The Science of Motor Control:
From Janda and Beyond

An Evolution from
Muscle Function to Motor Patterns

Albert J Kozar DO, FAOASM, RMSK

Board Certified in NMMOMM, FP, CAQSM, RMSK
Clinical Associate Professor, University of New England – Biddeford, ME
Clinical Associate Professor, Edward Via College of Osteopathic Medicine – Blacksburg, VA
Team Physician - University of Hartford
Valley Sports Physicians - Avon, CT

AAO Convocation
Louisville, KY
March 13th, 2015
Goals

- To discuss what is ideal movement and how might we assess it
- To review the developments of motor control from a clinical perspective in last 30 years from Vladimir Janda, MD to present
- To understand the important differences in teaching patients to learn motor patterns compared to strength training the muscle system
- For you to *THINK & TREAT* functionally & integratively to the systemic responses of the human body to injury when dealing with patients
What is Normal or Ideal Movement?

- Is it difficult to define?
- Is there not more than one correct way to move?
- Isn’t it normal to be able to perform any functional task in a variety of different ways?
- Can we agree? … Optimal movement or movement competency might ensure that functional tasks and postural control activities are performed in an efficient manner, controls physiological stresses, uses lowest possible energy.
What is required to create Normal or Ideal Movement?

Movement system comprises the coordinated interaction of:

- Articular
- Muscular
- Fascial
- Neural

- CNS
- Physiological
- Pscho-social
What is Normal or Ideal Movement

Sounds Like:

**Somatic Function:**

- Normal function of related components of the somatic (bodywork) system including: the skeletal, arthrodial, and myofascial structures, and their related vascular, lymphatic, and neural elements.
Normal or Ideal Movement

The concepts of

- stability
- movement control

the process of how it is achieved

has different interpretations depending on the background of the authors.

- Still debate as to whether spinal stability exists, but no debate the spine must be stable to function

- Models that either assess
  1) Control of movement and assessment & retraining of uncontrolled movement ... or
  2) Motor patterns and retraining of motor patterns ...

appear to be a better approach rather than simply a model stability
"Weekend Warrior" and the Fitness Trend of more sets, more reps, and weight ... without consideration of the quality of movement has led to a widespread nonimpact related musculoskeletal pain syndromes of overuse.

An inadequate foundation of movement competency or literacy is seen in faulty movement patterns involving fundamental motor programs such as:

- upright posture
- squatting
- gait
- breathing
How can we assess Movement?

Key to Management of Movement Dysfunction

- Thorough assessment – of norms
- Accurate diagnosis – of what’s really dysfunctional
- Localized & specific treatment – retention by patient
How can we assess dysfunctional Movement?

*Functional Evaluation of Faulty Movement Patterns*

Janda, Cook, and others have called for the functional assessment of movement patterns to be the “gold standard” for individuals with musculoskeletal pain syndrome.
How can we assess Movement?

Identifying & classifying movement faults has become the cornerstone of contemporary rehabilitative musculoskeletal practice.

- Substitution strategies (Richardson et al 2004; Jull et al 2008)
- Compensatory movements (Comerford & Mottram 2001)
- Muscle imbalance (Comerford & Mottram 2001; Sahramann 2002)
- Faulty movement (Sahramann 2002; Liebenson 2014)
- Abnormal dominance mobiliser synergists (Richardson et al 2004)
- Co-contraction rigidity (Comerford & Mottram 2001)
- Movement impairments (Sahramann 2002; O’Sullivan et al 2005)
- Control impairments (O’Sullivan et al 2005; Dankaerts et al 2009)
- Stability / motor control dysfunction (Cook et al 2005)
Subgroup Classification of Non-specific musculoskeletal pain related to movement dysfunction

**Site & Direction of Uncontrolled Movement**
- Site & Direction of Uncontrolled Movement  (Comerford & Mottram 2001a)
- Direction Susceptible to Motion (Sahrmann 2002)
- Control impairments & movement impairments  (O’Sullivan 2005)
- Stability/motor control dysfunction (SMCDs) (Cook 2005)

**Recruitment Efficiency of Local Muscle System**
- Changes in Feedforward mechanism
  - Transversus abdominus, multifidus, pelvic floor, diaphragm (Richardson et al 2004)
  - Deep neck flexors (Jull et al 2008)
  - Upper trapezius (Wadsworth & Bullock-Saxton 1997)
- Recruitment Efficiency Changes
  - Deep neck flexors (Jull et al 2008)
  - Psoas, subscapularis, upper & lower trapezius, posterior neck extensors (Gibbons 2007: Comerford & Mottram 2010)
  - Deep sacral glut max (Gibbons 2007)
  - Clinical rating system (Comerford & Mottram 2011)
- Ultrasound Changes
  - Transversus abdominus (Richardson et al 2004)
  - Psoas (Gibbons 2005: Comerford & Mottram 2011)
  - Pelvic floor (Peng et al 2007: Whittaker 2007)

**Patterns of Movement Provocation & Relief with Postural Positioning**
- Derangement patterns  (McKenzie & May 2006)
- Jones positional release (strain-counterstrain) (Jones et al 1995)

**Muscle Imbalance**
- Relative flexibility (Sahrmann 2002)
- Restriction & Compensation (Kinetic Control - Comerford & Mottram 2011)
- Recruitment sequencing (Janda 1986)

**Patterns of Symptom Relief Associated With Manual Mobilization**
- Nags, snags, MWM (Mulligan 2003)
- Pelvic dysfunction (DonTingny 1997)

**Positional Diagnosis**
- Osteopathy
Historical Development of the Influence of Muscle Function on Movement and Performance

**Stretching & Strengthening**

**Traditional Strength**
Overload training for power & endurance

**Core Strength**
Overload training of trunk & girdle

**Core Strengthening**
McGill

**Assessment of Muscle Function**
Kendall & McCreary

**Sahrmann**
Global – whole body

**Janda**
Global – trunk & limbs

**Hodges, Richardson, Hides, Jull**
Global Trunk Stability – local spinal motor control stability

**Alternative Therapies & approaches**
Global – trunk & limbs

**O’Sullivan**
Integration of trunk stability into function

**Integrative Assessment of Motor Patterns**

**Kinetic Control**
Comerford & Mottram
Evidenced based synthesis – whole body
Local & global motor control Test & Rx

**Functional Movement Systems**
Grey Cook
Evidenced based synthesis – whole body
Motor pattern Test & Rx – SFMA, FMS

**Leibenson**
Magnificent 7
Evidenced based synthesis – whole body

**Lewit**

**Kolar**
DNS
Muscle Imbalance

Neuromuscular system, systemically, responds to dysfunction in a characteristic, non-random, pattern, irrespective of the cause/diagnosis

“is a systemic reaction of the muscle system that develops due to the quality of CNS as a reaction to our lifestyles”

Janda 2001

Janda Thought:

- muscular system lies at a functional crossroads since it is influenced by BOTH CNS & PNS
- Muscles can be considered a “window into the function of the sensorimotor system”
- Posture is the expression of the sensorimotor system
Muscle Imbalance

characterized by impaired relationship between muscles prone to tightness / shortness and muscles prone to weakness / inhibition  Janda 1964, 1978

Tendency:

Tonic / Postural Muscles: facilitated, hypertonic, tight
Phasic / Dynamic Muscles: inhibited, hypotonic, "weak" (pseudoparesis)

