Module One
• Concepts
• Evidence
• Core Function/Dysfunction

Module Two
• Alignment

Module Three
• Diaphragm
• Breathing Mechanics

Module Four
• Pelvic Floor
• Transversus Abdominis

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• Synergists: POS

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• Synergists: RS
• Gait
• Plyometrics

Module One: Core Function Concepts and Evidence

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Foundation of Our Physical House

The Unstable House

- Local
- Remote
- Alignment
- Balance
- Agility/Performance
- Incontinence/Prolapse

Zoe 101

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Anticipatory Core

- Respiratory Diaphragm (D)
- Pelvic Floor (PF)
- Transversus Abdominis (TA)
- Multifidus (M)

Return to Fitness

Pelvic Foundation = Tug O’ War Anchor

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Integration: TAP

Stability that is responsive to the demands of function (non-uniform response)

- Teamwork
- Alignment
- Preparation

Integration: TAP

Stability that is responsive to the demands of function (non-uniform response)

- Teamwork

Gears in the Core Machine

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Teamwork

**The Core Machine**
- Machine only works if all gears work together.
- Gears must move or the machine will fail.
- Coordinated action will produce central stability

Teamwork

**Postural and Respiratory Functions of the PF**
Hodges, Sapsford, Pengel (2007)
- PF followed respiratory cycle (anterior, not posterior)
- PF expiratory activity more associated with abdominals
- Low-level tonic activity w/ bursts at movement frequency
- PISTON

Diaphragm

**Phase-locked Parallel Movement of Diaphragm and Pelvic Floor During Breathing and Coughing— a Dynamic MRI Investigation in Healthy Females**
Talasz et al (2011)
- Diaphragm R>L excursion
- Quiet breathing: 15 ± 6 and 9 ± 7 mm
- Forceful breathing: 32 ± 15 and 28 ± 16 mm
- Coughing: 32 ± 13 and 28 ± 7 mm.
Diaphragm

Phase-locked Parallel Movement of Diaphragm and Pelvic Floor During Breathing and Coughing—a Dynamic MRI Investigation in Healthy Females
Talasz et al (2011)
- Pelvic floor excursion varied but always cranial on exhalation
- Quiet breathing: mean 2.1 mm
- Forceful breathing: mean 7.0 mm
- Coughing: mean 3.8 mm

Waist Excursion

Phase-locked Parallel Movement of Diaphragm and Pelvic Floor During Breathing and Coughing—a Dynamic MRI Investigation in Healthy Females
Talasz et al (2011)
- Waist excursion varied but always inward on exhalation
- Quiet breathing: mean 5.1 mm
- Forceful breathing: mean 10.4 mm
- Coughing: mean 9.2 mm

Teamwork

Contraction of the PFM During Abdominal Maneuvers
Sapsford and Hodges (2001)
- 3 levels of abdominal contraction
- Consistent increase in PF before abdominal pressure
- PF increase matched abdominal force

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Teamwork: Intra-abdominal Pressure (IAP)

Changes in IAP during Postural and Respiratory Activation of the Human Diaphragm
Hodges et al. (2000)

Teamwork

![Graph showing changes in IAP during inspiration and expiration]

Teamwork: Intra-abdominal pressure (IAP)

Ideal: Balance
Real: Disrupts the IAP System

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Teamwork: Intra-abdominal Pressure (IAP)

- Balanced interplay between the diaphragm, pelvic floor and abdominals preserves relative IAP throughout the respiratory cycle.
- A dynamic and coordinated model of core function
- 5th member of our team
- Intersection of multiple systems
- Breath gives us a new gateway

Integration: TAP

Stability that is responsive to the demands of function (non-uniform response)
- Teamwork
- Alignment

Alignment

The Core Machine

Machine works best if all gears connect and line up.
Alignment

- Muscles are strongest at the midpoint of available ROM (availability)
- Muscles are weakest when long or short.
- Neutral Pelvis and Ribcage alignment (ribcage over pelvis) puts the Core in midrange positioning.

