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FUNCTIONAL ANATOMY – CORE SLINGS

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The muscles of the core form the base from which are movement forces are generated. Kibler et al. (2006) describe the core as the musculature of the trunk and pelvis that are responsible for the maintenance of stability of the spine and pelvis, this musculature also transfers energy from proximal (core) to distal (limbs) in motor patterns required for sport and activity.

For the purposes of this workshop, the science and application of movement and the alignment of the rehabilitative and fitness industries, anatomically, the core's **mobility** is created by a series of kinetic chains or myofascial slings. Core **stability i**n this article is defined as "the ability to control the position and motion of the trunk over the pelvis to allow optimum production, transfer and control of force and motion to the terminal segment in integrated athletic activities." (Kibler et al, 2006, p. 189) Core stability is needed for all activities, from sitting at the computer to kicking a soccer ball.

Movements, anatomy, muscular coordination & function of the core units

In addition to extension (back bending) and flexion (fwd bending) of the spine, the core is designed to maintain the **stability &** create **mobility** required to generate the functional movements push, pull, stride, squat, lunge, chop, lift, & bend with multiple speeds and directions. The core has two major neuromuscular activation patterns *1) preACTivation and 2) sequential firing.* Together they are referred to as the '*set - fire sequences'***.**

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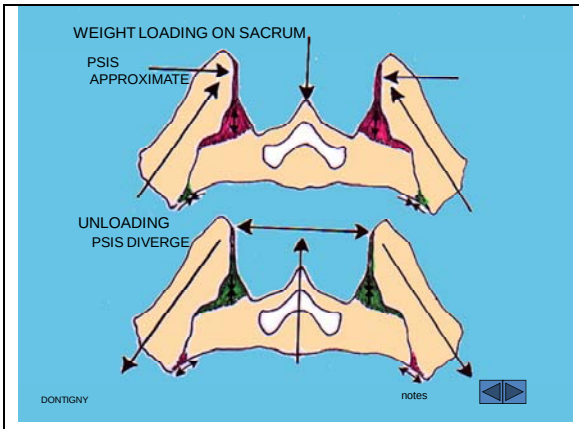

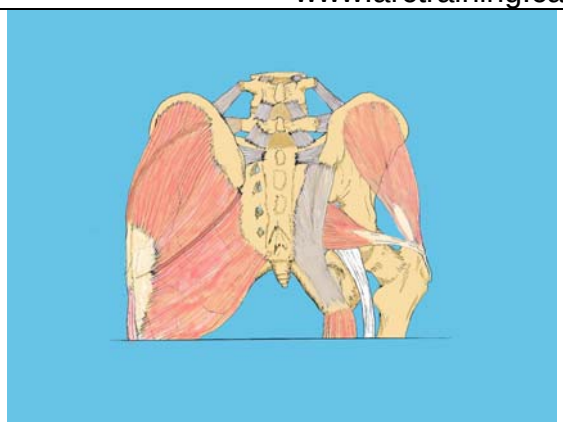

- *Setting / PreACTivation* of the deep inner unit including TA, Multifidus, pelvic diaphragm, & thoracoabdominal diaphragm to stabilize the spine and pelvis 30-110 ms prior to movement or change of force (Richardson,Jull, Hodges & Hides 1999). This setting to increase IAP before initiation of large segment movement of the extremities is quite small for the larger gain of movement. There is only a small amount of activation needed in the multifidi and abdominal muscles to stiffen the spinal segments, "5% of MVC for daily living and 10% MVC for rigorous activity" Kibler et al., 2006, p. 190.
- *Firing / Activation* of core mobilizers, like the obliques, rectus, erectors, QL's etc to create and dissipate movement (Celebrini & Mckechnie, 2004).

