SACROILIAC JOINT BIOMECHANICS AND ITS POTENTIAL CLINICAL IMPLICATIONS

by

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STRUCTURE

Chapter 1: **SINGULAR**

Chapter 2: **SACROILIAC JOINTS BIOMECHANICS**

Chapter 3: **SACROILIAC JOINTS PAIN PATTERNS**

Chapter 4: **POTENTIAL CLINICAL IMPLICATIONS**

Chapter 1: **SINGULAR**

Sacroiliac joint anatomical complex

- Largest axial joint in the body. (Dijkstra et al, 1989; Bernard & Cassidy, 1991).
- Surrounded by ligaments and muscles and receives innervations L5-S4 (Grob et al, 1995; Willard, 1997).
- Capable of producing pain (Fortin, et al.1994,a,b; Vilensky et al. 2002).
- Diagnosis and treatment of sacroiliac joint (SIJ) dysfunction poorly defined in the literature. (Zelle et al., 2005)
- Significant extra-articular pain exists. Intra-articular diagnostic blocks underestimate the prevalence of sacroiliac region pain. (Borowsky and Fagen, 2008).

EPIDEMIOLOGY

- SIJ pain is common cause of axial low back pain (lbp) affecting between 10% and 25% of people (Bernard & Kirkildy, 1987; Fortin, et al., 1994a; Cohen, 2007).
- Fourth common cause of lbp and pelvic pain (Paris & Viti, 2007).
- 6-13% source of lbp, pelvis or referred lower extremity pain (Schwarzer, et al., 1995a, Bogduk, 1995).
- SIJ & posterior SIJ ligaments source of posterior pelvic pain (Fortin, et al., 1994b; Vleeming, et al., 2002).
- 10.000.000 in USA have osteoporosis (National Osteoporosis Foundation,2010),34.000.000 have low bone density increase the risk for fractures (Am Academy of Orthopaedic Surgeons,1993,(revised 2009)).
- One in 2 women,1 in 4 men older 50 osteoporosis-related fracture during lifetime (Office of the Surgeon General, 2004).

EPIDEMIOLOGY, Continued

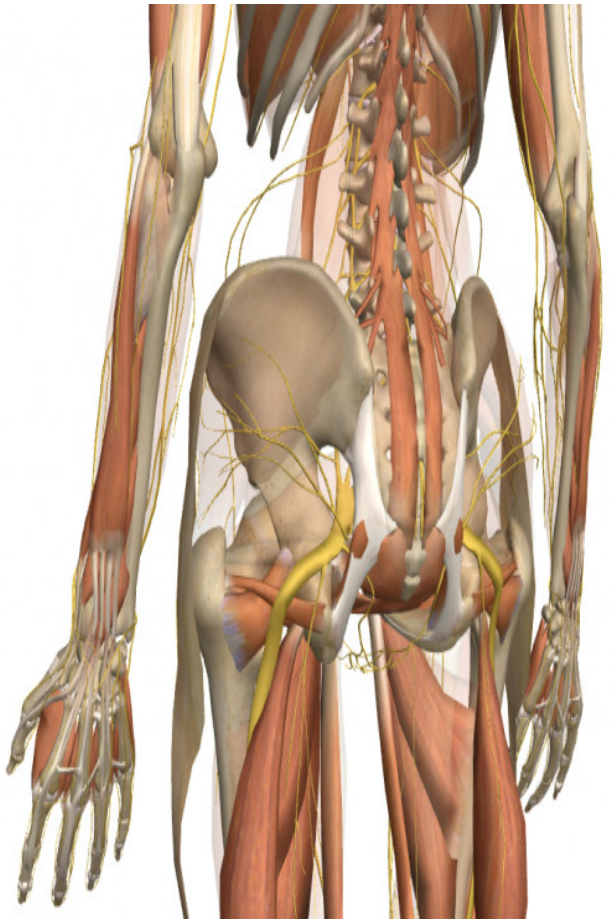
- SIJ bridging (Dar et al.,2006).
- SIJ surface area is greater in males than females (Ebraheim & Biyani, 2003) increased biomechanical loading in males (Vleeming et al.,2012).
- European guideline: PGP (pelvic girdle pain) is specific from LBP (Vleeming et al.,2008).
- Myofacial hypertonicity → biomechanically link characteristics spinal & SIJ lesions observed in ankylosing spondilitis (AS) (Masi et al.,2007; Masi et al.,2011; Vleeming et al.,2012)
- Bony pelvis widens more than 20 mm over the course of a lifetime (Berger et al. 2011).
- Manual therapists (i.e. physical therapist, chiropractors, and osteopaths) various procedures when treating SIJ dysfunction (Mooney, 1997).
- These treatments are based on belief that a small range of movements exists in SIJ (Kapandji, 1987; Sturesson, et al., 1989; Aldernik, 1991; Itoi, 1991; Vleeming, 1992; Oldreive, 1996; Cibulka, 2002).

WHY IS IT THE LEAST UNDERSTOOD JOINT ?

Very difficult to scientifically analyze

Reliable tests need to be :

- 3-dimensional
- multiple titanium spheres into the bones or rigidly fixed external devices
- In vivo- standing, prone, supine, hip movements



Chapter 2: **SACROILIAC JOINTS BIOMECHANICS**

TERMINOLOGY

SIJ dysfunction is defined by :

- Pain in or around the region of SIJ. (Dreyfuss et al.,1994)
- Hypo- or hypermobility. (Dreyfuss, et al., 1994; Tulberg, et al., 1998; Van der Wurff, et al., 2000a; Cibulka, 2002; Riddle and Freburger, 2002).
- From Hippocrates (460-377 BC) till Vesalius (1514-1564),

No movement in SIJ, other than during pregnancy and birth. (Lynch,1920)

- Gynecologists were the first, to be interested in this joint, followed later by orthopedic physicians (Klein & Sommerfeld,2004).

Chapter 2: **SACROILIAC JOINTS BIOMECHANICS**

AGE YEARS	**SIJ**
0-20	Smooth gliding planes
20-50	Interlocking irregularities
>50	Hypomobility
>80	Osteophytic, Immobile

SACROILIAC JOINT STRUCTURE

- ***Diarthrodial joint*** with two bony surfaces, sacrum and ilium 1-2 mm wide.

- ***Joint surfaces*** are lined with hyaline cartilage, and the iliac cartilage seems thinner and more fibrocartilaginous than that of sacrum side.

- ***Superior third*** of hyaline iliac cartilage is strongly attached to surrounding stabilizing ligaments, forming wide margins of fibrocartilage.

- ***Inferior third*** of the joint along iliac bone has some histologic characteristics of a ***"synovial joint".***

(Puhakka et al., 2004)

ARTICULAR SURFACES AND FUNCTIONAL ANATOMY

- Hyaline cartilage on sacral side moves against fibrocartilage on iliac side (Bowen & Cassidy, 1981).
- Numerous ridges and depressions indicating its function for stability more than motion (Schwarzer, 1995a; Hungerford et al., 2003).
- SIJ articular surfaces not smooth but have interdigitating symmetrical grooves and ridges (Solonen, 1957; Vleeming, 1990; Vleeming et al., 1990a, 1990b).
- SIJs act as important stress-relievers in “force-motion” relationships between trunk and lower limb (Snijders et al., 1993a, 1993b; Vleeming et al., 1997; Lee, 2007).

THE LIGAMENTS

- Strong passive, viscoelastic ligamentous system (McGill, 1992). Surrounded by an extensive network of ligaments and fascias.
- The primary function of this ligamentous system is to bolster stability while allowing for adequate range of motion in multiple planes of movement. (Mitchell,1995)
- **The ligaments include:**