Key Points:

NO correlation between histology (slow, fast twitch) of muscles and whether muscle is prone to inhibition or tightness, it is a functional aspect
- Rooted in neurodevelopment
- Fiber type doesn’t always influence function: a muscle performs based on functional demands and sensorimotor system
- Not rigid classification - some muscles exhibit characteristics of both

Think muscle function in relation to one-legged stance
muscles of upright posture this way show a tendency to tightness  Janda 1983
Tonic System Muscles Prone to Tightness

- facilitated, hypertonic, tight
- maintains a low level of tone nearly all the time
- functions primarily as postural muscle; usually function as movers

**LOWER QUARTER**
- Psoas & Iliacus, Rectus femoris
- Hamstrings, Piriformis
- Tensor fascia latae
- Quadratus lumborum
- Short & Long thigh adductors
- Tibialis posterior
- Triceps Surae (esp Soleus)
- Lumbar erector spinae, T/L Jxn

**UPPER QUARTER**
- SCM, Levator scapula
- Scalenes, Upper trapezius
- Pectoralis, esp minor
- Latissimus dorsi
- Suboccipitals, Masticators
- Subscapularis
- Flexors of UE, esp biceps
- UE pronators
Phasic System Muscles Prone to Weakness

- inhibited, hypotonic, "weak" (pseudoparesis)
- exhibit quicker, shorter bursts of activity with phases of rest in between
- usually function as stabilizers

**LOWER QUARTER**
- Gluteus Complex
- Transversus Abdominis
- Rectus Abdominis
- External / Internal Obliques
- Vasti, esp medialis
- Peroneals
- Tibialis anterior
- Intrinsics of Feet

**UPPER QUARTER**
- Mid & esp Lower Trapezius
- Serratus Anterior
- Rhomboids
- Supra and Infraspinatus
- Deltoid
- Deep Neck Flexors
- Extensors UE
Key Janda Concepts

- Muscle list was not meant to be rigid

- **Concept of patterns - predictable patterns:**
  - The weakness causes the tightness and the tightness causes the weakness.
  - You cannot just fix only one because they are mutually dysfunctional

- “muscles prone to weakness” usually function as stabilizers
- “muscles prone to tightness” usually function as movers.

Consider -- the underlying causes of muscle tightness to be a dysfunctional stabilizer system that causes movers to shorten in an attempt to create support

Simply stretching muscles that appear tight will only address part of the problem and will rarely get to the cause.
Consequences of Muscle Imbalance

- Altered joint mechanics - biomechanics
- Uneven pressure distribution on joints = dysfunction
- Pain
- **Altered Movement patterns**
- Impaired proprioception
Muscle Imbalance leads ...

Faulty Movement Patterns
- found in children as young as 8 yrs  Janda 1987b
  - normal muscle tightness ↑ from 8-16 yrs, then constant
  - correlation body height, poor fitness, & tightness
  - Imbalances in children begin in upper extremity

Altered recruitment patterns
- delayed activation of primary mover or stabilizer + early facilitation of a synergist  Janda 1987
- Within 6 weeks these local changes can become centralized  Janda 1978
- Adaptive changes in sensorimotor system (vertical or horizontal) progress proximally to distally
- muscle reaction is specific for each joint  Janda 1986a
- often due lack variety of movement  Jull & Janda 1987
Identified 6 basic movement patterns that provide overall information about a patient’s movement quality & control

- Hip Extension
- Hip Abduction
- Curl-up
- Cervical Flexion
- Push-up
- Shoulder Abduction

Observe the patients preferred pattern with only minimal verbal cues
Do not touch patient, as touch is facilitatory
Observe over 3 trials of slow movement
Hip Extension Test

Normal Pattern:
- Hamstrings
- GMax – bilateral
- Contralateral low lumbar ES
- Ipsalateral low lumbar ES

Compensation Pattern:
- Late / non-firing GMax - deep
- Early firing (in order of progressively worse compensation)
  - Contralateral T-L paraspinal
  - Ipsalateral T-L paraspinal
  - Contralateral lower Trap
  - Ipsalateral lower Trap
  - Contralateral Upper Trap
  - Ipsalateral Upper Trap

Maintainers:
- Any LB or LE pain
- Ipsalateral Psoas / Iliacus length
- Ipsalateral RF length
- Tight Hip Capsule
Hip Abduction Test

Normal Pattern:
- GMed
- TFL
- QL
- Erector Spinae

Compensatory Pattern:
- Early QL / TFL
- Late / non-firing GMd
- Hiking of the pelvis

Check for:
- Tight ipsilateral short adductors
- Tight ipsilateral QL
Shoulder Abduction Test

Normal Pattern:
- Supraspinatus
- Deltoid
- Infraspinatus
- Middle & lower Traps
- Contralateral QL

Compensatory Pattern:
- Late/non-firing SST/D/IST
- Early firing (in order of progressively worse compensation):
  - Contralateral QL
  - Ipsalateral QL
Muscle Hypertonicity

- In general, muscles prone to tightness are 1/3 stronger
  Janda 1987

- Three important factors in muscle tightness:
  Janda 1993
  1. muscle length
  2. irritability threshold
  3. altered recruitment
<table>
<thead>
<tr>
<th>Function</th>
<th>Anatomically Distributed</th>
<th>Spontaneously Painful</th>
<th>Palpably Tender</th>
<th>EMG at Rest</th>
<th>Other Signs</th>
</tr>
</thead>
</table>
| Limbic                       | no                        | no                    | yes             | Constant    | Chronic stress, fatigue -stress, i.e. tension headache  
Location: Shld/ Face, neck, LB, pelvic floor |
| Segmental (of spinal cord)   | yes                       | yes                   | yes             | None        | Imbalance between antagonists antagonist weak, painful to stretch           |
| Reflex “spasm”               | not always                | yes                   |                 | ↑           | “Defense Musculare” i.e. wry neck                                           |
| Trigger Points (partial “muscle spasm”) | yes | active TP - yes muscle latent TP - no |               |             | parts of muscle hyperirritable  
neighboring muscles fibers inhibited  
↑ EMG at rest |
| Muscle Tightness             | yes                       | no                    | yes (palpably hard) |             | ↓ extensibility primary reason  
↑ irritability (decreased threshold)  
progressively decreased strength  
MUST stretch BEFORE strengthening |
# FUNCTIONAL TYPES of MUSCULAR HYPERTONICITY Treatment

Janda 1991

<table>
<thead>
<tr>
<th></th>
<th>Amount Force</th>
<th>Timing of Force</th>
<th>Other Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Limbic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Segmental</strong></td>
<td>Medium</td>
<td>Wait for relaxation</td>
<td>Goal: aimed at muscle system, not muscle group use general inhibitory technique - autogenic, Yoga, Feldenkriest, Alexander</td>
</tr>
<tr>
<td><em>(of spinal cord)</em></td>
<td>Strong</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reflex “spasm”</strong></td>
<td>Medium</td>
<td>Wait for relaxation</td>
<td>Goal is release ME is treatment of choice</td>
</tr>
<tr>
<td></td>
<td>Strong</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trigger Points</strong></td>
<td>Minimal 1-2</td>
<td>Wait for relaxation, slow release, elongate slowly</td>
<td>Goal is selective release of active fibers Have lower inhibitory threshold INC muscle tone of limited # motor units</td>
</tr>
<tr>
<td><em>(Acute)</em></td>
<td>fingers 4-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>grams</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trigger Points</strong></td>
<td>Minimum</td>
<td>Slow</td>
<td>Goal is to stretch the connective tissue</td>
</tr>
<tr>
<td><em>(Chronic)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Muscle Tightness</strong></td>
<td>Strongest</td>
<td>Wait for relaxation</td>
<td>Main Goal is stretch cannot stretch CT unless max # of motor units is inhibited, therefore muscle must be fully inhibited</td>
</tr>
</tbody>
</table>
Neuromuscular Imbalance