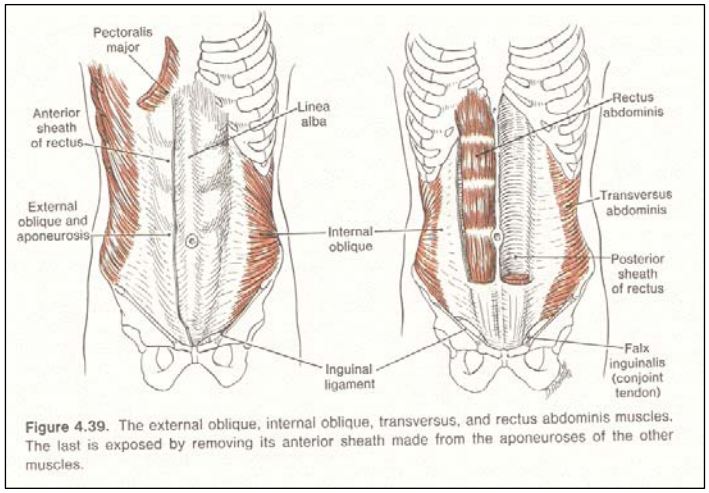

Figure 4.39. The external oblique, internal oblique, transversus, and rectus abdominis muscles. The last is exposed by removing its anterior sheath made from the aponeuroses of the other muscles.

Palpate the inguinal ligament to determine if the deep muscles are setting, prior to firing.

-place your hands on your over top your iliac crest, then wrap your index finger around the front of your ASIS

-when 'setting' the inguinal ligament will gently pressure into your finger tips.

-'firing' the abs will cause the internal obliques to 'pop out' or bulge.

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These set fire sequences are key connection needed to create power in movement. For example, in baseball throwing, there is an anticipatory 'setting', followed by sequential 'firing' of the external oblique prior to the arm muscles (Hirashima et al., 2002). In fact, force generated for any throwing activity is generated through the core, translated to the upper limb via the thoracolumbar fascia. Studies have shown that "a decrease in 20% of kinetic energy developed by the core resulted in a requirement of 80% more shoulder mass to deliver the same energy to the ball in a tennis serve." (Kibler et al., 2006, p.194)

Inner Unit Anatomy & Function

Thoracoabdominal Diaphragm: functions to coordinate respiratory timing, postural control and core stability (Hodges et al 1997). It functions through 3 dimensional shape changes to the abdominal and thoracic cavities.

- Sternal portion: two small muscular slips from the Xiphoid Process
- Costal portion: from the lower 6 ribs where it connects with slips from the TA
- Lumbar Portion: consist of the anterior layer of the TLF over top of Psoas and QL, blending with the anterior longitudinal ligament and lower lumbar vertebrae.

Function: Increases intra-abdominal (IAP)pressure and trunk stabilization creating a "girdle" with other muscles, the diaphragm is the "roof" of the cylinder.

Rx:

1. Pilates, setting the rib cage, establishes connection with the diaphragm as well as decreases postural stress (Kibler et al., 2006)
2. Various yoga & deep breathing techniques - Prana, Apana, Sukha, Dukha (Kaminoff, 2007)

Pelvic Diaphragm: functions in combination with the TD to control intra-abdominal pressure. It may also function to stimulate early TA activation and creates force closure through the SI and pubis symphysis.

- Levator Ani: consisting of Pubococcygeus, Puborectalis & Iliococcygeous
- Coccygeus

Function: Co-activation of pelvic floor along with the abdominal musculature is necessary for development of intra-abdominal pressure (IAP), which contributes to spinal stability (Sapsford et

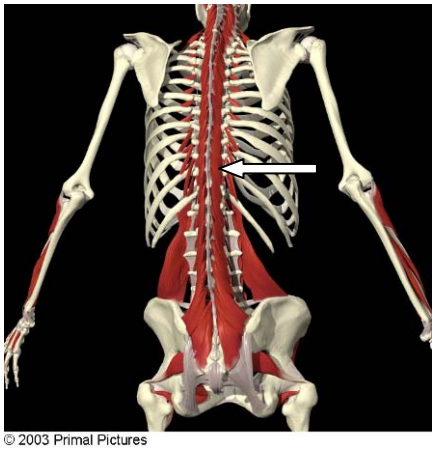
al., 2001)

Rx: -Kegel Exercises (ie: using the muscles needed to stop the flow of urination). (It is also referred to as the "root lock" in yoga called mula bandha, together with uddiyana bandha, the abdominal lock, this is also another way to "set" the core.)