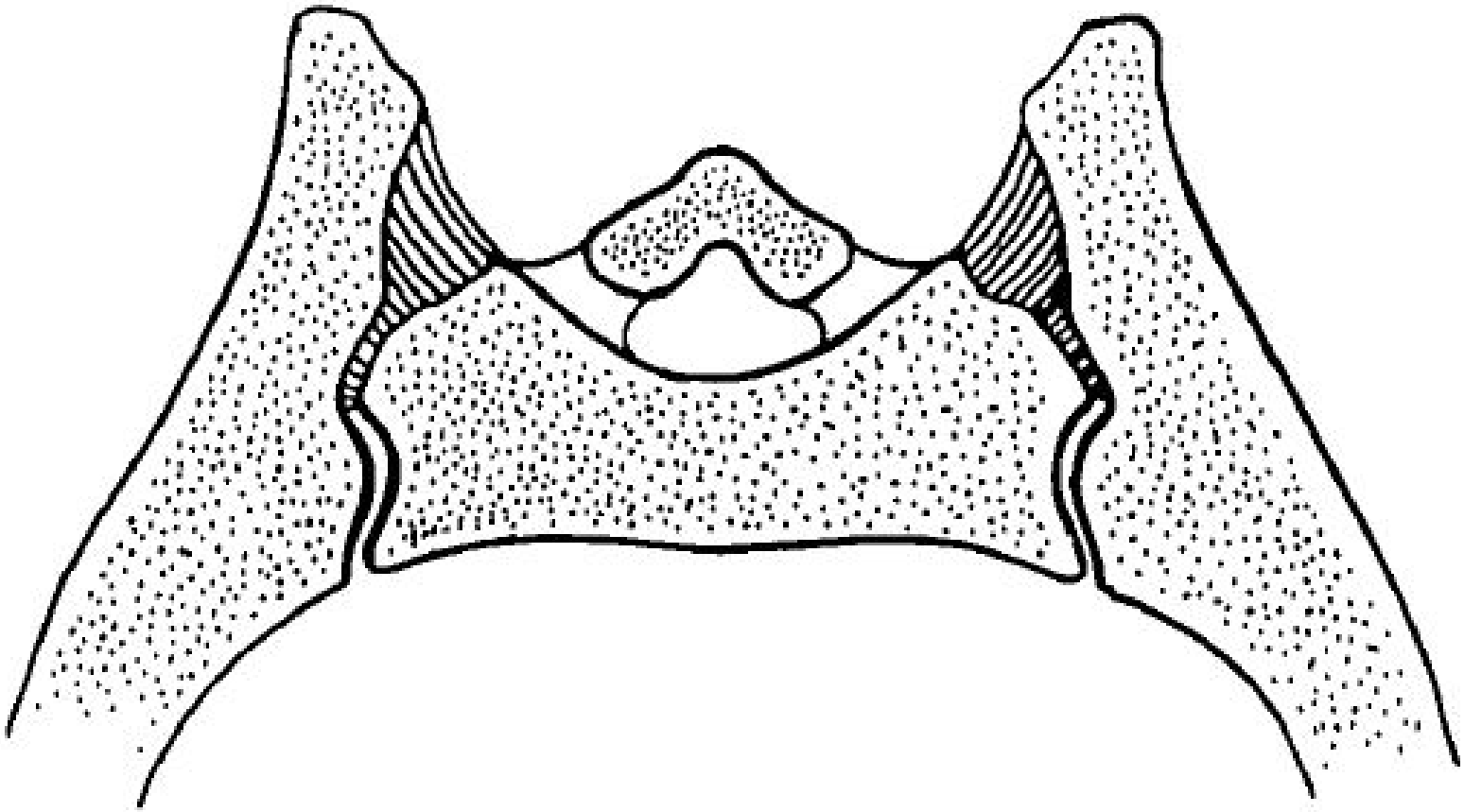
THE LIGAMENTS

Articulation of pelvis, Anterior view of sacroiliac ligament

(Gray, 1918)

THE LIGAMENTS

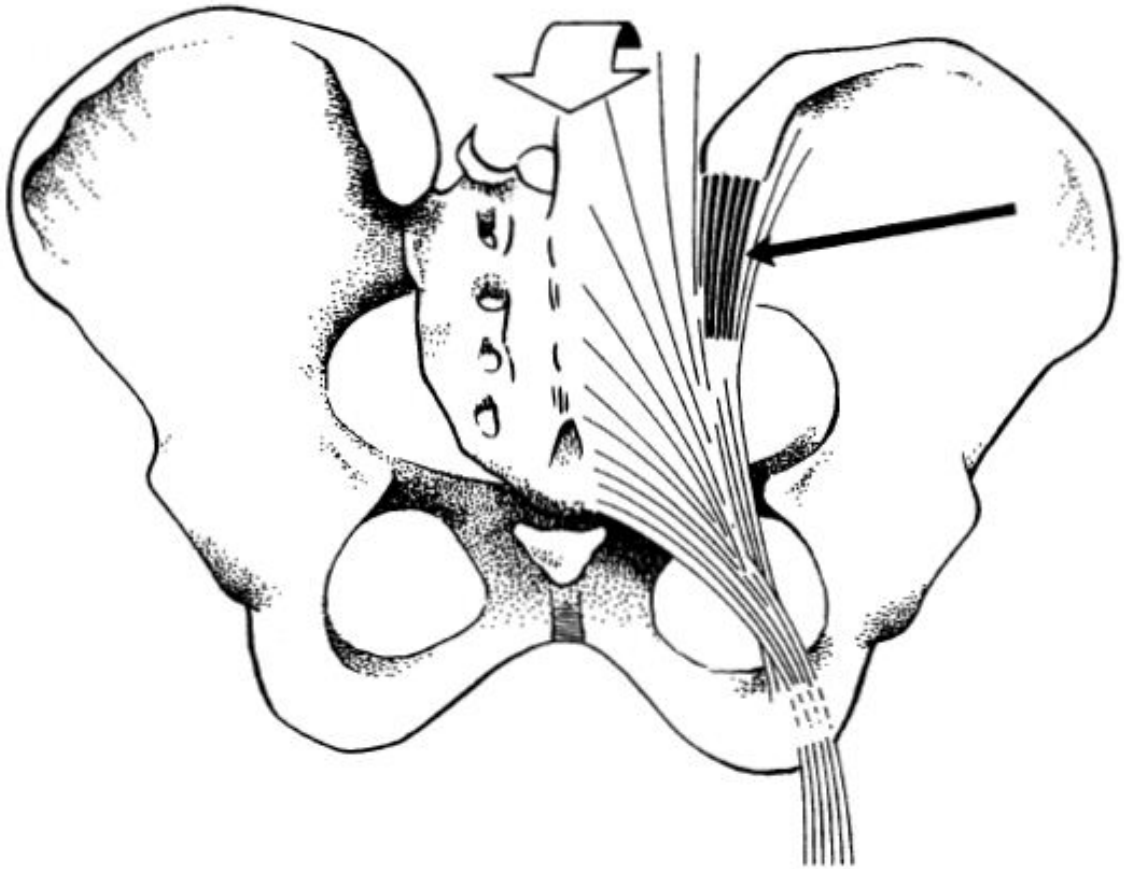
Interosseous ligament (Harrison et al., 1997)



THE LIGAMENTS

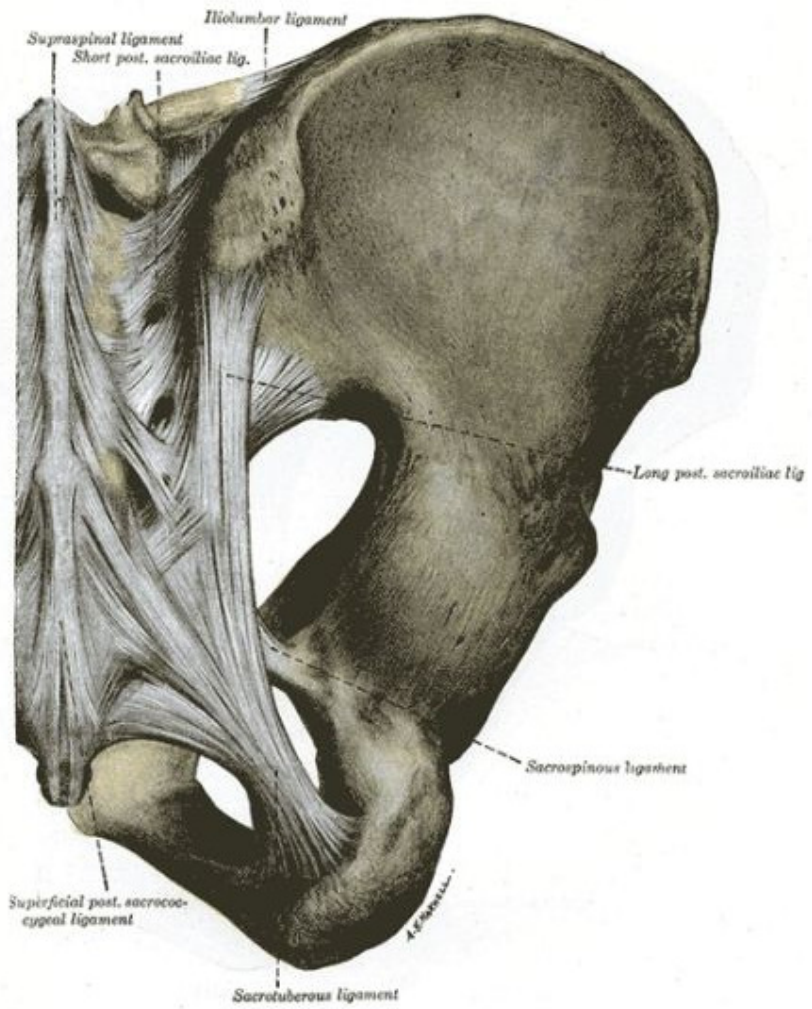
The long dorsal sacroiliac ligament

(Vleeming, A., Pool-Goudzwaard, A.L., Hammudoghlu, 1996)



