The Model of Regional Interdependence

Jennifer Shamus, MSPT, DPT, PhD, COMT

Regional Interdependence

Dysfunction and impairments in distant regions, both extremity and spine may precipitate or perpetuate the patient’s primary complaint

• Need to examine all joints proximal and distal to the region of the reported pain and dysfunction
• It is important to remember, regional interdependence is different than referred pain.
• The regional interdependence model focuses on how joints interact with each other neurologically and biomechanically


Regional Interdependence

• “With respect to musculoskeletal problems, regional interdependence (RI) refers to the concept that seemingly unrelated impairments in a remote anatomical region may contribute to, or be associated with, the patient’s primary complaint.”
• Important during history taking and objective exam

• There are numerous examples in the literature of the concept of regional interdependence being a viable option for PT examination and intervention planning.

• Start with the upper quarter
  
  • Tyler Shultz
  • [http://www.physio-pedia.com/Regional_Interdependence#cite_note-Reg-1](http://www.physio-pedia.com/Regional_Interdependence#cite_note-Reg-1)

Interventions aimed at the elbow have been used to treat:

• Shoulder
  – Mobilization with movement applied to the elbow affects shoulder range of motion in subjects with lateral epicondylalgia

  – Abbott
  – [Manual Therapy](http://manualtherapy.com)
  – Related to decreased shoulder ROM
Elbow MWM affects Shoulder ROM

– 23 subjects
– Significant differences in pre-intervention ER/IR ROM were found between unaffected and affected shoulders of subjects with lateral epicondylalgia
– No significant difference remained post-intervention
– Intervention addressed a facilitated level of shoulder rotator muscle tone
– These ROM increases are also apparent on the ‘unaffected’ limb. These findings suggest that the MWM causes a neurophysiologically mediated decrease in resting muscle tone.

Interventions aimed at the cervical Spine have been used to treat:

• Elbow

– Prevalence of pain and dysfunction in the cervical and thoracic spine in persons with and without lateral elbow pain

  – Bergland, Persson & Denision
  – Manual Therapy
  – Volume 13, Issue 4, August 2008, 295–9
  – Cervical and thoracic pain accompany lateral elbow pain
Pain in the C/S and T/S: Elbow Pain (C2-T7)

- 31 subjects with lateral elbow pain and 31 without lateral elbow pain.
- The assessment comprised a pain drawing, provocation tests of the cervical and thoracic spine, a neurodynamic test of the radial nerve, and active cervical range of motion.
- 70% of the subjects with lateral elbow pain indicated pain in the cervical or thoracic spine, as compared to 16% in the control group ($p<0.001$).
- The frequency of pain responses to the provocation tests of the cervical and thoracic spine was significantly higher ($p<0.05$) in the lateral elbow pain (LEP) group.

Pain in the C/S and T/S: Elbow Pain (C2-T7)

- Frequency of pain responses to the neurodynamic test of the radial nerve were higher ($p<0.001$).
- Cervical flexion and extension ROM was significantly lower ($p<0.01$) in the LEP group.
- A relationship between lateral elbow pain and pain in the vertebral spine (C2–T7). The cervical and thoracic spine should be included in the assessment of patients with lateral elbow pain.
Interventions aimed at the Cervical Spine have been used to treat:

- Lateral Elbow Pain
  - Screening for Head, Neck, and Shoulder Pathology in Patients with Upper Extremity Signs and Symptoms
  - Lateral elbow pain referred from cervical spine

  - Yung, Asavasopon & Godges
  - *Journal of Hand Therapy*

Additional Research to Support the Model

- Lateral Epicondylitis
Interventions aimed at the thoracic spine and ribs have been used to treat:

- Neck pain

Interventions aimed at the thoracic spine and ribs have been used to treat:

- Shoulder Impingement Syndrome
Interventions aimed at the thoracic spine to treat the UE

- T4 syndrome:
  - Mobilization of T4 region eliminates hand paresthesias and pain

T4 Syndrome

- A clinical pattern that involves upper extremity paresthesias and pain with or w/o symptoms into the head or neck (Maitland, 1986)
- Mobilization of an upper thoracic vertebrae (T4) reproduces or eliminates these symptoms (Grieve, 1988)
- The sympathetic nervous system may provide a pathway for referral from the thoracic spine to the head and arms, but the link between the sympathetic and the somatic nervous system is not clearly understood (Evans, 1997).
Interventions aimed at the thoracic spine have been used to treat:

• Shoulder

• The short-term effects of thoracic spine thrust manipulation on patients with shoulder impingement syndrome

  • [Robert E. Boylesa, Bradley M. Ritlandb, Brian M. Miracleb, Daniel M. Barclayb, et al.](#)

---

Thoracic Spine: Shoulder Impingement

• 56 patients (40 males, 16 females; mean age 31.2 ± 8.9) with SIS underwent a standardized shoulder examination, immediately followed by TSTM techniques. Outcomes measured were the Numeric Pain and Rating Scale (NPRS) and the Shoulder Pain and Disability Index (SPADI), all collected at baseline and at a 48-h follow-up period. Additionally, the Global Rating of Change Scale (GRCS) was collected at 48-h follow-up to measure patient perceived change.
Thoracic Spine: Shoulder Impingement

- At 48-h follow-up, the NPRS change scores for Neer impingement sign, Hawkins impingement sign, resisted empty can, resisted external rotation, resisted internal rotation, and active abduction were all statistically significant ($p < 0.01$).
- The reduction in the SPADI score was also statistically significant ($p < 0.001$) and the mean GRCS score = $1.4 \pm 2.5$.