Lumbar Multifidus:

Function: controls rotation in combination with flexion. Increases tension of the TLF via "hydraulic amplifier effect". The more superficial multifidi cross 5 segments and react in response to extremity movement, whereas the deeper segments cross 2 segments and are purely stabilizers. (Moseley et al., 2003)

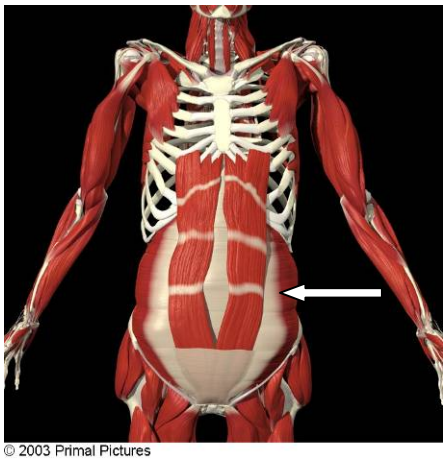
Rx: side lying clam, side to side knee drops



Transverse Abdominus: is the deepest layer of the abdominal group with a direct influence on transversalis fascia.

Function: the TA is non-directionally activated prior to displacement of the C of G or predictable load application, increases stability of the pelvis and spine via fascial connections and increases intra-abdominal pressure (IAP). This effect enhances stiffness (stability) of the lumbar spine. (Kibler et al., 2006)

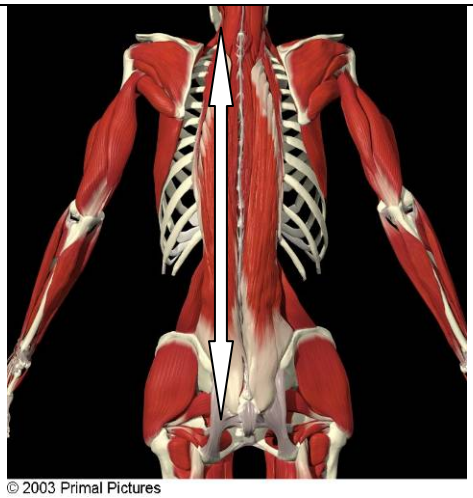
Rx: Setting the core (i.e. drawing the belly button) or in yoga is referred to uddiyana bandha for the same action.



Anatomy & function of the superficial outer unit

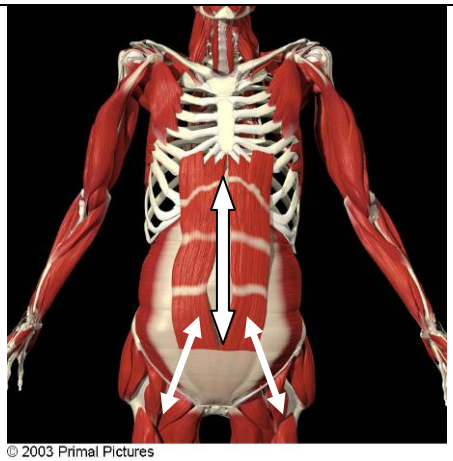
Posterior Longitudinal Sling or Superficial Back Line: Erector Spinae, Sacrotuberous Ligament, Ischial Tuberosity, Hamstrings

Function: Creates extension & hyperextension of the head to knees, and flexion of the gastrocs and plantar fascia. Maturationally, the development is slower than the muscles on the front as it is the line that develops when a baby learns to stand.



Anterior Longitudinal or Superficial Front Line: Rectus Abdominus, Rectus Femoris, Sub Patellar Tendon

Function: creates flexion of trunk and hips, extension below the knee.



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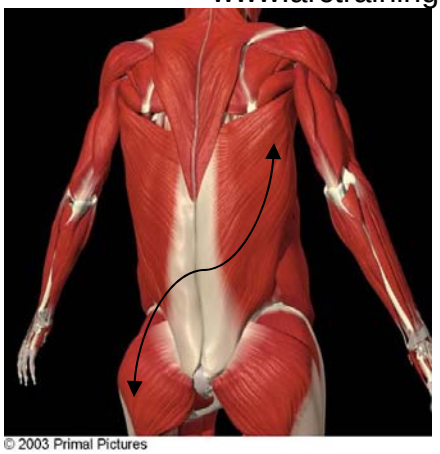
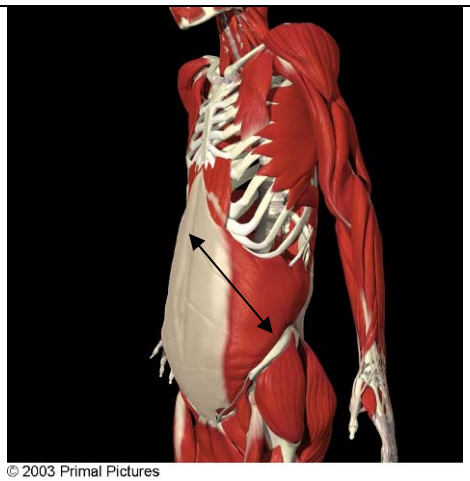
Posterior Oblique / Functional Back Line: Rhomboids, Latissimus Dorsi, Intervening ThoracoLumbar Fascia, contralateral Gluteus Maximus