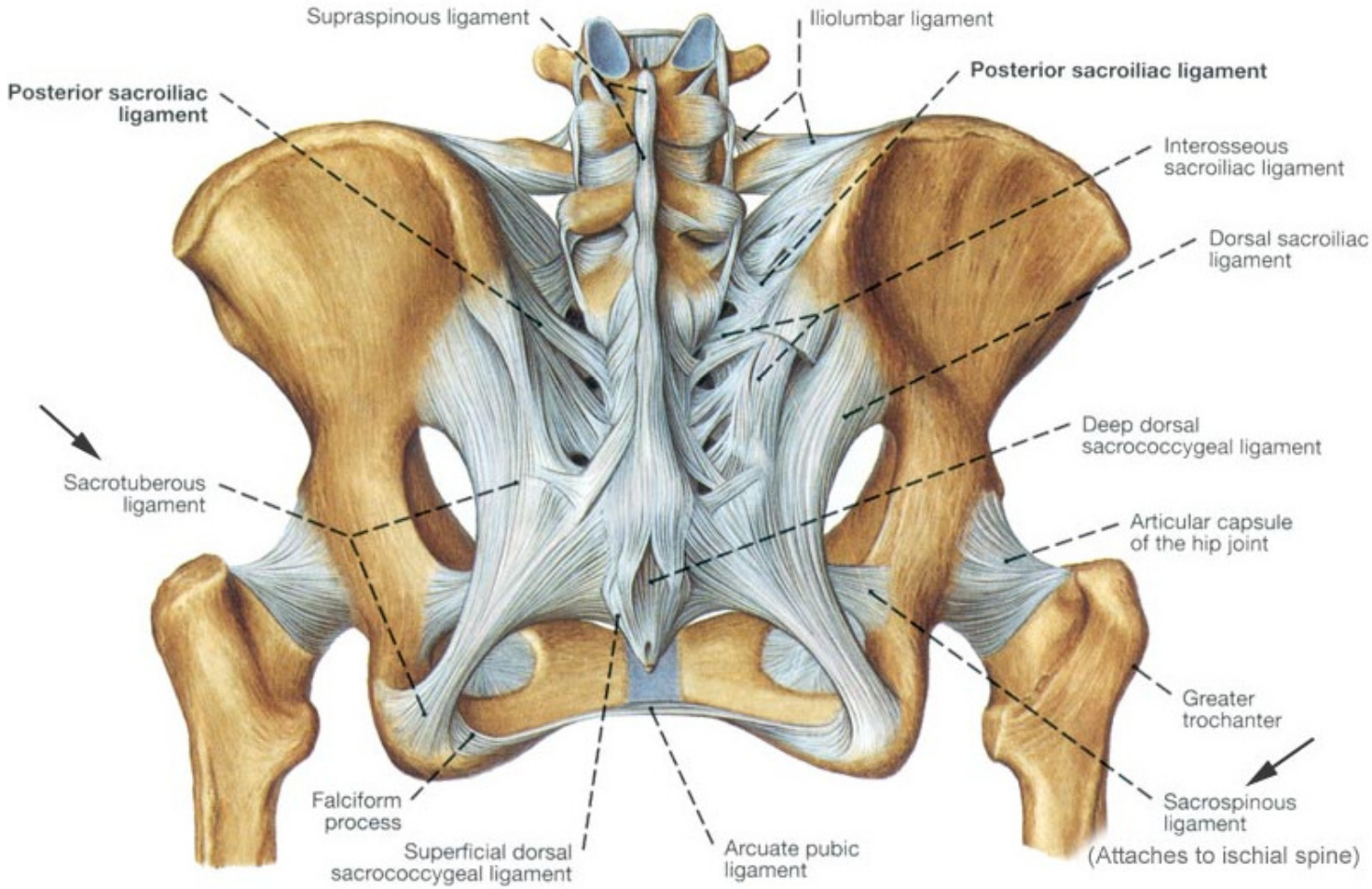
THE LIGAMENTS

Articulation of pelvis. Posterior view (Gray, 1918)



THE LIGAMENTS

Pelvis and Ligaments, Rear View, Female (edoctoronline.com)

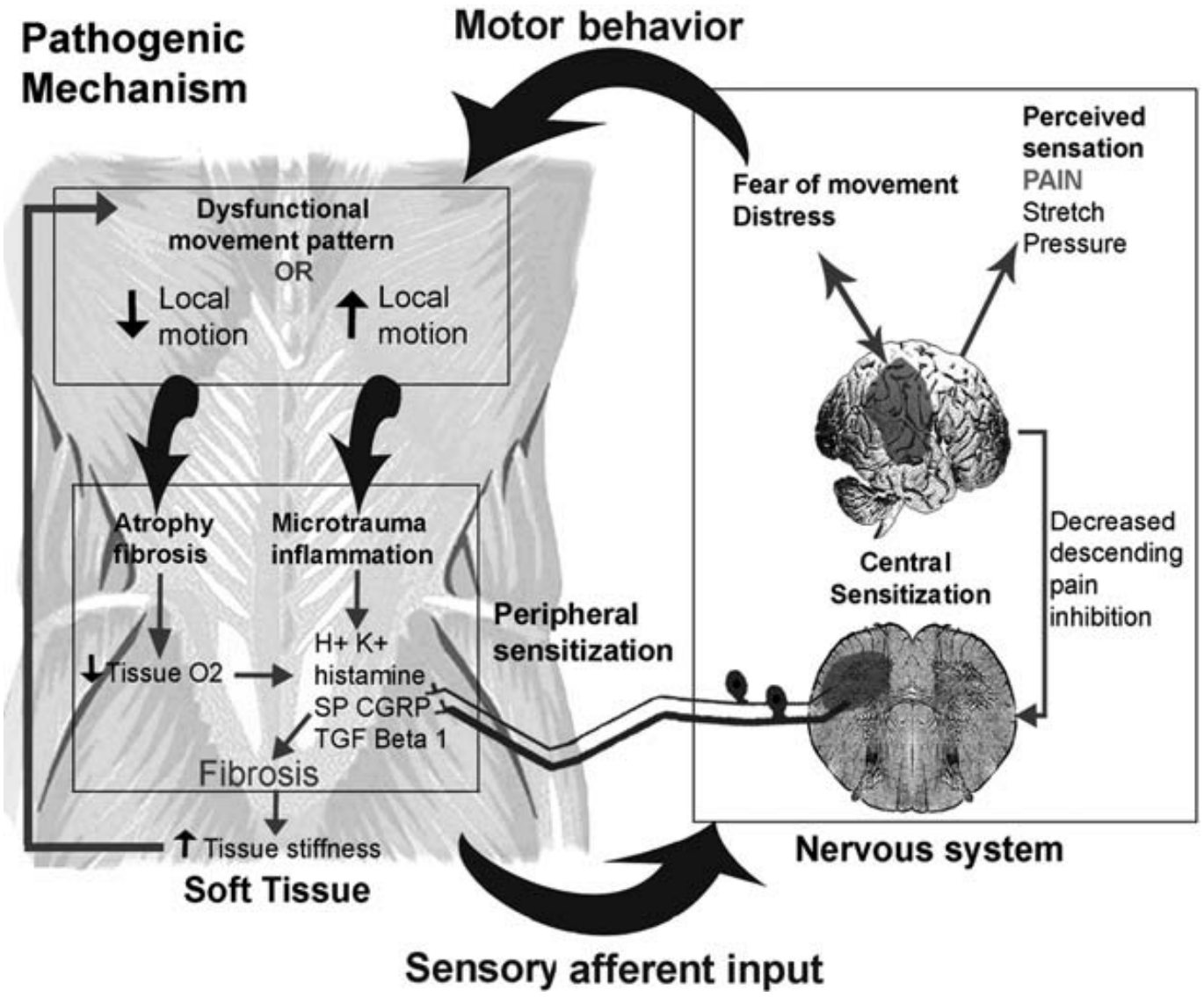


SENSORY-MOTOR CONTROL AND BIOMECHANICAL ASPECTS OF LIGAMENTS, AS MAY BE CONTRIBUTORY TO NEUROMUSCULAR DISORDERS (SOLOMONOW, 2006)

A project of 25 years presents the following 8 hypothesis:

1. **Ligaments** (Ligt) **major sensory organs**, kinesthetic and proprioceptive data.
2. **Excitatory & inhibitory reflex arcs, recruit/de-recruit:** Joint Stability.
3. **Synergy of Ligt:** Joint Stability.
4. **Viscoelastic elastic properties** & **classical responses,** decreases effectiveness as joint & exposes the **joint to injury**.
5. **Long-term exposure to static or cyclic loads/movements**.
6. **Continued exposure to static or cyclic load:** chronic inflammation & chronic neuromuscular disorder; **cumulative trauma disorder**.
7. Knowledge: **basic & applied research** on the senory-motor function of ligts as infrastructure for translational research.
8. Knowledge: **basic & applied research** → new therapeutics modalities.

BROADER MODEL OF CARE



(Langevin & Sherman, 2006)

MAJOR MUSCLE GROUPS ASSOCIATED WITH LUMBOSACRAL LIGAMENTOUS STRUCTURES

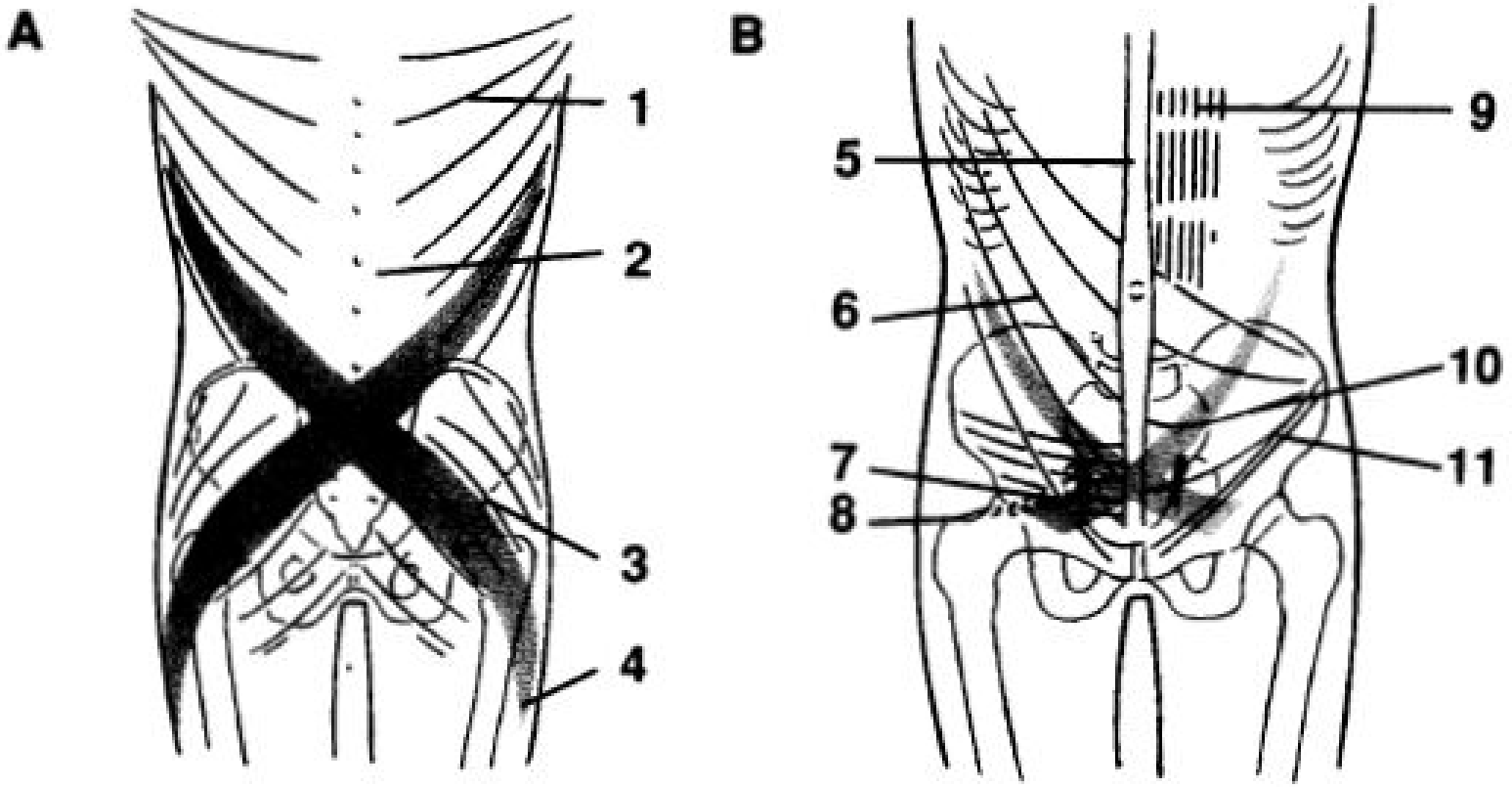
- **35 muscles** attach directly to the sacrum and/or innominate (Lee, 2007).
- **Five Major muscle groups** associated with the lumbosacral structures:

1) **MULTIFIDUS** divided in 5 bands (Macintosh,Valencia, Bogduk & Munro,1986).
2) **LATISSIMUS DORSI** (Willard,2007).
3) **GLUTEUS MAXIMUS** (Willard, 2007; Vleeming et al,1995b).
4) **BICEPS FEMORIS** (long Head) (Ericson, Nisell,& Ekholm, 1986; Vleeming et al.,1989a).
5) **PIRIFORMIS** (Vleeming et al.,1989a).

MUSCLE SLINGS OF THE LUMBOPELVIC REGION

A. Posterior oblique Sling (Vleeming et al., 1993; Vleeming, 1995b)

B. Anterior oblique Sling (Snijders et al., 1993b; Vleeming 1995b)

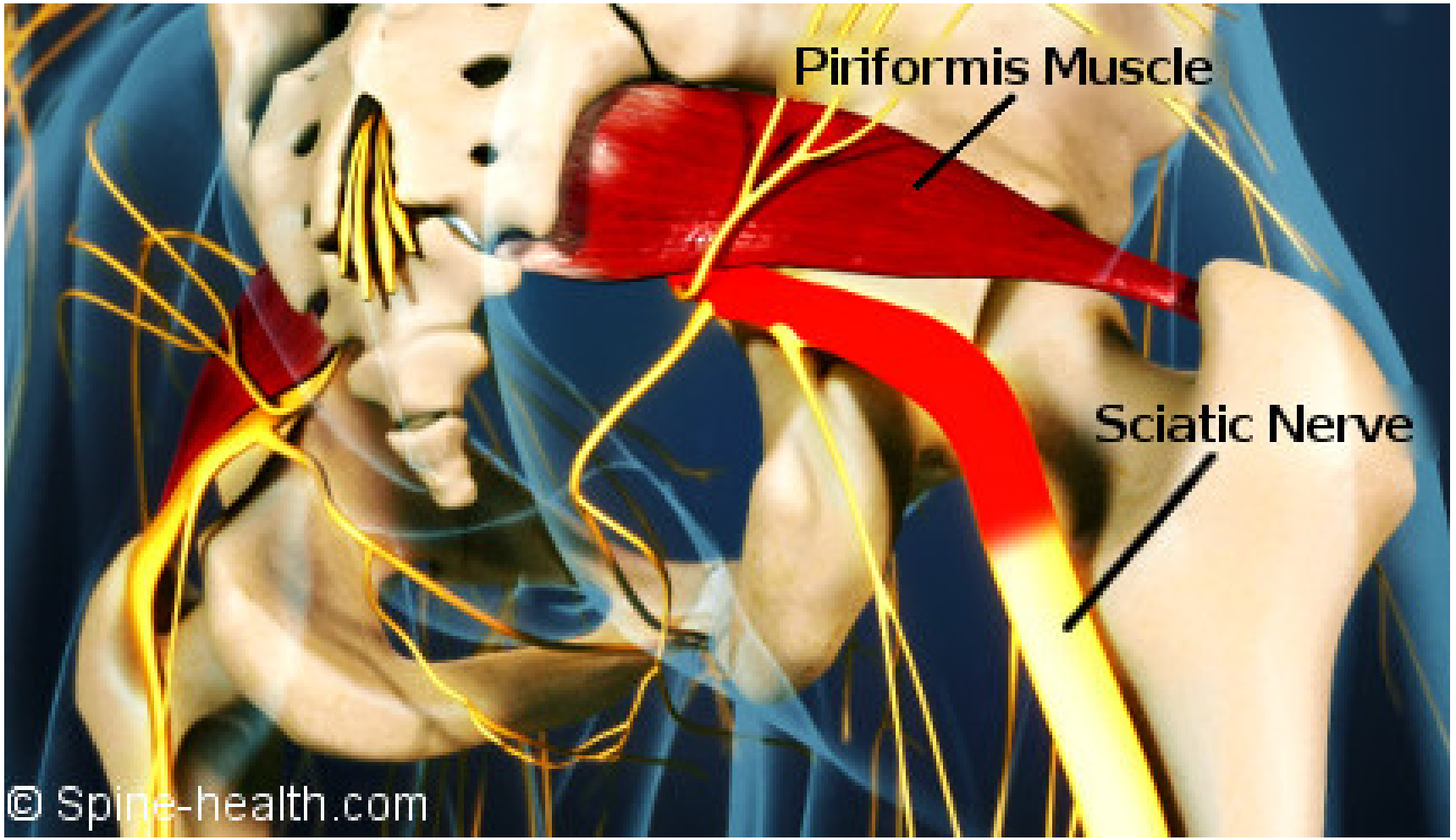


INNERVATIONS

- Solonen (1957) SIJ innervated by L4-S1.
- Bradley (1985) supply from dorsal rami L5, S1, S2 and S3.
- Ikeda (1991) supply by fifth lumbar nerve.
- Grob et al. (1995) exclusively innervated by S1-S4 dorsal rami.
- Willard et al. (1998) dorsal sacral plexus (S1-S3).
- Various studies demonstrated the close relationships between SIJ capsule and adjacent neural structures (Fortin et al., 1999b; Atlihan et al., 2000).