Alignment

Different Ways to Balance the Spine
Claus et al. (2009)
- Flat, Long Lordosis, Short Lordosis, Slump
- Short Lordosis best activity for TA and Multifidus
- Flat-Least

Alignment: Claus et al

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Alignment: Claus et al

Different Ways to Balance the Spine

- Flat, Long Lordosis, Short Lordosis, Slump
- Short Lordosis best activity for TA and Multifidus
- Flat-Least

Alignment

Sitting Postures Affects PF Activity in Parous Women

- Slump, Upright Unsupported, and Very Tall Unsupported (thoracic)
- Increased resting activation of PF as alignment improved
Alignment: Sapsford et al

Sitting Postures Affects PF Activity in Parous Women
Sapsford et al. (2006)

- Slump, Upright Unsupported, and Very Tall Unsupported (thoracic)
- Increased resting activation of PF as alignment improved

Alignment

Neutral Rib Cage and Pelvis

- Position of optimum Core recruitment (Anticipatory and Reactive Cores)
- Move toward neutral
- “Sweet Spot”
Integration: TAP

Stability that is responsive to the demands of function (non-uniform response)
- Teamwork
- Alignment
- Preparation

Preparation

Neuromuscular Strategy:
Preprogrammed motor control system, engaged through nervous system. The sensory system feeds information to create a graded response.

Anticipatory + Reactive = Function (Fxn)
Prepares for task + engaged based on demands of task = Function/movement

Preparation

Transverse Abdominis is not Influenced by the Direction of Arm Movement
Hodges et al. (1997)
- TA EMG increased prior to deltoid regardless of UE direction
- EMG of superficial abdominals varied with movement direction
Contraction of the Human Diaphragm During Rapid Postural Adjustments

Hodges et al. (1997):
- Same result for the Diaphragm
- Anticipatory contraction occurred regardless of phase of respiration
- Same result for elbow motions, not hand or digits

Hodges et al. (2007)
- Same result for the PF
- PF preceded the abdominals

Sjodhal et al. (2009)
- PF precedes supine lower extremity movement

Luginbuehl et al. (2013)
- PF precedes heel strike in running

Integration

Build a clinical model that:
- Teamwork: All gears moving
- Alignment: Optimized
- Preparation: Strategy
Core Redefined

CORE STRATEGY: NEUROMUSCULAR/MULTISYSTEM

CORE EXERCISE: MUSCULOSKELETAL

Clinical Application

The Relationship between Urinary Bladder Control and Gait in Women
Booth et al (2013)
- Spatial and temporal gait parameters studied in 36 continent women FDV, SDV, and PV
- Decreased gait velocity and stride length with SDV

Core Strategy

Changes in IAP during Postural and Respiratory Activation of the Human Diaphragm
Hodges et al. (2000)
Core Strategy is a system that harnesses the neuromuscular relationship that exists between the Anticipatory Core, Reactive Core, IAP Stability Cycle, Sensory System and the Brain. A cascade of force from the inside-out that provides both the stability and flexibility required to respond to the task at hand. #balance

MODULE ONE: CORE DYSFUNCTION ACROSS THE LIFE SPAN
Core Dysfunction = PF Dysfunction

- Central instability
- Alignment disorders
- Gait dysfunction
- Balance deficits
- Upper and lower quarter musculoskeletal imbalances
- Gap to fill: Present as a low back, hip, neck, shoulder
- Know when to refer**

PF Dysfunction = Core Dysfunction

- Incontinence
- Pelvic Organ Prolapse
- Post-prostatectomy
- Painful Sex
- “Women’s Health”
- MSK co-morbidities
- Functional re-training
- Prep for fitness

Core Dysfunction

Gender Neutral

- Pain
- Alignment
Core Dysfunction

**Gender Neutral**

- Pain

**Gender Neutral: Acute Pain**

*Experimental Muscle Pain Changes in Feedforward Postural Responses of the Trunk Muscles*

Hodges et al. (2003)

- TA had immediate delay and decrease in amplitude
- Variable response from the other trunk muscles ("lost their anchor")

**Gender Neutral: Chronic Pain**

*Why Do Some Patients Keep Hurting Their Back?*

MacDonald et al. (2009)

- Short (SM) and long Multifidus (LM) responses
- Controls and non-painful side of low back pain (LBP) demonstrated SM first
- Delay of SM on painful side of LBP group
Core Dysfunction