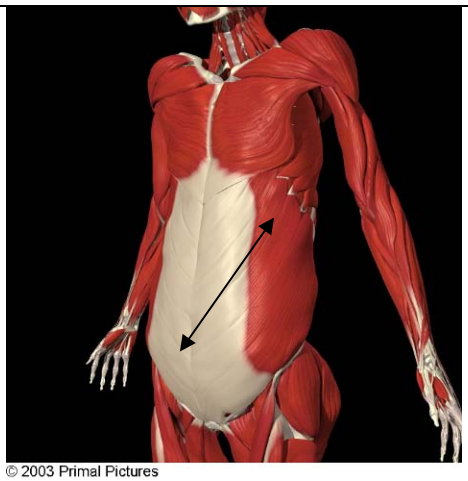
Function: provides contralateral (leg- arm) counterbalance, power and precision required for gait, striking, & throwing



Anterior Oblique / Front Functional Line: Pectoralis Major, Serratus Anterior, External Oblique, intervening Anterior Abdominal Fascia, contralateral Internal Oblique, and Adductor muscles (same side as internal oblique)

Function: provides contralateral (leg- arm) counterbalance, power and precision required for gait, striking, & throwing





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Lateral Sling / Line: Quadratus Lumborum, Gluteus Medius and Minimus, Tensor Fascia Lata and opposite (contralateral) Adductors of the thigh *Function:* Mediates force from the other superficial lines to maintain an upright torso particularly during heel strike. Creates lateral flexion of the spine, abduction at the hip. It also functions as a brake against lateral and rotational movements of the trunk.	

Table 1. illustrations from interactive functional anatomy, Human Kinetics

Functional Injury Prevention Concepts & Common Problems:

These musculoskeletal components of the core include those described by Chad, as the:

- **(S)**pine
- **(H)**ips
- **(A)**bdomen
- **(P)**elvis
- **(P)**roximal lower limb muscles

What happens when there is injury?

- A deficiency in the ability to generate energy from the core resulting in decreased power, and reliance on extremity muscles to take on extra shear and stress
- Aberrant movement in the myofascial slings creating aberrant motor patterns

How to prevent injury:

- Screening of the body during dynamic warm up and cool-down. This involves reading the body, checking range of motion in the three-planes. Comparing front to back, side to side and with rotation in power, range and ease of movement will test all anatomical slings.
- Using the mind-body connection during training to visualize power being generated from the center
- Engaging pelvic floor, diaphragm, and transverse abdominals to create IAP
- Training intelligently (adequate rest, proper form etc…)

Examples of injuries and sequelae:

Pelvic floor

- 100% of women who have recently (or not recently) had a baby will have damage to the pelvic floor muscles (at least), and more so if they have delivered naturally. It is paramount to rebuild core strength from the inside out, focusing more on exercises like pelvic tilts, Kegels, planks, pilates etc..as opposed to crunches. Women who have recently given birth will be in spinal flexion constantly with nursing and carrying the baby, pelvic floor strengthening exercises should emphasize a neutral thoracic spine.
- People with chronic back pain or abdominal conditions, the nerves innervating the pelvic area are also affected by these conditions and could inhibit these muscles (although this is not a rule)

Transverse abdominus/internal obliques

- Injury results in inability to create sufficient IAP, these individuals will have the rectus abdominus pop out during exercises requiring the abdominals.

Multifidus

- Injury to the multifidus can create “buckling” of vertebral segments. This results in the back “catching” and is quite painful and leads to instability related pathologies such as disc herniations. The more superficial spinal erectors will

spasm around this area decreasing movement of the spine especially in flexion and rotation.