Pseudoparesis

Inhibition, not true weakness

Attempt at strengthening increases inhibition (will see decreased recruitment with added weight)

May not appear grossly weak, but fatigues quickly (poor endurance)

Treat cause(s) inhibition first (neural reflex)
Janda’s Classification of Muscle Imbalance Patterns

Defined 3 stereotypical patterns:

- Upper-Crossed Syndrome
- Lower-Crossed Syndrome
- Layered Syndrome

Typical muscle response to joint dysfunction is similar to muscle patterns found in UMN lesions.

Muscle imbalance is controlled by CNS (Janda 1987).

Muscle tightness or spasticity is predominant.

Weakness results from reciprocal inhibition of the tight antagonist.

Patterns lead to postural changes, joint dysfunction and degeneration.

Specific patterns of muscle weakness & tightness cross between the dorsal & ventral sides body.

Degree of tightness & weakness varies, but the pattern rarely does.

Muscle Imbalance Progression:

Adults: distal in pelvis --> to --> proximal shoulder & neck

Children: proximal --> to --> distal
Upper Crossed Syndrome
(Proximal or Shoulder Girdle Crossed Syndrome)

- TIGHTNESS: upper trap & levator (ventral) cross to pec maj/min (dorsal)
- WEAKNESS: deep cervical flexors (ventral) cross mid/lower trapezius (dorsal)
- JOINT DYSFUNCTION: (at transition zones in morphology)
  - occipito-atlantal (OA) jt
  - C4-5 segment
  - cervicothoracic (C-T) jt
  - glenohumeral jt
  - T4-5 segment
Upper Crossed Syndrome
(Proximal or Shoulder Girdle Crossed Syndrome)

POSTURAL CHANGE:
- forward head
- increased cervical lordosis
- thoracic kyphosis
- elevated & protracted shoulders
- rotation, abduction, & winging scapula

DYSFUNCTION:
- decreased glenohumeral stability (as glenoid fossa becomes more vertical due to serratus anterior weakness leading to abduction, rotation, & winging scapula)

COMPENSATION:
- increased activation levator scapula & upper trapezius to maintain glenohumeral centralization  Janda 1988
Lower Crossed Syndrome
(Distal or Pelvic Crossed Syndrome)

- **TIGHTNESS:** thoracolumbar extensors (dorsal) to iliacus/psoas & rectus femoris (ventral)

- **WEAKNESS:** deep abdominals (ventral) gluteus max/min (dorsal)

- **JOINT DYSFUNCTION:**
  - L4-5 & L5-S1 segments
  - SI jt
  - hip jt
Lower Crossed Syndrome
(Distal or Pelvic Crossed Syndrome)

POSTURAL CHANGE:
• anterior pelvic tilt
• increased lumbar lordosis
• lateral lumbar shift
• lateral leg rotation
• knee hyperextension

DYSFUNCTION:  Janda 1987
• LCS Type A: deep, short lordosis - pelvic muscle imbal
  • more hip flexion and extension for movement
  • standing posture demonstrates anterior pelvic tilt with slight hip & knee flexion
• LCS Type B: shallow, long lordosis: trunk muscle imbal
  • more low back & abdominal movement
  • minimal lumbar lordosis extending into thoracics
Lower Crossed Syndrome
(Distal or Pelvic Crossed Syndrome)

COMPENSATION: 2 Subtypes:

LCS Type A:
- lumbar limited hyperlordosis
- thoracolumbar & upper lumbar hyperkyphosis

LCS Type B:
- lumbar to thoracolumbar hypolordosis
- upper thoracic hyperkyphosis
- head protraction (cervical lordosis)
- COG shifted back, shoulders behind
- knee hyperextension

Deep trunk stabilizers are inhibited; substituted by activation superficial muscles  Cholewicki, Panjabi, & Khachatryan 1997
- Tight hamstrings subst for anterior pelvic tilt & inhib glut max

Direct affects on dynamic movement:
- decreased hip extension leads more anterior pelvic tilt & lumbar extension
Layered Syndrome
(Stratification Syndrome)

Lower Crossed Syndrome + Upper Crossed Syndrome
Progressive marked motor impairment - poorer prognosis

WEAK MUSCLES
- Cervical flexors
- Lower Stabilizers of the Scapula
- Lumbosacral erector spinae
- Gluteus Maximus

TIGHT MUSCLES
- Cervical erector spinae
- Upper trapezius
- Levator scapulae
- Thoracolumbar erector spinae
- Hamstrings
Historical Development of the Influence of Muscle Function on Movement and Performance

Stretching & Strengthening

Traditional Strength
Overload training for power & endurance

Core Strength
Overload training of trunk & girdle

Core Strengthening
McGill

Assessment of Muscle Function
Kendall & McCreary

Sahrmann
Global – whole body

Hodges, Richardson, Hides, Jull
Global Trunk Stability – local spinal motor control stability

Janda
Global – trunk & limbs

O’Sullivan
Integration of trunk stability into function

Alternative Therapies & approaches
Global – trunk & limbs

Integrative Assessment of Motor Patterns

Kinetic Control
Comerford & Mottram
Evidenced based synthesis – whole body
Local & global motor control Test & Rx

Functional Movement Systems
Grey Cook
Evidenced based synthesis – whole body
Motor pattern Test & Rx – SFMA, FMS

Lewit

Leibenson
Magnificent 7
Evidenced based synthesis – whole body

Kolar
DNS
Stabilizer vs Mobilizer Muscle Roles

Rood in Goff (1972), Janda (1996), Sahrmann (2002)
Described & developed functional muscle testing based on these roles
Some muscles are more efficient at one and less efficient in the other

<table>
<thead>
<tr>
<th>Stabilier Role Characteristics</th>
<th>Mobiliser Role Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ One joint (mono-articular)</td>
<td>✓ Two joint (bi-articular or multi-segmental)</td>
</tr>
<tr>
<td>✓ Broad aponeurotic insertions</td>
<td>✓ Superficial (longer lever, large moment arm, greatest bulk)</td>
</tr>
<tr>
<td>✓ Leverage for load maintenance, static holding, joint compression</td>
<td>✓ Unidirectional fibers or tendonous insertions (to direct force to produce movements)</td>
</tr>
<tr>
<td>✓ Postural holding role assoc with eccentrically decelerating or resisting momentum (esp axial pl - rotation)</td>
<td>✓ Leverage for range and speed and joint distraction</td>
</tr>
<tr>
<td></td>
<td>✓ Repetitive or rapid movement role and high strain/force loading</td>
</tr>
</tbody>
</table>
Local vs Global Muscle Roles