Gender Neutral
- Pain
- Alignment

Gender Neutral: Alignment

PF Activity in Different Sitting Postures in Continent and Incontinent Women
Sapsford et al. (2008)
- Upright Unsupported vs. Slump
- Both incontinent and continent had inc in PF, IO, & TA in UU
- Continent had greater lumbar lordosis
- "Prolapse greater kyphosis"

Alignment: Sapsford et al
Gender Neutral: Alignment

PF Activity in Different Sitting Postures in Continent and Incontinent Women
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- "Prolapse greater kyphosis"

Alignment

Lumbosacral Spine and Pelvic Inlet Changes Associated with Pelvic Organ Prolapse
Nguyen et al. (2000):
- X-rays (hands across chest): Lordotic angle significantly lower in women with prolapse (loss of lordosis in prolapse group)
- Larger pelvic inlet angle in the prolapse group (less vertical)
- Correlation not causative

Core Dysfunction

Venus vs Mars

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Venus vs Mars

Gender Differences

- Women are 2x more likely to sustain running injuries PFS, ITBS, tibial stress fracture (Taunton, 2002)
- Greater hip width to femoral length angle, (Horton and Hill, 1989), static genu valgum (Benzon, 1984), and active hip IR (Simoneau, 1998)
- Greater frontal plane and transverse plane (hip ADD/IR, knee ABD/ER) motion throughout stance phase (Ferber, 2003)
- Same findings for walking and running (Chumanov, 2008)

Gender Differences

- Greater vertical movement and GRF than men (Li, 2001) Expected vertical displacement/bounce 6-8 cm. Female recreational runners 12-14 cm (Heiderscheit, 2013)
- Females are 4-6x more likely to experience an ACL non-contact injury.
- ACL lit: Similar LE pattern noted greater peak hip IR and ADD, knee valgus and ABD, decreased flexion (Pollard, 2007; Hewett, 2006)
Gender Differences

- Decreased hip extensor moments and observed increase trunk lean over stance leg. Proximal control strategy (compensatory?) (Pollard, 2007)
- Frontal plane pelvic tilt (tilt) increased when running during pregnancy, unchanged at 6 month F/U (Chumanov, 2013)

Venus vs Mars

Venus vs Mars
- ACL non-contact tears
- Pregnancy/Postpartum
- Menopause

Venus vs Mars
- ACL non-contact tears
Deficits in Neuromuscular Control of Trunk Predict Knee Injury Risk
Zazulak et al. (2007)
- Trunk displacement, proprioceptive repositioning errors, and history of low back pain predictive in females
- Only history of low back pain predictive in males

The Importance of Trunk Neuromuscular Control in Knee Rehabilitation and Injury Prevention: The Core of Evidence
Hewitt and Zazulak (2010)
- Girls lack a “neuromuscular spurt” at puberty

- Programs are now addressing mounting evidence of poor neuromuscular control
- LE neuromuscular control through balance, single leg stability, plyometrics, and sport specific agility drills
- Hip strengthening, pronatory control (LE kinetic chain)
- Pelvic stability is closed chain in reverse
Evidence to Consider

- Pelvic floor changes at puberty diminish pelvic stability
- Pelvic stability facilitates control of the pelvic-hip-knee complex at landing
- Pelvic stability contributes to core/trunk stability

Evidence to Consider

- Breast development!
- Structural shift of rib cage to accommodate breast growth
- Diminished diaphragm capacity to set up IAP stability system

Future Research Questions?

- Could alignment be predictive of knee injury risk?
- Could Zazulak's markers be predictive of incontinence?
- Could neuromuscular re-education programs that integrated the pelvic floor successfully reduce knee injury risk?
- Incontinence in elite athletes?
Other Populations: Cystic Fibrosis

A Comparison of the Prevalence of Urinary Incontinence in Girls with Cystic Fibrosis, Asthma, and Healthy Controls
Prasad et al. (2006)
- 11-17 year old females self-reporting questionnaire
- 33% CF, 16% A, 7% HC
- Less common in males

Venus vs Mars

Venus vs Mars
- ACL non-contact
- Pregnancy/Postpartum

Venus Has A Baby

Three out of four Core muscles are directly impacted by pregnancy (damage not only due to delivery!)
Venus Has A Baby