Psoas

- The psoas acts as a flexor of the lower limb, but its effects on the spine when it is tight or when the hip is fixed is to cause large compression and sheer loads on the joints of the lumbar spine. (Bogduk et al., 1992)

Exercise Prescription to Train the Slings:

(Using the myofascial slings as delineated by Myers, 1997 and Chad Benson, 2009)

Superficial Front line (looking at the "core" components, not comprehensive)

Core Components	Strengthen	Lengthen
Rectus femoris Rectus Abdominis Pectoralis Palpable landmarks -Humerus -Sternum -Pubic bone -AIIS	• Abdominal crunches • Plank • Push-up to pike on stability ball • Squatting • Cycling	• Any exercise that strengthens superficial back line • Yoga-Bow position • Yoga Camel Pose • Yoga-Wheel • Yoga-Upward dog • Yoga Warrior 1 and exalted warrior

Superficial Back line

Core Components	Strengthen	Lengthen
Hamstrings Erector Spinae Lumbosacral fascia Palpable Landmarks -Transverse process -Sacrum -Ischial tuberosity	Back extensions • Deadlifts / Squat • Hip extensions • Rowing	• Any exercise that strengthens superficial front line • Knees to Chest Hug • Yoga-forward fold • Yoga-plough pose

Lateral line

Core Components	Strengthen	Lengthen
Iliotibial band Tensor Fasciae latae Glute Maximus	• Side plank + abduction • side sit-up	• Any exercise that strengthens the opposing lat line

External/Internal obliques External/Internal intercostals Palpable Landmarks -Greater trochanter -Iliac crest -Ribs	• lateral bounds / cutting • Oil Wells • Cartwheels	• Yoga-Gate Latch Pose • 10 & 2 O'clock Child's Pose • Yoga-triangle pose • Standing Crossover Side Bend Away

Front functional line

Core components	Strengthen	Lengthen
Pectoralis Major Serratus Anterior External Oblique Linea Alba Contralateral internal oblique and adductors Palpable landmarks -Medial humerus -Body of sternum -Lateral scapula -Sternal xiphoid -Pes anserene	• Kicking • Axe chop • *diagonal crunch,* • *plank – opp arm / leg lift,* • *split stance 1arm chest press*	• Any back functional line strengthening exercise • Kneeling Hip Flexor + Rotation • Wide leg split with arms in reverse prayer • Yoga-One legged bow

Back functional line

Core components	Strengthen	Lengthen
Rhomboids Latissimus Dorsi Thoracolumbar fascia Contralateral glute maximus Palpable landmarks -Medial scap border -Humerus -T12 (up from last rib) -Iliac crest -Sacrum -Greater trochanter	• Swimmer back extension • Bird/dog • Bridge (particularly 1ft with contra elbow dig), • R split squat + L arm row • Lunges with rear-fly • Running with full stride and arm pull	• Any front functional line strengthening exercise • Seated Spinal Twist • Eagle Pose • Crossover Lunge + Spinal Twists • Pigeon + Opp Arm Reach Under

References

Hirashima, M, Kadota, H, Sakurai, S, et al. (2002) Sequential muscle activity and its functional role in the upper extremity and trunk during overarm throwing. *Journal of Sport Science*, 20: p. 301-310.

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Hillman, S (2003). Interactive Functional Anatomy (DVD). Primal Pictures Ltd. www.humankinectic.com

Hodges et al. (1996). Contraction of the human diaphrapm during postural adjustments. J Physiol (London) 505, 239-48.

Kaminoff, L (2007). Yoga Anatomy. Human Kinetics.

Kibler, B., Press, J. & Sciascia, A. (2006) The role of core Stability in Athletic Function. *Sports Medicine*, 36(3), p. 189-198.

Myers (2009). Anatomy Trains (2nd Ed): Myofascial Meridians for Manual and Movement Therapists. Kinesis Inc. http://www.anatomytrains.com/

Sapsford, R. Hodges, P., Richardson, C., Cooper, D., Markwell, S. & Hull, G. (2001) Co-activation of the Abdominal and Pelvic Floor Muscles During Voluntary Exercises. *Neurourology and Urodynamics* 20,p.31–42.

Moseley, G., Hodges, P., & Gandevia, S. (2003) External perturbation of the trunk in standing humans differentially activates components of the medial back muscles. *Journal of Physiology*, 547.2, p. 581-587.

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