Bergmark (1989)
Developed to describe the load transfer across the lumbar spine

<table>
<thead>
<tr>
<th>Local Muscle System Characteristics</th>
<th>Global Muscle System Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Deepest, one joint</td>
<td>✓ Deep one joint or superficial</td>
</tr>
<tr>
<td>✓ Minimal force / stiffness</td>
<td>multi-joint</td>
</tr>
<tr>
<td>✓ No or minimal length change</td>
<td>✓ Force efficient</td>
</tr>
<tr>
<td>✓ Do not produce or limit range of</td>
<td>✓ Concentric shortening to produce</td>
</tr>
<tr>
<td>motion</td>
<td>range</td>
</tr>
<tr>
<td>✓ Controls translation motor control in all ranges, all directions</td>
<td>✓ Eccentric lengthening or isometric holding to control range</td>
</tr>
<tr>
<td>✓ No antagonists</td>
<td>✓ No translational control</td>
</tr>
<tr>
<td></td>
<td>✓ Direction specific / antagonist influenced</td>
</tr>
</tbody>
</table>
Functional Classification of Muscle Roles
Comerford & Mottram (2001)


- **Local Stabilizers**
  - maintain joint congruity and stiffness
  - contracting continuously, relatively independent of the joint’s direction of movement -- tonic
  - provide proprioceptive data

- **Global Stabilizers**
  - generates force (usually eccentrically) to control range of motion, especially rotation in the axial plane – phasic

- **Global Mobilizers**
  - generates motion concentrically, especially in the sagittal plane -- phasic
  - can also absorb shock load eccentrically
## Functional Classification of Muscle Roles

Comerford & Mottram (2001)

<table>
<thead>
<tr>
<th>Local Stability Muscle Role / Strategy</th>
<th>Global Stability Muscle Role / Strategy</th>
<th>Global Mobility Muscle Role / Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function and Characteristics</strong></td>
<td><strong>Function and characteristics</strong></td>
<td><strong>Function and characteristics</strong></td>
</tr>
<tr>
<td>• Inc muscle stiffness to control segmental motion/translation</td>
<td>• Controls range of motion (force)</td>
<td>• Generates torque to produce range of joint movement</td>
</tr>
<tr>
<td>• Controls the neutral joint position</td>
<td>• Contraction = eccentric length change – throughout range</td>
<td>• Concentric acceleration of movement – especially sagittal plane flex/ext</td>
</tr>
<tr>
<td>• Contraction = no length change No range of movement</td>
<td>• Functional ability to 1) shorten through the full inner range of joint motion  2) isometrically hold position  3) eccentrically control the return against gravity &amp; control hypermobile outer range of joint motion if present</td>
<td>• Shock absorption of high load</td>
</tr>
<tr>
<td>• Activity is often anticipatory (or same instant) to expected displacement or movement to provide protective muscle stiffness prior to motion stress</td>
<td>• Deceleration of low load/force momentum – esp axial plane rot</td>
<td>• Very direction dependent</td>
</tr>
<tr>
<td>• Recruitment is not anticipatory if the muscle is already active or loaded</td>
<td>• Non-continuous activity</td>
<td>• Intermittent muscle activity very on/off basic pattern of activity – often brief bursts of activity to accelerate the motion segment then momentum maintains movement</td>
</tr>
<tr>
<td>• +/- muscle activity independent of direction of movement</td>
<td>• Direction dependent – powerfully influenced by muscles with antagonistic actions</td>
<td></td>
</tr>
<tr>
<td>• +/- continuous activity throughout movement</td>
<td>• High threshold activations under situations of load &amp; speed</td>
<td></td>
</tr>
<tr>
<td>• Proprioceptive input re: joint position, range, &amp; rate of movement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Functional Classification of Muscle Roles

**Comerford & Mottram (2001)**

### Local Stability Muscle Role / Strategy Dysfunction
- Motor control deficits associated with **delayed timing** or **recruitment deficiency**
- Reacts to pain & pathology with inhibition
- Decrease muscle stiffness and poor sentimental control
- Loss of control of joint neutral position

### Global Stability Muscle Role / Strategy Dysfunction
- Muscle lacks the ability to 1) shorten through the full inner range of joint motion 2) isometrically hold position 3) eccentrically control the return
- **Inefficient low threshold tonic recruitment**
- Poor rotational dissociation
- If hypermobile – poor control excessive range
- Inhibition by dominant antagonists
- Altered recruitment patterns and uncontrolled movement with high threshold recruitment
- Strength deficits on high threshold recruitment

### Global Mobility Muscle Role / Strategy Dysfunction
- Loss of myofascial extensibility – limits physiologic and/or a accessory motion (which must be compensated for elsewhere)
- **Overactive** low threshold, low load recruitment
- Reacts to pain & pathology with spasm
- Demonstrates **uncontrolled sagittal movement** under high threshold recruitment testing
How Do We Identify a Muscle’s Primary Role?
Critical Appraisal of Muscle Characterization

Muscles ideal role should consider the co-relation of 4 significant features

**Supportive Findings**: then we can be reasonably confident that we understand a particular muscles primary functional role

- This support is only available for: TrA, EOA, RA, Hams

**Conflictive Findings**: then we can be reasonably confident that there is confusion, misunderstanding, or interpretation of a particular muscles primary functional role

**Reasons for confusion**:
- Discrepancies of measured features
  - QL, Lat, Piriformis
- Misinterpretation of measured features
  - Psaos Mj, U Trap, L Trap, VMO
- Muscle is designed to participate in more than one primary functional role
  - GMax, Infraspin

Large % muscles we work with on regular basis do not have enough information on all 4 features to claim adequate understanding of its 1st role

- Serratus Ant, Add Magnus, Subscap

**Function**
1. Anatomical location & structure
2. Biomechanical potential
3. Neurophysiology

**Dysfunction**
4. Consistent and characteristic changes in the presence of Pain or Pathology
Identifying a Muscle’s Primary Role

**Task Specific Muscles**

- Have a specific task oriented role associated with one classification.
- In the presence of pathology and/or pain, very specific dysfunctions can develop and are associated with the recognize specific primary role. These dysfunctions are consistent and predictable.
- The specific training is typically nonfunctional and designed to correct very specific elements of dysfunction.
- Training may or may not integrate into normal functional activity.

*There is no currently no method to predict or clinically measure automatic integration into normal function.*

- In many patients this integration has to be facilitated.
Identifying a Muscle’s Primary Role

**Multitasking Muscles**

- Less specific roles or participate in a variety of roles in normal function
- There is good evidence to support the muscle having
  - 1) both a local and global roles … or
  - 2) contribution to stability & mobility roles
  - Ex: glut max; infraspinatus, pelvic floor
- In *presence of pathology and/or pain*, a variety of different dysfunctions may develop
- These dysfunctions can be identified as being associated with either or all of the multitasking rolls and are related to the “weak links” in an individual’s integrated stability system
- Different dysfunctions can present with pain and are not predictable
- More detailed assessment is required with a clinical reasoning process
- Treatment and retraining has to address the particular dysfunction that presents, usually needs to be multifactorial, and should emphasize integration into normal function
What comes 1\textsuperscript{st} … Pain or Dysfunction?

**Global**
- Global muscle dysfunction can precede and contribute to the development of pain & pathology.
- Pain & pathology are not a necessary consequence of global muscle dysfunction.