→ **COMPLEXITY OF SIJ INNERVATIONS !!!**

SACROILIAC JOINTS NERVES PIRIFORMIS

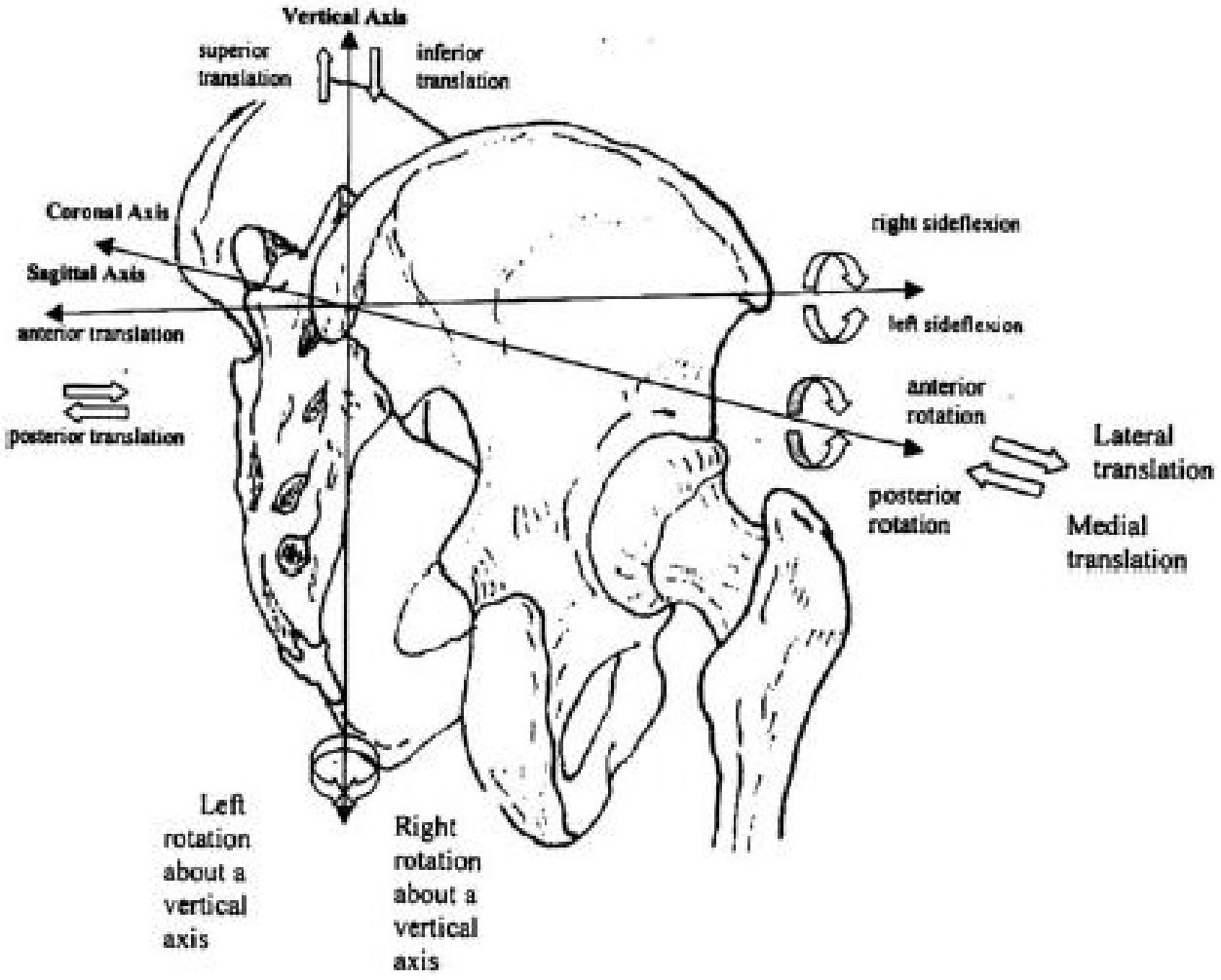


SACROILIAC JOINT BIOMECHANICS

Definitions of Movement Axis and Mobility

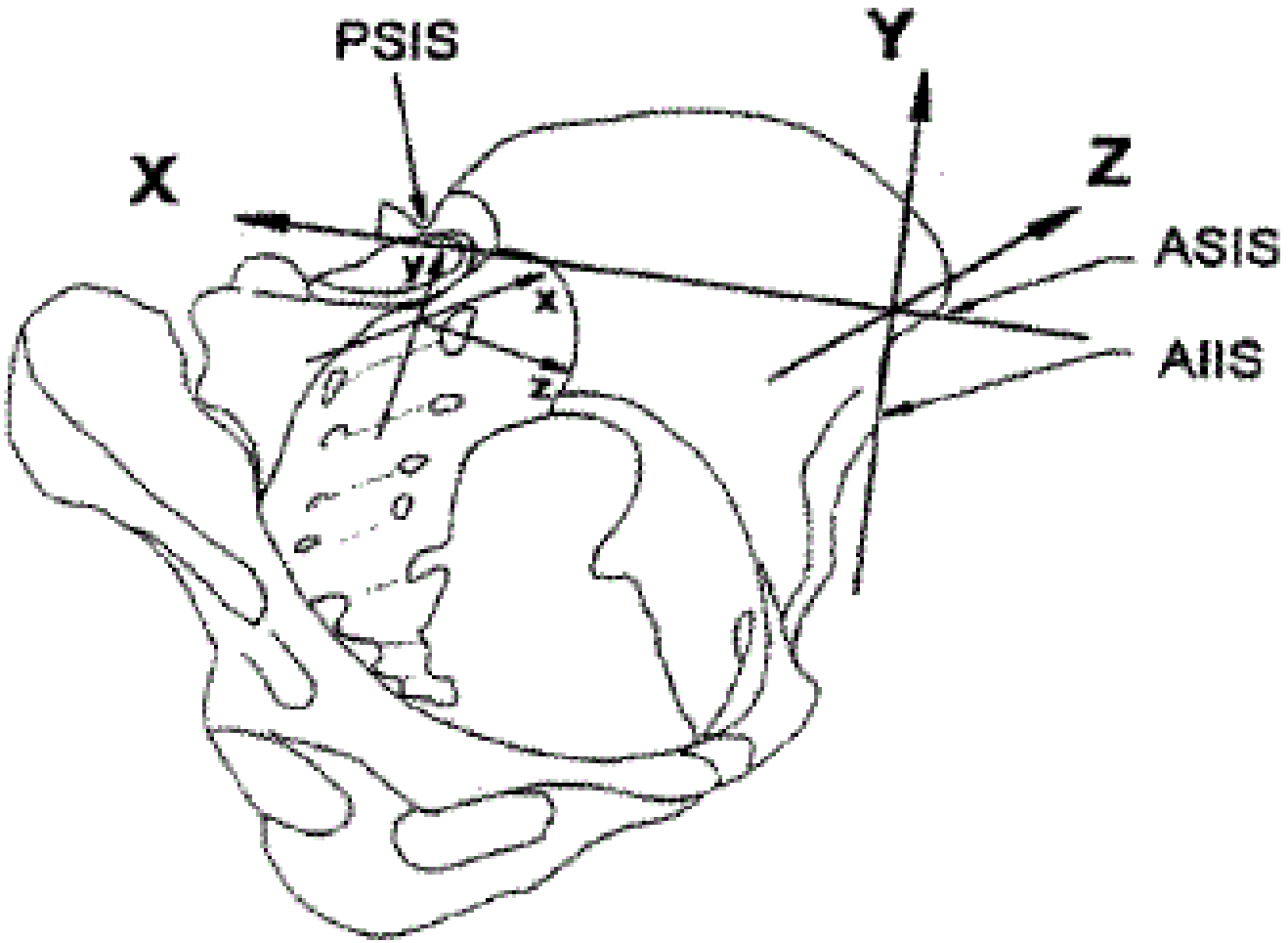
- SIJ designed primarily for stability (Dreyfuss, 2004).
- Rotating and translating along three axes (Smidt et al., 1995).
- Motion about X, Y and Z axes (Egund et al., 1978; Sturesson et al., 2000a, 2000b; Bussey et al., 2004; Hungerford et al., 2004).
- These axes constitute a Cartesian coordinate system & used by investigators to account for the 3-D Sacral motion at SIJ in reference to a fixed pelvis with occasional alterations of X and Z axes (Egund et al., 1978; Miller et al., 1987; Sturesson et al.,1989; Smidt et al., 1995; Sturesson et al., 1999; Sturesson et al., 2000a, 2000b; Bussey et al., 2004; Hungerford et al., 2004

SACROILIAC JOINT BIOMECHANICS



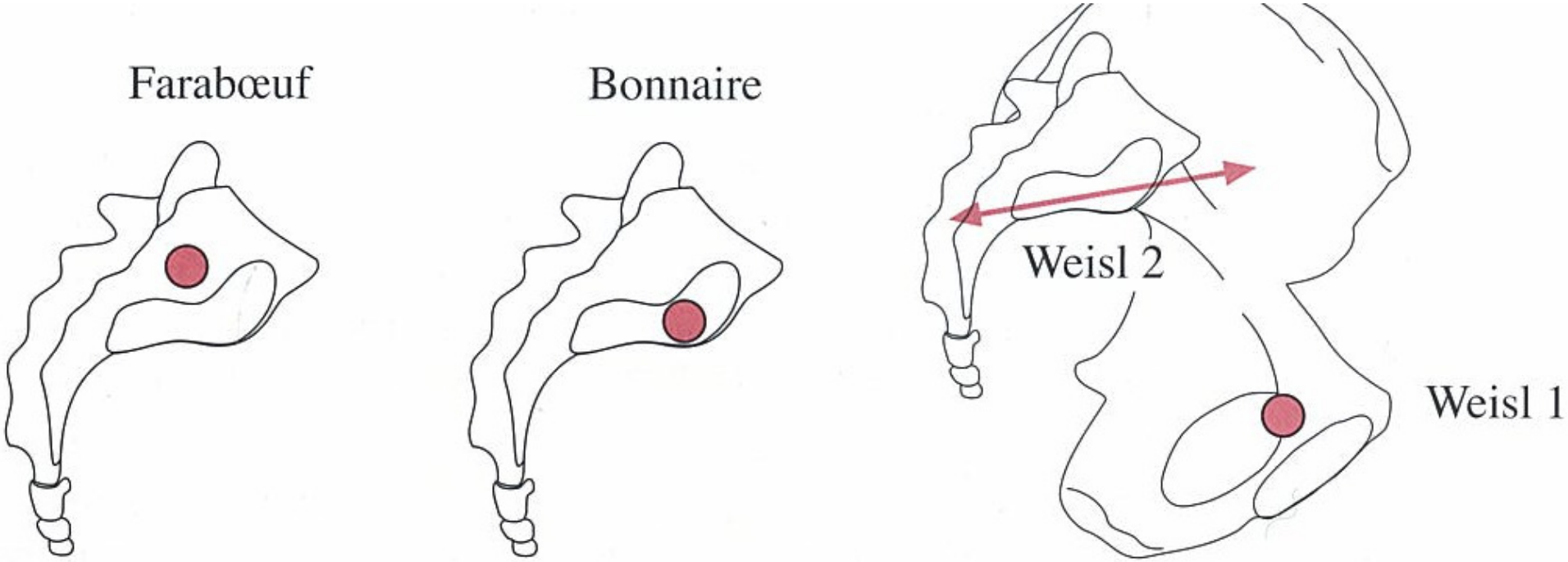
Three axes for angular and translational motion of innominate relative to the sacral segment (Hungerford et al., 2004)

SACROILIAC JOINT BIOMECHANICS



(Wang & Dumas, 1998)