- Respiratory Diaphragm:
  Descent compromised
- Transversus Abdominis:
  Stretched out rubber band
- Pelvic Floor:
  Workload increase
- Multifidus:
  Tends to be preserved

Venus Has A Baby

- Muscular changes
- Structural changes
- Soft tissue adaption
- Hormonal changes

Pregnancy Alignment

Spinal curvature and characteristics of postural change in pregnant women

Okanishi et al. (2012)
- 11/15 demonstrated lumbar kyphosis and sacral posterior inclination

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Venus Has A Baby

- Muscular changes
- Structural changes
- Soft tissue adaption
- Hormonal changes

Venus Has Back, Hip, Knee….Pain

- Core component asynchrony
- Muscular length, strength and coordination changes
- Compensation patterns
- Poor recovery strategies
- Poor fitness strategies
- Injury vulnerability
- “Just what happens after pregnancy….”

Future Clinical Considerations

- Pelvic floor dysfunction is rarely considered as a contributing factor in low back, knee, hip, shoulder, jaw, cervical, etc. pain
- A new clinical model of inclusion must emerge.
- Clinical Tip: Add to intake; red flags for referral
**Venus vs Mars**

- ACL non-contact
- Pregnancy/Postpartum
- Menopause

**Venus Has Hot Flashes**

**Common Co-morbidities**

- Balance deficits
- Incontinence
- Common denominator: Pelvic Floor dysfunction

**Is Balance Different in Women with and without Stress Urinary Incontinence (SUI)**

- Smith et al. (2008)
- Greater Center of Pressure (COP) displacement in SUI group
- Both groups had greater COP displacement w/full bladder
Venus Has Hot Flashes

Integrated Balance:
- Sensory
- Musculoskeletal
- Neuromuscular
- LOL

Venus Has Hot Flashes

Role of the Medullary Reticular Formation in Relaying Vestibular Signals to the Diaphragm and Abdominal Muscles
Mori et al. (2001)

[Diagram showing the diaphragm receiving input from the vestibular nuclei via the brain stem]

- Pre-cognitive

Balance/Continence Win-Win

Trunk/Pelvic Stability
- Mainstay of balance programming
- Applying IAP Piston/Core Strategy will optimize central stability and pelvic floor function
Balance/Continence Win-Win

**Foot Intrinsic Weakness**
- Mainstay of balance programming
- Shared nerve roots (S2, S3)
- Integrate these linked system to enhance responsivenes of foot and trunk stabilizers in a balance challenge

Lifespan Balance Dysfunction

**DIZZY MOMMY BOOT CAMP**

Future Research Questions?

- Would a more supple, functional pelvic floor be more responsive to medical/hormonal interventions, maintain elasticity, maintain continence, reduce falls, age related joint issues?
- Imagine if we normalized the pelvic floor at puberty!
Concept Synthesis/Module Summary

Correlation: SUI to LBP

Disorders of breathing and continence have a stronger association with back pain than obesity and physical activity. Smith, Russell, Hodges (2006)

- N= 38,050 women, in 3 age cohorts (18-23, 45-50, 70-75), self-reported low back pain in the last 12 mo
- Incontinence, respiratory issues, BMI, physical activity
- Incontinence and allergies significantly correlated across all 3 cohorts.
- Respiratory issues in mid and older.

Correlation: SUI to LBP

Incontinence, breathing difficulties, and gastrointestinal symptoms increase the risk of future back pain? Smith, Russell, Hodges (2009)

- Follow-up at 4, 2, 3 years (2943 younger, 2298 mid, 2258 older)
- Developed incontinence or breathing difficulties between surveys significantly related with the development of low back pain in the 12 months prior to the data collection across all 3 cohorts.
Discussion

Smith studies support the suggestion that the muscles of continence and respiration (D, TA, and PF) also contribute to trunk control, a common deficit noted in those with low back pain.

INTEGRATE VS ISOLATE

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<td>LINK UPPER AND LOWER QUARTER</td>
<td>FOCUS ON TRUNK ONLY</td>
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What's Next...Module Two

- Alignment: Optimizing the relationship of D/PF
- Rib cage assessment
- Pelvic position
- Corrective cueing