**Local**
- Local muscle dysfunction does not precede the development of pain & pathology, but rather is due to pain & pathology.
- Pain & pathology does not have to be present in the presence of local muscle dysfunction (may be related to distant history).
Predisposition for recurrence

Continued global imbalance & tissue overload

Motor control deficit of the local stability system

Degenerative changes within the movement system

Pain & Pathology

Non-mechanical pain

Cumulative micro-inflammation

Trauma or injury

Direction-specific mechanical stress and strain of articular, myofascial, neuromeningeal, & connective tissues

Imbalance in the global stability system & loss of global control

Inhibition or functional weakness of the global stability muscles

Abnormal neuro-dynamic sensitivity

Increased stiffness or shortening of the global mobility muscles

Poor movement habits & / or poor postural alignment
Recruitment Changes Associated with Inhibition

In Stability Dysfunction:

**INHIBITION:**

can be identified as failure of normal recruitment

- **poor recruitment under low load stimulus**
  - evidence in both local & global system

- **delayed recruitment timing**
  - evidence in the local system

- **altered recruitment sequencing**
  - evidence in global system

PROBLEM: timing on order of millisec (60-150)

Inhibition ≠ “off”
Inhibition ≠ “weak”

Mounting evidence that the failure of low load recruitment efficiency is the most consistent & reliable indicator of recurrence injury & pain

Redefining Core Stability Rehabilitation

“core stability” has achieved generic status in exercise & fitness industry

- representing large range exercises from
  - almost imperceptible activation of deep abdominals … to …
  - lifting weights while balancing on a physioball
## Similarities & Differences between Core Rehabilitation Processes (Comerford 2009)

<table>
<thead>
<tr>
<th></th>
<th>Traditional Strengthening (Limbs)</th>
<th>Core Strengthening (Trunk)</th>
<th>Motor Control Stability (Global)</th>
<th>Motor Control Stability (Local)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Training Threshold</strong></td>
<td>high</td>
<td>high</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td><strong>Muscle Bias</strong></td>
<td>global mobilizers</td>
<td>global stabilizers</td>
<td>global stabilizers</td>
<td>local stabilizers</td>
</tr>
<tr>
<td><strong>Position/Plane of Primary Loading</strong></td>
<td>sagittal plane +/- coronal</td>
<td>neutral position +/- axial plane</td>
<td>neutral position +/- axial plane</td>
<td>neutral position +/- axial plane</td>
</tr>
<tr>
<td><strong>Type of Loading</strong></td>
<td>isotonic (concentric) +/- isometric &amp; isokinetic</td>
<td>isometric +/- isotonic (concentric)</td>
<td>isotonic (eccentric) &amp; isometric</td>
<td>isometric</td>
</tr>
</tbody>
</table>
Indications for **LOW LOAD TRAINING** of the **LOCAL SYSTEM** as a clinical priority

1. Relevant symptom presentation:
   a. assoc low load normal daily function
   b. non-direction specific pain
   c. assoc static position & all postures

2. Uncontrolled compensatory articular translation

3. History of insidious recurrence (prevention)

4. Poor voluntary low threshold recruitment efficiency

(Comerford 2009)
Indications for **LOW LOAD TRAINING** of the **GLOBAL SYSTEM** as a clinical priority

1. Relevant symptom presentation:
   a. assoc low load normal daily function
   b. direction specific pain - assoc specific direction movement provocation

2. Direction related mechanical pain

3. Low threshold recruitment imbalance between stabilizers & mobilizers

4. History recurrence - usu related precipitating event where specific direction of stress or strain is implicated in mechanism injury

5. Asymptomatic uncontrolled (direction specific) segmental movement

(Comerford 2009)
Indications for **HIGH LOAD TRAINING** of the **LOCAL SYSTEM** as a clinical priority

1. Relevant symptom presentation:
   a. unilateral pain
   b. Only assoc high load activity
   c. Direction specific pain - assoc specific direction movement provocation
   d. provoked with asymmetrical activity

2. Atrophy (disuse) or load related weakness

3. Rotation “give” under high load testing
   a. with unilateral or asymmetrical (rotational) load
   b. with bilateral or symmetrical (sagittal) load

(Comerford 2009)
Indications for **HIGH LOAD TRAINING** of the **GLOBAL SYSTEM** as a clinical priority

1. Relevant symptom presentation:
   a. midline pain
   b. only assoc high load activity
   c. Direction specific pain - assoc specific direction movement provocation
   d. symptoms provoked with symmetrical or sagittal (flexion/extension) activity

2. Atrophy (disuse) or load related weakness

3. Sagittal (flexion/extension) “give” under high load testing:
   a. with bilateral or symmetrical (sagittal) load
   b. with unilateral or asymmetrical (rotational) load

   (Comerford 2009)
Motor Control Stability vs Strength

<table>
<thead>
<tr>
<th>Strength</th>
<th>Good Motor Control</th>
<th>Poor Motor Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>++</td>
<td>-+</td>
</tr>
<tr>
<td>Weak</td>
<td>+−</td>
<td>−−</td>
</tr>
</tbody>
</table>

- Pain Free
- Painful

Good Performance → Poor Performance
Implications for Manual Muscle Testing

Motor Control Stability Assessment

- reliably tested under low-load conditions
- ability pass / fail low threshold test of motor recruitment:
  - PASS
    - no movement induced pathology
    - pain free function
  - FAIL
    - development of movement pathology
    - painful function

Muscle Strength Assessment

- ability pass / fail a test of resisting or supporting a high load
- graded 1-5
- PASS
  - good power
  - good endurance
  - performance
- Fail
  - weakness
  - loss performance
Low-Threshold Deficits

- only clinically and functionally identified with very specific test of low-load recruitment efficiency

- Some develop prior to onset of symptoms/injury … precursors or contributors Comerford et al 2001, Sahrmann 2002

- Evidence that it is a consistent and reliable predictor of recurrence Richardson et al 1998, Hides et al 2001
Historical Development of the Influence of Muscle Function on Movement and Performance

**Stretching & Strengthening**

**Traditional Strength**
Overload training for power & endurance

**Core Strength**
Overload training of trunk & girdle

**Core Strengthening**
McGill

**Assessment of Muscle Function**
Kendall & McCreary

**Sahrmann**
Global – whole body

**Janda**
Global – trunk & limbs

**Hodges, Richardson, Hides, Jull**
Global Trunk Stability – local spinal motor control stability

**Alternative Therapies & approaches**
Global – trunk & limbs

**O’Sullivan**
Integration of trunk stability into function

**Integrative Assessment of Motor Patterns**

**Leibenson**
Magnificent 7
Evidenced based synthesis – whole body

**Kinetic Control**
Comerford & Mottram
Evidenced based synthesis – whole body
Local & global motor control Test & Rx

**Functional Movement Systems**
Grey Cook
Evidenced based synthesis – whole body
Motor pattern Test & Rx – SFMA, FMS

**DNS**
Kolar
Motor Learning & Control

How are specific movement patterns selected out of the vast number of options available?
Motor Program Theory (MTP)

- Central control of movement instructions
- Neural Storage of motor plans

PROBLEMS:

- **Storage** – infinite volume
- **Novelty** – new: where does program originate
- **Motor Equivalence** – same action can be accomplished using different patterns – how is it a program