SACROILIAC JOINT BIOMECHANICS



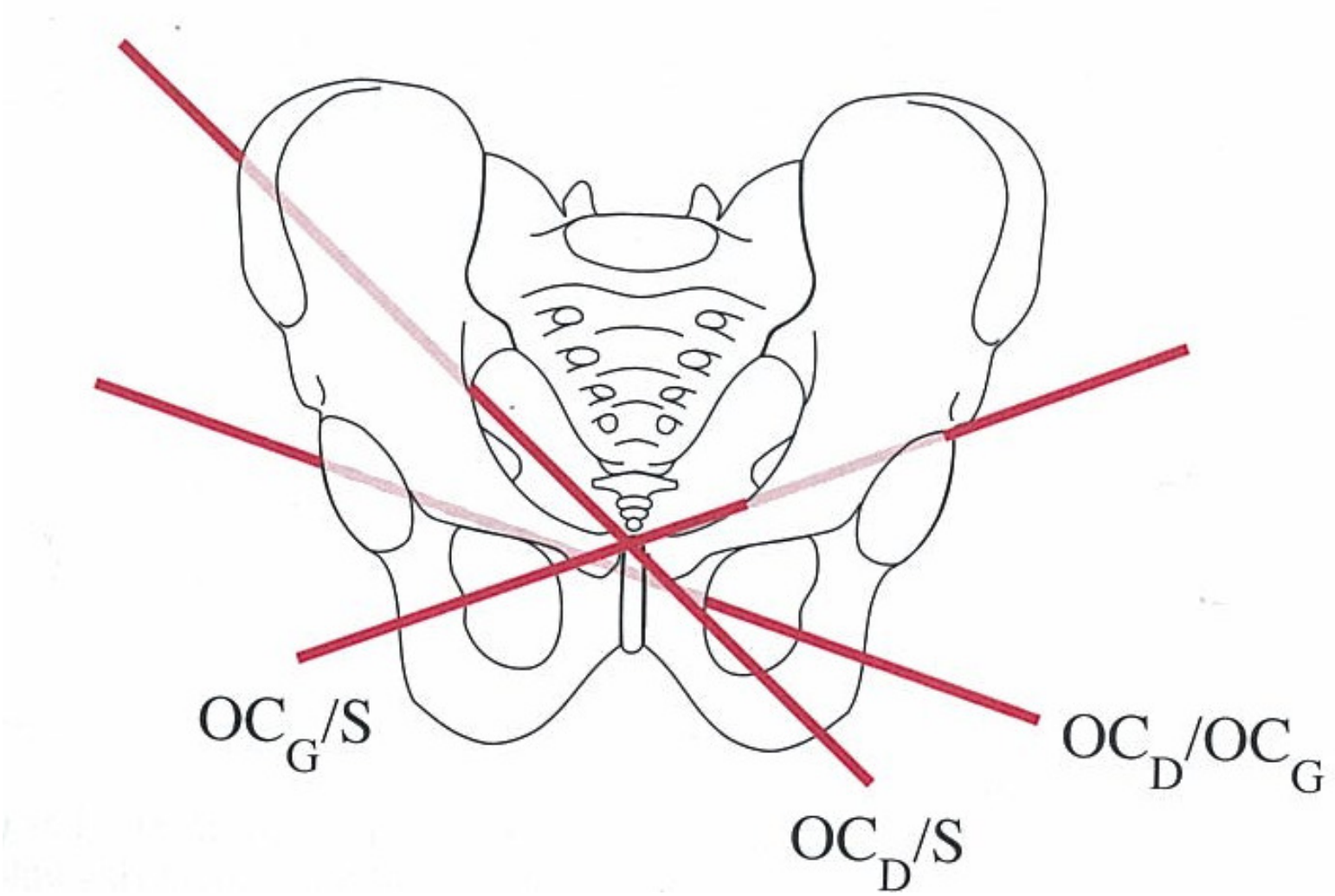
Centers of rotation from SIJ in the conventional models (Klein & Sommerfeld, 2004)

SACROILIAC JOINT BIOMECHANICS

Recent Models

- Colachis et al. (1963) **inserted Kirchner** wires PSIS:**5mm of translation**.
- Egund et al. (1978) used **RSA:** max. rot. & translations 2.0° & 2 mm. Axis of nutation: **iliac tuberosities**.
- Lavignolle et al. (1983) **tridimensional oblique axis**.
- Miller et al. (1987) studied **load-displacement behavior of single and paired SIJ;** one leg immobile: movements in all planes ranged 2 to 7.8 times more than those measured with both legs fixed.
- Sturesson et al. (1989,2000a, 2000b) RSA, **no difference** between symptomatic and asymptomatic joints.

SACROILIAC JOINT BIOMECHANICS



(Lavignolle et al., 1983)

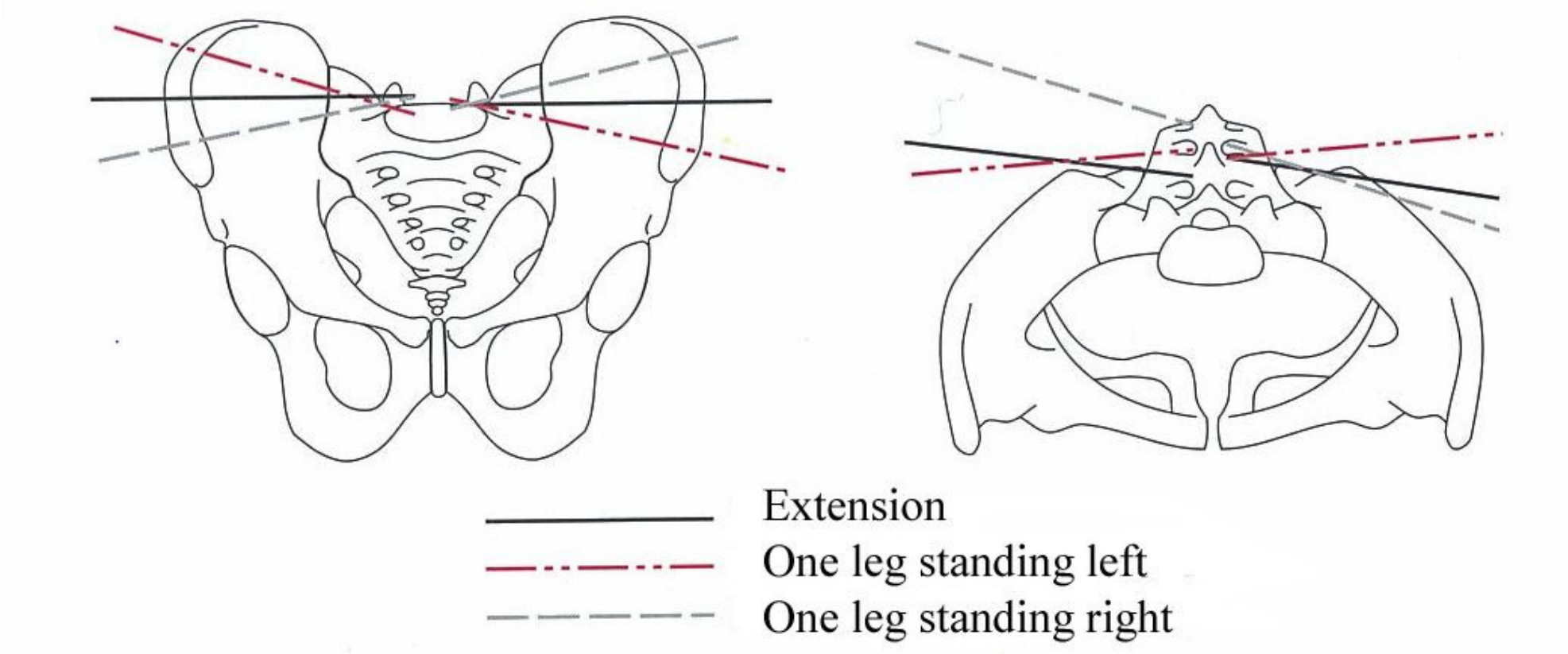
SACROILIAC JOINT BIOMECHANICS

- Jacob and Kissling (1995) Kirchner wires into iliac bones & sacrum, used RSA to investigate mobility of SIJ. They measured motion amplitude a **helical axis** with **three rotation** components.

- Smidt et al. (1995) SIJ & Pelvic in neutral and straddle position. iliac position not always fit the expected movement in function of the hip joint position.

- Bussey et al.(2004) RSA to investigate SIJ motion in prone position with knees in flexion.

SACROILIAC JOINT BIOMECHANICS



Localization and orientation of helical (Jacob & Kissling,1995)

SACROILIAC JOINT BIOMECHANICS

Summary of Recent SIJ Biomechanics Findings

- Range of motion 2 to 4 degrees.
- No significant differences women & men.
- Tulberg et al. (1998) RSA, no difference before and after manipulation.
- All studies detected **Helical oblique axis** indicating the existence of a three dimensional movement in SIJ.
- **Major movement component Sagittal plane**. (Klein & Sommerfeld,2004)
- No common axis exists for both joints. (Klein & Sommerfeld,2004)

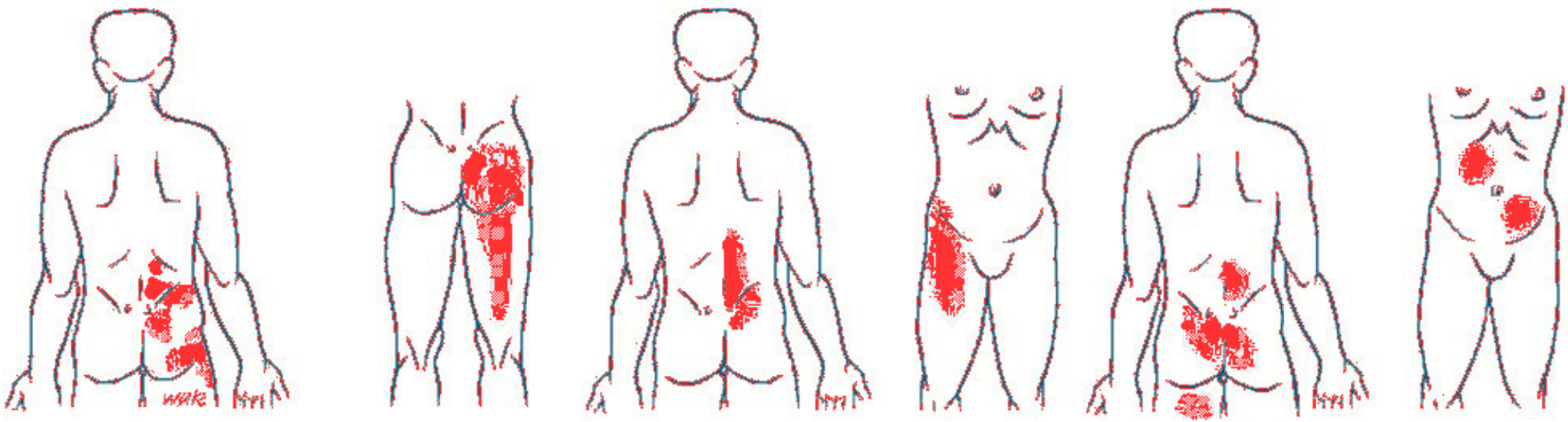
SACROILIAC JOINT BIOMECHANICS

Limited Movements of the SIJ

- **Multifidus muscle** (MacIntosh & Bogduk, 1991): limiting nutation (anterior flexion of sacrum)

- **Transfer load through pelvis depends** (Hungerford, 2004):
  - **Optimal function of bones, joints and ligaments** (Vleeming et al, 1989b, 1990);
  - **Optimal function of muscles and fascia** (Hungerford et al., 2003; Richardson et al., 2002; Snijders et al., 1998; Vleeming et al., 1995a, 1995b);
  - **Appropriate neural function** (Hodges & Richardson, 1997; Hungerford et al., 2003).

