if treatment only includes manual therapy (mobilization, manipulation or muscle energy) for correction of “posture”, “position”, “alignment”, relief tends to be temporary and dependence on the health care practitioner providing the manual correction is common.

Treatment requires a specific distraction manipulation (form closure – first component) (Lee 1998, 1999, Hartman 1997) to reduce the articular compression and restore the symmetric resting position of the pelvis. Repeat analysis of the neutral zone will now

reveal a *decrease* in the stiffness of the effected SIJ compared to the opposite side. Treatment now requires the restoration of force closure (second component) and motor control (third component) with an individually prescribed exercise program. In the meantime, the temporary application of a sacroiliac belt is often useful to augment the force closure mechanism.

This impairment requires manual therapy first followed by exercise and education for a successful outcome.

INSUFFICIENT ARTICULAR COMPRESSION

This situation arises when there is either inadequate or inappropriate motor control such that there is insufficient articular compression during movement and loading. The cause can be a single major trauma, a repetitive minor trauma (habitual postures), hormonal or systemic. The patient often complains of sensations of giving way or a lack of trust when loading through the involved extremity. This impairment is readily apparent during the one leg standing test and the ASLR test. During one leg standing, the weight bearing innominate anteriorly rotates (Hungerford 2001) when the contralateral hip is flexed. During the ASLR test, the pelvis commonly rotates to the side of the elevating leg. Associated with this, is over-activation of the posterior pelvic floor and under-activation of the transversus abdominis and anterior pelvic floor. Other common substitution strategies for stabilization will be found in Hodges and Richardson's work and the video Imagery for Core Stabilization (Lee 2001).

Once again, this is an impairment of the second and third component of the Integrated Model of "Joint" Function and the focus of treatment is exercise and education.

CONCLUSION

The Integrated Model of "Joint" Function was developed in an attempt to understand the past and present research pertaining to the pelvis and patients with pelvic pain. With this model, we can now establish sound inclusion criteria for further studies of treatment outcomes. Patients can be investigated according to their impairment as opposed to the location of their pain. This integrated model requires integrated treatment protocols that are reasoned clinically and can be researched for efficacy in a more logical manner. With this model, we can begin to answer the "WHY" questions and provide the evidence-based treatment demanded by health care payer.

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