Schmidt – **Generalized Motor Program (GMP)**

- Not every action has a specific program
- Generalized programs that contain **rules for a large class of similar actions**
  - Reduces volume
  - New actions are versions of others
  - Not muscle specific – Invariant features – specified by program … timing, force … these define the class and decrease volume information stored
Contemporary evidence for Motor Patterns

1) studies of reaction time in humans
2) studies in which feedback has been removed (animals & humans)
3) studies on impact on performance when movement is expectantly blocked
4) analysis of behaviors when humans attempt to stop or change an action
5) studies of movements initiated by startling stimuli

Schmidt RA & Lee TD. *Motor Learning And Performance: From Principles to Application*. 5th Ed. 2013
Uncovering the Secrets of Human Memory

Case Study

- Head Trauma Age 9
- Progressive epilepsy b/l temporal lobes
- Age 23 – 1953 – Dr William Scoville at Hartford Hospital performed lobectomy b/l anterior two thirds of his hippocampi & amygdalae
- Cured Seizures & Lost short term memory
- Retained long term
- Retained & could still learn MOTOR SKILLS

H. M.
Henry Gustav Molaison
Feb. 26, 1926
Hartford, Connecticut
Dec. 2, 2008 (age 82)

http://thebrainobservatory.ucsd.edu/hm
http://www.bbc.co.uk/programmes/b00t6zqv

Brain was sliced 70 micrometers thin (2401 slices) 57 years worth of behavioral data
What Research Says About Muscle Memory

EMG result from:
1) agonist (upper) muscles & 2) antagonist (lower) muscles when subject:
1) actually produced movement (normal trial – RED) Agonist-Antagonist-Agonist “triple burst” of rapid movt
2) movement was blocked by a mechanical perturbation (blocked trial – BLUE) SAME PATTERN

Contradicts theories that feedback from moving limb activates antagonist at correct time

Wadman et al 1979
(taken Schmidt RA & Lee TD. Motor Learning And Performance: From Principles to Application. 5th Ed. 2013)
What Research Says About Brain Plasticity

Data from ACL rupture as model of peripheral joint injury
  • Compared w healthy indiv & those good vs bad outcomes


TMS (transcranial magnetic simulation) Studies:

*Increased requirements for movement planning, even for simple movements of flexion / extension only*

*All data supports that neuropastic changes occur after peripheral joint injury … modifications in cortical involvement*

Ward et al. Muscle & Nerve. 2015
What is Motor Control?

Brain knows movement patterns!! Not, muscles

Motor control patterns come from the brain, not muscles

Each pattern is highly characteristic “book” that sits on the shelf in our brain

Motor programs are planned in advance and executed without many changes in the triggered action for at least first 120ms

Skill memory is processed in the cerebellum, which relays information to the basal ganglia. It stores automatic learned memories like tying a shoe, playing an instrument, or riding a bike
What is Motor Control?

- Poor movement can exist anywhere in the body … Poor movement patterns exist to large extent in the brain.

- Dysfunction in motor control results in “Functional” pathology.

- Altered or restricted movement patterns.

Principle 1:

TRAIN THE BRAIN, Stop training muscles !!!
Causes of Restricted Mobility

1) Soft-Tissue Dysfunction
   Generally identifies multi-articular dysfunction
   - Fascial tension
   - Neural tension
   - Muscle shortening
   - Hypertrophy
   - Active/Passive muscle insufficiency
   - Trigger Points
   - Type I SDs
   - Scarring & fibrosis

2) Joint Dysfunction
   Generally identifies single-segmented dysfunction
   - Type II SDs
   - Articular Restrictions
   - Subluxation / Dislocation
   - Adhesive Cap
   - Osteoarthritis
   - Fusion or Instrumentation

3) Stability / Motor Control Dysfunction
   Generally identifies multi-segmented dysfunction
   - Brain problem
   - Not local issue
   - Can resolve with treatment of local resisted pathologies
   - Can persist despite lack local pathologies
Normal ROM Barriers

- Physiological Barrier (Active ROM)
- Elastic Barrier (Passive ROM Limit)
- Anatomical Barrier

Mobility (ST/JT) Restriction ROM Barriers

- Elastic Barrier
- New Passive ROM
- Pathological Barrier
- New Active ROM
- Pathologic Neutral

Movement Pattern Dysfunction ROM Barriers

- Elastic Barrier
- Normal Passive ROM Limit
- Apparent Pathological Barrier
- New Apparent “Active” ROM Limit
- Pathologic Neutral
Skill Acquisition

- **Skills** are those that demonstrate
  - **Consistency** – repeatable over period of trials
  - **Flexibility (transferability)** – modifiable with changing environment
  - **Efficiency** – sustainable with endurance

Stages of Skill Acquisition

- **Initial**
  - learn basic movement
  - Identify components environment important to task

  *Should be encouraged to actively explore the environment thru trial & error*

  *Learning is not linear*

- **Later** – less cognitive

Measurement of Motor Learning

- **Acquisition** – initial practice of new skill
- **Retention** – ability to demonstrate attainment goal or improvement following a delay in practice
- **Transfer** – performance of task similar in movement yet different

Acceptable *performance* of a motor skill within a single session (or series of sessions) does NOT demonstrate that the skill has been learned

**Skill is not learned** until retention & transfer is demonstrated

So What’s the Best Way to Train for the Brain?

Promoting Skill Acquisition

<table>
<thead>
<tr>
<th>Block Training</th>
<th>Random Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Do one exercise for a certain number of repetitions per set</td>
<td>- Do multiple exercises per set and one rep of each</td>
</tr>
<tr>
<td>- Each rep has the same movement</td>
<td>- Each rep has some different movement</td>
</tr>
<tr>
<td>- No stopping between reps</td>
<td>- Take time with each rep</td>
</tr>
<tr>
<td>- Focus on form</td>
<td>- Focus on feel</td>
</tr>
</tbody>
</table>
Random vs Blocked Practice

Jerky

FORM

Smooth

PRACTICE

RANDOM

BLOCKED
Random vs Blocked Practice

- **Random**
- **Blocked**

**Jerky** vs **Smooth**

FORM

PRACTICE vs RETENTION
Random vs Blocked Practice

Jerky vs Smooth Form

Random vs Blocked Practice

PRACTICE

Retention Block Random
So What’s the Best Way to Train for the Brain?

Random vs Blocked Practice

Even though random conditions result in much less skilled performance than blocked conditions in acquisition ... random practice conditions produce more motor learning

Principle 2:

TRAIN RANDOMLY, Reduce Block Training !!!
Illusions of Learning

Jerky

FORM

Smooth

PRACTICE
Illusions of Learning

- Jerky
- Smooth

FORMATION

PRACTICE

Predicted

RETENTION
Motor Programs are Different than Cognitive Skills

- Retention of motor skills is better and more enduring than factual information
- If you write a “book” you can’t change the book
- Motor programs are almost never lost, just put on the shelf
- In some cases, they may have never been learned
- You CAN always write a new book

**Principle 3:**
WRITE A NEW BOOK or RECALL AN OLD ONE, Stop trying to change the old one !!!
How to Provide Feedback during motor control retraining

Possible Types

- Fading Techniques
- Learner Requested Feedback
- Error-Detection Feedback
- Performance Bandwidth
- Summary Technique
- Playing Stats
How to Provide Feedback during motor control retraining

Possible Progression

- Start with Performance Based Feedback
- Ask for Patient Feedback with a successful pattern
  - Learn *THEIR* language and adapt your words
  - Ask them: “What did that one *FEEL* like to you”
- Move quickly to Error-Detection Feedback (Random)
  - Provide feedback based on their response
- Performance Bandwidth feedback next
- Learner Requested Feedback next
- Summary Technique after time

Principle 4:
Allow them to learn from mistakes, don’t overdue feedback
How do we choose to sample or screen motor patterns?