Chapter 3: **SACROILIAC JOINTS PAIN PATTERNS**



A B C D

Myotomal pain referral regions from muscle trigger points:

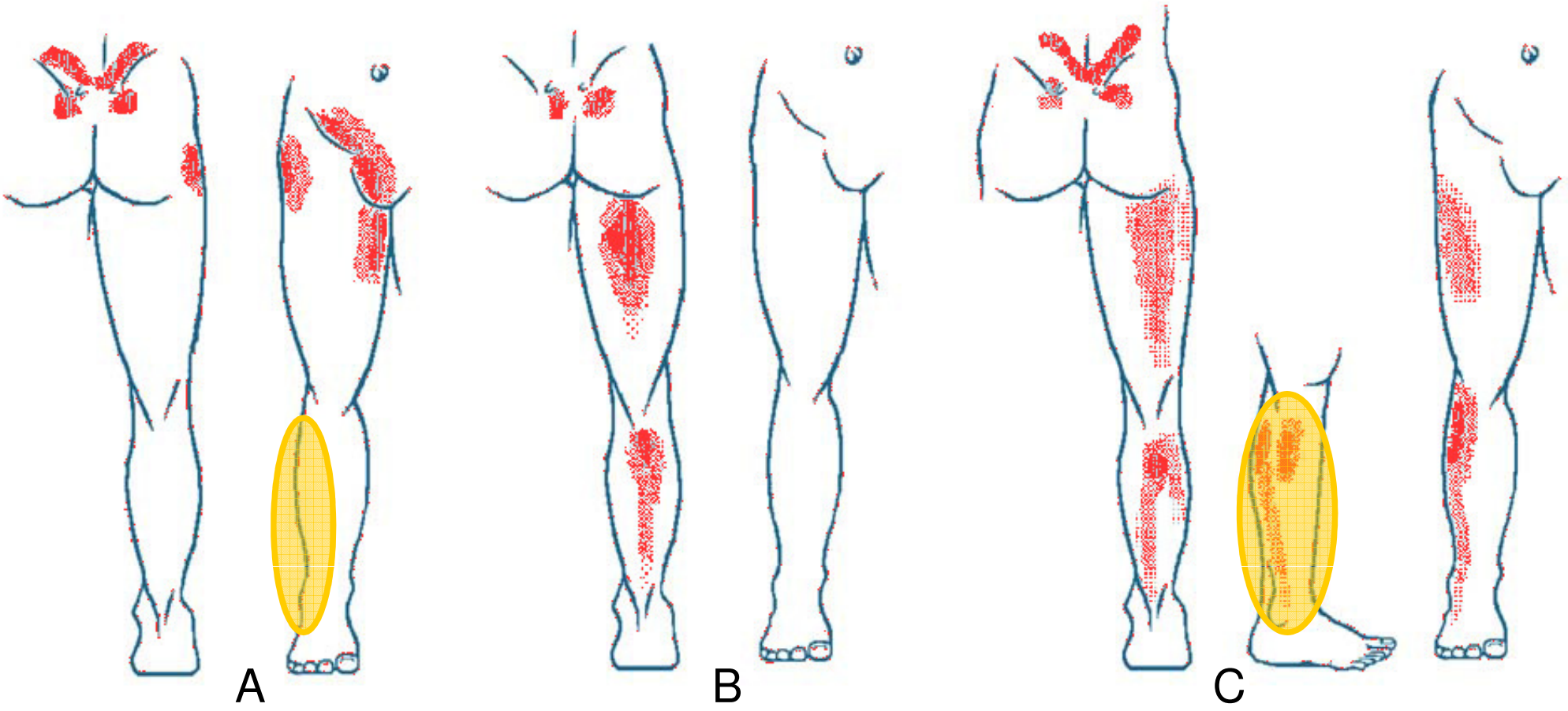
(A) quadratus lumborom.

(B) piriformis.

(C) iliopsoas.

(D) rotatores and multifidis muscles.

(Kuchera,2007, Journal of American Osteopathic Association, ES31, Suppl6, 107, 11)

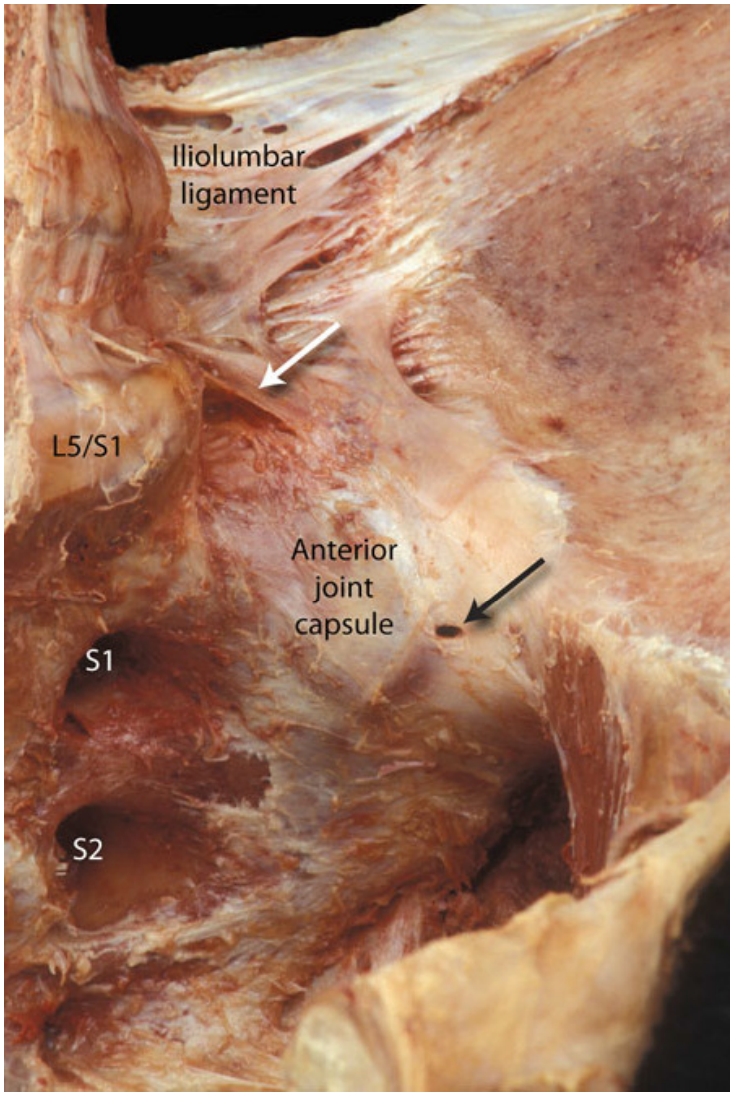


Sclerotomal pain referral regions from ligaments:

(A) iliolumbar ligament, according to my experience
(B) sacrospinous and sacrotuberous ligaments.
(C) posterior sacroiliac ligament.

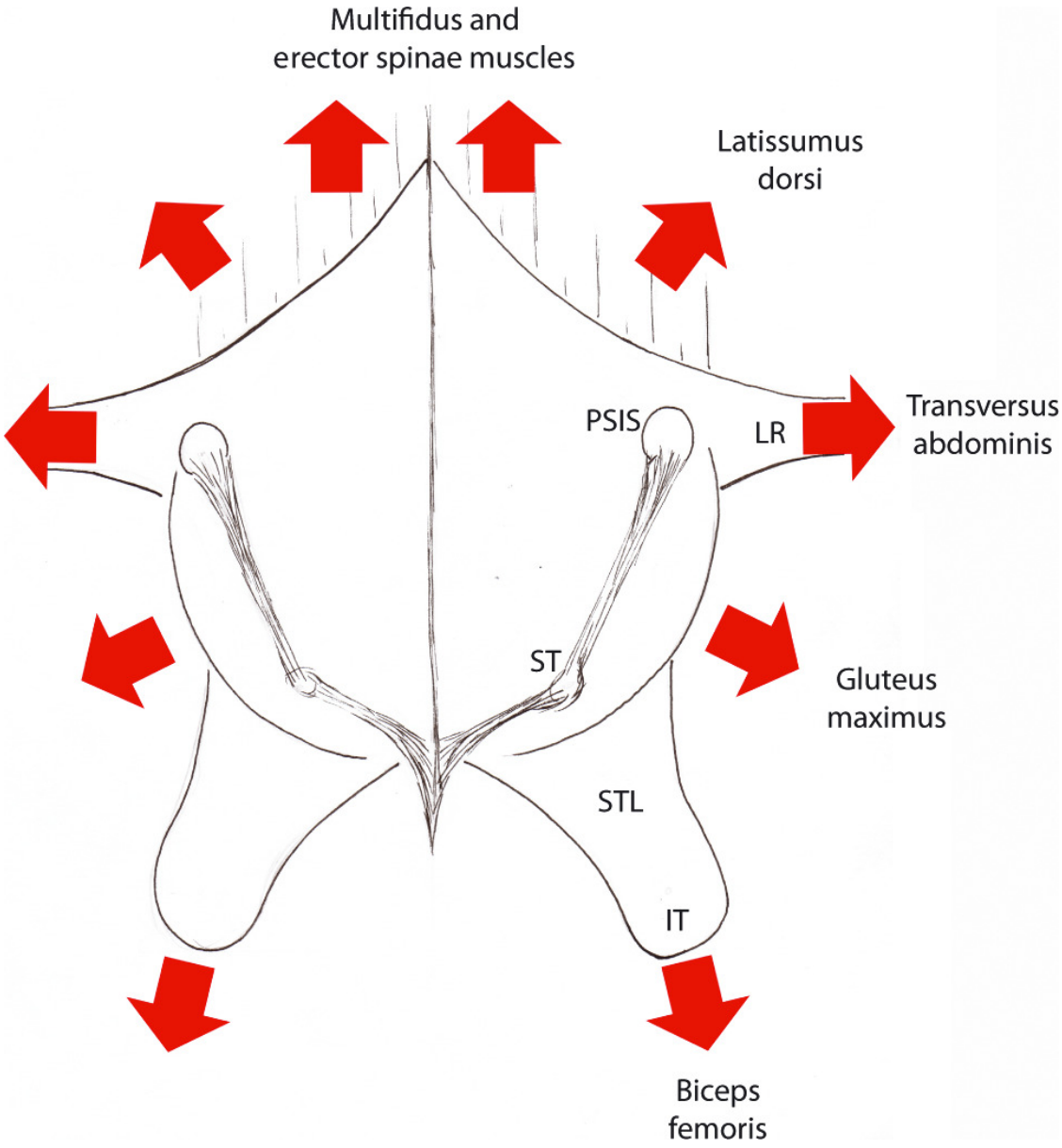
(Kuchera,2007, Journal of American Osteopathic Association, ES31, Suppl6,107,11)