Which patterns should we choose?
Historical Development of the Influence of Muscle Function on Movement and Performance

**Stretching & Strengthening**

- **Traditional Strength**
  - Overload training for power & endurance

- **Core Strength**
  - Overload training of trunk & girdle

- **Core Strengthening**
  - McGill

**Assessment of Muscle Function**

- **Sahrmann**
  - Global – whole body

- **Janda**
  - Global – trunk & limbs

- **Hodges, Richardson, Hides, Jull**
  - Global Trunk Stability – local spinal motor control stability

- **Alternative Therapies & approaches**
  - Global – trunk & limbs

- **O’Sullivan**
  - Integration of trunk stability into function

**Integrative Assessment of Motor Patterns**

- **Kinetic Control**
  - Comerford & Mottram
  - Evidenced based synthesis – whole body
  - Local & global motor control Test & Rx

- **Functional Movement Systems**
  - Grey Cook
  - Evidenced based synthesis – whole body
  - Motor pattern Test & Rx – SFMA, FMS

- **Lewit**

- **Kolar**
  - DNS

- **Leibenson**
  - Magnificent 7
  - Evidenced based synthesis – whole body
Normal sequence of learning movement follows:

- Breathing
- Grasping / Gripping
- Head & Eye Movement
- Limb Movement
- Rolling
- Crawling
- Kneeling
- Transitional Movements
- Standing

Tree of Growth

https://www.youtube.com/watch?v=elkRygLpcNk
https://www.youtube.com/watch?v=8zuUV6fz-iU
The Selective Functional Movement Assessment
Top Tier Screen

1) **Active Cervical ROM**
   - Active Cervical Flexion
   - Active Cervical Extension
   - Active Cervical Rotation

2) **Upper Extremity Patterns**
   - Pattern 1: MRE -
   - Pattern 2: LRF -

3) **Multi-Segmental Flexion**
   (Touch your Toes)

4) **Multi-Segmental Extension**
   (Hands overhead Backward Bend)

5) **Multi-Segmental Rotation**
   (Standing Rotation Test)

6) **Single Leg Stance**

7) **Overhead Deep Squat**

<table>
<thead>
<tr>
<th>FN</th>
<th>FP</th>
<th>DP</th>
<th>DN</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image_url" alt="Image" /></td>
<td><img src="image_url" alt="Image" /></td>
<td><img src="image_url" alt="Image" /></td>
<td><img src="image_url" alt="Image" /></td>
</tr>
</tbody>
</table>

Increasing Neurodevelopmental Order
When Should We Suspect Stability / Motor Control Dysfunction?

- History of recurrence
- Traumatic hypermobility (passive restraints)
- Lack of ability for typical muscles prone to tightness to reproduce extensibility (recurrent stiffness)
- Abnormal muscle firing sequences on ROM testing
  - “Weak” phasic muscles on exam
  - Easy fatigability of phasic muscles
  - Poor “core” strength
- Poor proprioception (esp w eyes closed)
- Poor awareness of axial position sense
- Need for frequent OMT, recurrent SD
Final Thoughts

Movement patterns come from the brain …

These patterns MUST be retrained after mobilization procedures to ensure

… a change in the engram within the brain

a change with how one will use their newfound ROM – it is often not automatic

Think gross motion in assessing these patterns

Improvements in hip flexibility do not transfer to mobility in functional movement patterns.
Understanding Movement & Function

This lecture/workshop is based on the clinical approach to the assessment and correction of movement dysfunction, with concepts integrated and developed from the following sources:

- Clinical development & collaborative research: KineticControl.com - Mark Comerford, Sarah Mottram, Sean Gibbons, Clark, Silvester, Bunce, Enoch, Andreotti, & Strassel
- Late Vladimir Janda, MD Check Republic
- Phillip Greenman, DO: Michigan State University, USA
- P Gunner Brolinson, DO, FAOASM, FAAFP: Virgin Polytechnic Insti & State Univ, Blacksburg, VA, USA
- S Sahrmann: Washington University, St Louis USA
- Perform Better: Gary Gray & Grey Cook
- Richardson, Jull, Hodges, & Hides: Physiotherapy Depart, Univ Queensland, Australia
- D Lee: Ocean Pointe Physiotherapy Consultants, White Rock, BC, Canada
- Vleeming & Snijders (Research Group Musculoskeletal System), Erasmus University, Rotterdam, Netherland
- Physiotools, Finland
- Ben Kibler, MD; USA
PERFORM BETTER!

3-DAY
FUNCTIONAL TRAINING SUMMITS

April 28 – 30, 2006
CHICAGO, IL

June 2 – 4, 2006
LONG BEACH, CA

July 21 – 23, 2006
PROVIDENCE, RI

Featuring
38 NATIONALLY KNOWN AND WELL-RESPECTED PROFESSIONALS

Home
About Us
Team
Courses
Our Courses
Upcoming Courses
The KC Process
KC Course Principles
Resources
Publications
Proceedings
References
Clinical Notes
News
Newsletter
Contact Us
Login

For Further Information Call Toll Free 800-555-7464 or Visit performbetter.com/seminars

Kinetic Control

The Modular System
Choose what you want to learn from our range of training courses. Build a bespoke learning programme that matches your specific learning requirements.

Theory & Concepts
Understanding Movement & Function - Assessment and Retraining of Uncontrolled Movement

Lumbar
Diagnosis of Uncontrolled Movement, Subgroup Classification and Motor Control Retraining of the Lumbar Spine

Thoracic Spine
Diagnosis, Mobilisation & Motor Control Retraining of the Thoracic Spine and Ribs

Neck
Diagnosis, Subgroup Classification & Motor Control Retraining of the Neck

Sacro-Iliac Joint
Diagnosis, Mobilisation & Functional Motor Control Retraining of the Sacro-Iliac Joint and Pelvis

Shoulder
Diagnosis, Subgroup Classification & Motor Control Retraining of the Shoulder Girdle
The Selective Functional Movement Assessment
Second Tier Breakouts

Mobility Restriction or Stability/Motor Control Impairment

Logic used:

- Ask what local joint movements are required for each movement pattern?
- Can you eliminate a body part? Unilateral vs Bilateral
- Can you change the stability requirements? Loaded vs Unloaded
- Confirm – compare Active vs Passive ROM
Example:

Logic used:

- Ask what local joint movements are required for each movement pattern?

- Can you eliminate a body part? Unilateral vs Bilateral

- Can you change the stability requirements? Loaded vs Unloaded

- Confirm – compare Active vs Passive ROM
SFMA Rehabilitative Approach

Laws of SFMA:
- Treat Mobility problems BEFORE stability correction
- Treat DN’s before DP’s
- Treat DP’s before FP’s
- Treat T-spine mobility problems before shoulder
- Treat T-spine mobility problems before lumbar

Once mobility problems are eliminated, If a stability problem still exists, must first do a fundamental test to r/o fundamental pattern problem
  - Supine & Prone, Upper & Lower Body Rolling Tests
Mobility vs Stability

MOBILITY
Joints w multiplane plane motion

STABILITY
Joints w primarily single plane motion

Joint by Joint Approach.
Boyle M. 2010
In Dysfunction

MOBILITY

THEY BECOME STIFF & INJURED
(need mobility)
- Ankle
- Hip
- Thoracic

STABILITY

THEY BECOME UNSTABLE
(Need Stability)
- Foot
- Knee
- Lumbopelvic
- Shoulder
- Cervical

Joint by Joint Approach.
Boyle M. 2010
"Real World" Muscle Function

Motor pattern of Ecconcentric Contraction

- def: During functional activity, different portions of the *same muscle* may undergo concentric, eccentric, isometric, or even *no* activity, simultaneously.

- Human function is three dimensional - All of our core functional activities require an integrated NMS system that reacts and moves in all three planes simultaneously.

- Walking forward obviously includes sagittal plane motion, but actually is dominated by transverse plane motion with significant frontal plane motion occurring concurrently.

- Successful standing and balancing requires three dimensional capabilities of the NMS system throughout the chain reaction.

Structure / Function Reciprocity

- Has moved beyond ‘simple’ muscle and bone to:
  - **BioTensegrity** (Levin)
    - Macro - system integration
    - Micro - Individual cellular structure
    - Nuclear - Proteonomics
  - **Neuromuscular Balance**
    - Systemic neuromotor integration of stability
    - Engrams or motor patterns
  - **Real Word Muscle Function** (G Brolinson & G Gray)
    - Eccentric contraction
    - Supination / Pronation Link (Spiral Power)
Basis of Functional Approach

Interdependence of all structures from both the CNS & MSK system in production and control of motion

- Osteopathic Principles
- Tensegrity / Biotensegrity
- Fascial Continuity

The muscle system lies at a functional crossroad because it is influenced by stimuli from both CNS & PNS system

Dysfunction any component of either of these systems is reflected in the MSK SYSTEM as:

- altered muscle tone
- muscle contraction
- muscle balance
- Dis-coordination
- altered motor patterns
- altered performance
Joint Stability

FORCE CLOSURE + FORM CLOSURE = CLINICAL STABILITY

Stability Dysfunction

- Bony Problem (Surgical)
- Enthesopathy: Ligament Laxity Tendinosis
- Neuromuscular Imbalance

CLINICAL INSTABILITY
Janda References

Distributed by: OPTI, PO Box 47009, Minneapolis, MN 55447-0009. (763) 553-0452.
Distributed by: OPTI, PO Box 47009, Minneapolis, MN 55447-0009. (763) 553-0452.


<table>
<thead>
<tr>
<th>Joint</th>
<th>Local Stabilizer</th>
<th>Global Stabilizer</th>
<th>Global Mobiliser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee</td>
<td>Popliteus VMO</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intrinsicsis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tibialis Posterior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foot / Ankle</td>
<td></td>
<td>Tibialis Posterior (CKC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tibialis Anterior</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soleus</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Biceps Femoris</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ITB (TFL &amp; SGM)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lateral Retinaculum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rectus Femoris</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gastroc</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Soleus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Peroneals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gastroc</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Toe flexors</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Toe Extensors</td>
</tr>
</tbody>
</table>
Principle Centered Rehabilitation

Treatment Thinking vs Preventive Thinking

Functional Analysis Rehabilitative Method:

- Goal: find root cause
- Functional evaluation / testing
- “Causative Cure” and “Integrated Isolation”

Real World muscle function

Consideration of Compensations

Success Imperative

Principle Centered Rehabilitation

**Pronation:**
- Chain collapse
- Shock absorption
- Reaction to gravity & ground reactive forces
- Succumbs to gravity
- Eccentric (deceleration) muscle function

**Supination:**
- Chain elongation
- Propulsion
- Overcomes gravity
- Concentric (acceleration) muscle function

“The transformation of pronation into supination is the KEY to the process of the locomotor system in sport movement”

Brolinson & Gray

This transformation is dominated by Isometric (stabilizing) and ecconcentric muscle function: a deceleration of motion at one joint and acceleration of motion at another joint or in another plane, all at the same time.
Principles of the Exercise Prescription

- **Spectrum** of Rehabilitation
  - *NOT* stages
    - Acute - Inflammation
      - Tools – rest/modalities/sensory balance/early mobilization
    - Recovery - Fibrosis
      - Tools – directional movements (unloaded), mobilization, specific progression, flexibility, proprioception
    - Retraining - Sclerosis
      - Tools – directional movements (loaded), functional program, power, endurance, skills

- Comprehensive functional spectrum therapy *begins with* function and *ends with* function

- Motion, stability, flexibility, and strength are facilitated concurrently and not independently
Principles of Stability Rehab

- Local/Global Stability System – **Control of Direction**
  1. Retrain Dynamic Control of the Direction of Stability Dysfunction
     - *Motor Control & Co-ordination of direction specific stress & strain*

- Local Stability System – **Control of Translation**
  1. **Control** of Translation in the Neutral Joint Position
     - *Low Threshold Recruitment of the local stability system to control articular translation*

- Global Stability System – **Control Of Imbalance**
  1. Rehabilitate Global Stabiliser **Control** through Range
  2. Rehabilitate Global Stabiliser **Extensibility** through Range
     - *Balancing functional length and recruitment dominance between global synergists*
Principles of Stability Rehab

Local/Global Stability System – Control of Direction

- Retrain Dynamic Control of the Direction of Stability Dysfunction
  - Control the ‘give’ & Move the restriction
  - Retrain control in the direction of symptom producing movements
  - Use *low load integration* of local and global stabiliser muscle recruitment to control and limit motion at the segment or region of ‘give’
  - Then actively move the adjacent restriction
  - Only move through as much range as the restriction allows or as far as the ‘give’ is dynamically controlled

- Control of direction directly unloads mechanical provocation of pathology and therefore is the key strategy to symptom management

Motor Control & Co-ordination of direction specific stress & strain
Principles of Stability Rehab

Local Stability System – Control of Translation

Control in the Neutral Joint Position

− Retrain tonic, low threshold activation of the local stability muscle system to increase muscle stiffness and train functional low load integration of the local and global stabiliser muscles to control abnormal translation in the neutral joint position

− Low Threshold Recruitment of the local stability system to control articular translation
Principles of Stability Rehab

Global Stability System – Control Of Imbalance

Rehabilitate Global Stabiliser Control through Range

- Rehab to control the full available range of joint motion
- These muscles are required to actively shorten and control limb load through to the full passive inner joint ROM
- They must also control any hypermobile outer range
- Control of rotational forces is critical
- Eccentric control of range is more important than concentric
  - Optimised by low effort, sustained holds in the muscles shortened position with controlled eccentric lowering

Rehabilitate Global Stabiliser Extensibility through Range

- When the 2-joint global mobility muscles demonstrate a lack of extensibility due to overuse or adaptive shortening, compensatory overstrain or ‘give’ occurs elsewhere in the kinetic chain in an attempt to maintain function
- Need to lengthen or inhibit dominance or over-activity in the global mobilisers to eliminate the need for compensation to keep function
  - Balancing functional length and recruitment dominance between global synergists