VARIATION IN THE LUMBOSACRAL LIGAMENT



(Briggs & Chandraraj,Clin Ana.,1995)

Chapter 4: **POTENTIAL CLINICAL IMPLICATIONS**



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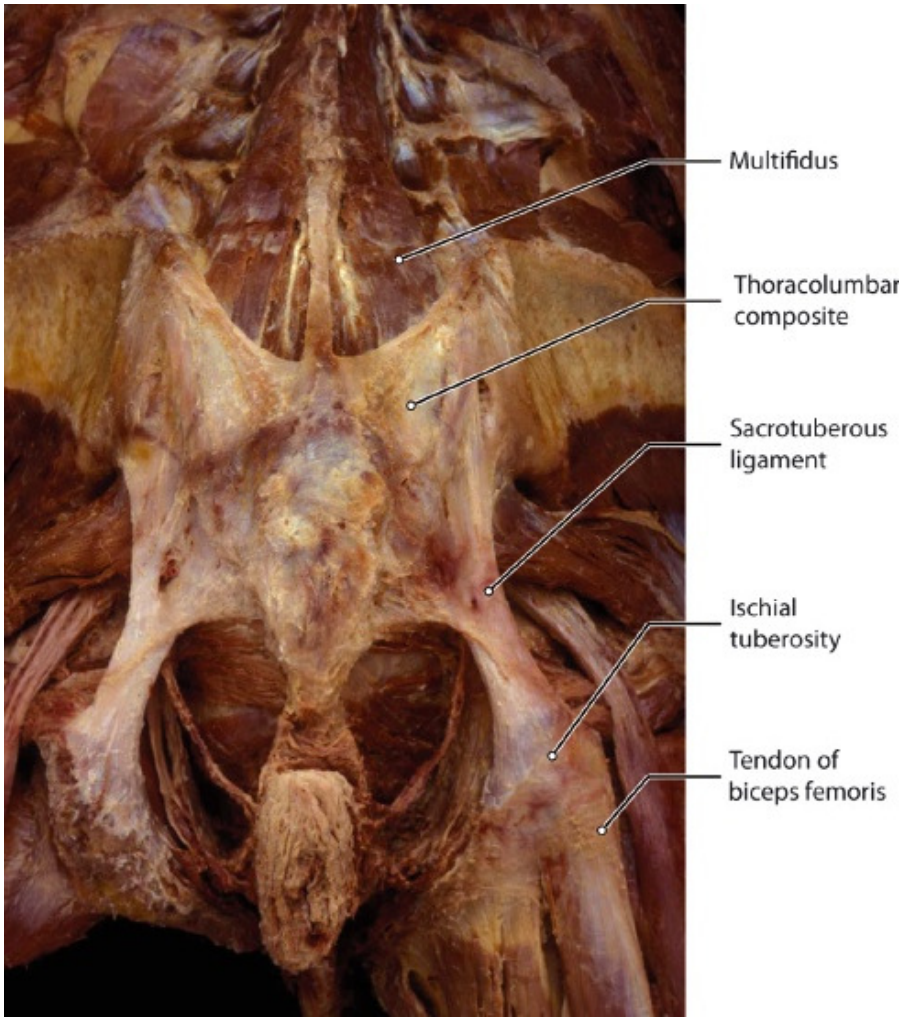


(Varga et al.,Injury,2008)

POTENTIAL CLINICAL IMPLICATIONS

- Differential diagnosis in SIJ pain: pain generated in SIJ or surrounding structures can present as low back pain, leg pain, sacral pain, pelvic pain, or gluteal pain.(Norman, 1968).
- New aspects for SIJ pain treatment have to be taken in consideration as well as biomechanics of SIJ.
- Clinical manual movement tests unreliable for SIJ (Vleeming et al., 2008)
- Recent research reveals that the pelvis does not stop expanding after skeletal maturation and cessation of longitudinal growth, this is thought to be adaptive response to compensate for loss of strength produced by endocortical bone loss (Berger et al. 2011).
- Altered motor function of the deep abdominal muscles in patients with PGP leads to insufficient bracing of the pelvis (Vleeming et al.,2012).
- Chronic spinal overloading:(Masi et al., 2007; Francois et al., 2000; Masi et al., 2011; Vleeming et al., 2012)
    - ➔ SIJ micro-damage & repair pathways
    - ➔ Synovitis, erosions & later stages enchondral ankylosing

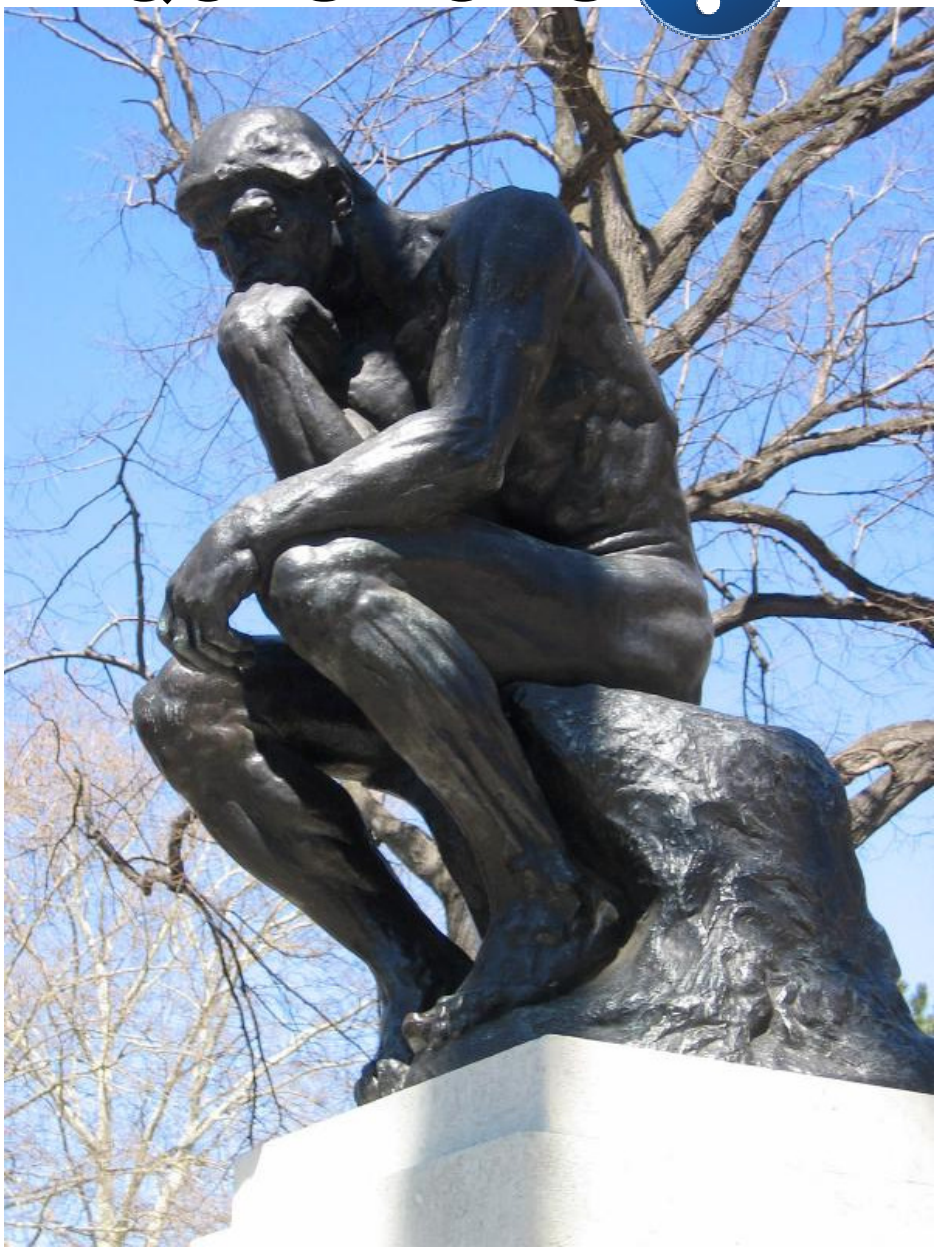
➔ **IMPORTANCE OF PRACTICING A SPORT ACTIVITY!!!!**

POTENTIAL CLINICAL IMPLICATIONS

According to McGrath (2010):

- ***First,*** where is the pain generator in the absence of discernible pathology ?
- ***Second,*** do SIJ pain provocation tests achieve what they purport to achieve ?
- ***Third,*** do physical tests stress the joint to the exclusion of all other potential generators ?
- ***Fourth,*** are all pain generators in the region identified ?
- ***Fifth,*** is intra-articular injection an effective 'gold standard' for the elimination of putative SIJ pain ?

QUESTIONS



Thank you for your attention