Cervical / Thoracic Spine: Carpal Tunnel Syndrome

- Cervical and thoracic mobes alleviate carpal tunnel syndrome

- Manual Therapy Vol. 10(4)292-296, 2005
- Conroy & Schneiders
Thoracic Spine: Adhesive Capsulitis

- Adding thoracic spine mobilizations to the treatment program increased active shoulder flexion ROM by 25 degrees in a patient with Adhesive capsulitis

  - McCormack, Joshua R

Lower Quarter

- “When the foot hits the ground everything changes”
- Biomechanically, the calcaneus everts …..

  - Barton et al. Sports Med. 2010
  - McPoil et al. JAPMA. 2011
Interventions aimed at the knee have been used to treat:

• Ankle
• The initial effects of knee joint mobilization on osteoarthritic hyperalgesia
• Knee mobilizations decreased pressure pain threshold in other sites (i.e. ankle)
• Rat study with capsaicin
• CRPS

• Moss P, Sluka K, Wright A.

Knee Mobilization: Pain: Ankle

• 38 subjects Thirty-eight subjects with mild to moderate knee pain participated.
• 9-min, non-noxious, AP mobilization of the tibio-femoral joint were compared with manual contact and no-contact interventions.
• Pressure pain threshold (PPT) and 3-m ‘up and go’ time were measured immediately before and after each intervention.
Knee Mobilization: Pain: Ankle

• Results demonstrated a significantly greater mean (95% CI) percentage increase in PPT following knee joint mobilization than after manual contact or no-contact
• Knee joint mobilization also increased PPT at a distal, non-painful site and reduced ‘up and go’ time significantly more than manual contact or no-contact control
• Accessory mobilization of an osteoarthritic knee joint immediately produces both local and widespread hypoalgesic effects

Interventions aimed at the SI have been used to treat:

• Weight distribution
• Immediate and lasting improvements in weight distribution seen in baropodometry following a high-velocity, low-amplitude thrust manipulation of the sacroiliac joint

• Daniel de Oliveira Grassia,
• Marcial Zanelli de Souza,
• Silvia Belissa Ferraretto,
• Maria Imaculada de Lima Montebelo,
• Elaine Caldeira de Oliveira Guirro,
• Manual Therapy. 2011;16:495-500
SIJ Mobilization: Weight distribution

• 20 asymptomatic subjects were submitted to computerized baropodometric analysis before, after, and seven days following sacroiliac manipulation.
• Data revealed significant reduction in peak pressure immediately after manipulation and at follow-up when compared to pre-manipulative values ($p < 0.05$). Strong correlation was found between the dominant foot and the foot with greater contact area ($r = 0.978$), as well as between the side of joint restriction and the foot with greater contact area ($r = 0.884$).
• The results suggest that sacroiliac joint manipulation can influence peak pressure distribution between feet.

Interventions aimed at the SI have been used to treat:

• Knee
• Isolated Knee Pain: A Case Report Highlighting Regional Interdependence

• Daniel W. Vaughn
  *doi:10.2519/jospt.2008.2759*
SIJ: Knee Pain

• Isolated Knee Pain: A Case Report Highlighting Regional Interdependence
  • Background A number of pain referral patterns for sacroiliac dysfunction have been reported in the literature. However, very little has been written about pain localized to the knee joint for cases involving sacroiliac dysfunction.
  • Case Description A 25-year-old female runner was self-referred to physical therapy for medial knee pain of 4% weeks’ duration without a significant onset event. The pain completely curtailed her training for the Boston Marathon. Examination of the patient’s knee and hip did not reveal any abnormal findings and there was no reproduction of pain with any test procedures except for medial knee joint tenderness to palpation. Additional, more proximal examination suggested significant asymmetry of sacral bony landmarks of the pelvic girdle without significant findings on the provocation tests of the sacroiliac joint. A single session of manual therapy procedures directed to the pubic symphysis and sacroiliac joint ipsilateral to the side of knee pain was provided.
  • Outcomes The patient was able to return to running without further incident of knee pain after a single therapy session.
  • Discussion This case suggests the importance of regional interdependence in the examination of patients with an apparently common clinical problem. Furthermore, the case describes a previously unreported presentation of local knee pain possibly attributable to sacroiliac joint dysfunction.

Regional Interdependence

• Maigne’s syndrome
• Thoracolumbar junction syndrome
• Presentation:
  – Low back pain – lumbar and SIJ
  – Groin/pubic symphysis
  – Lower abdominal pain
  – Trochanteric bursitis

Interventions aimed at the Hip have been used to treat:

• Knee pain
  
  

Interventions aimed at the Hip have been used to treat:

• Low back pain
  
  
  
Regional Interdependence

- 70 y.o. with complaints of 7/10 knee pain for 3 months
- History of 1/10 lumbar pain for 10 years
- Treatment to knee and lumbar spine x 12 visits
- 0/10 pain and follow-up at 1 year no return of symptoms


Manual Therapy

- Manipulation and mobilization
  – Not the only possible interventions
Muscle Energy

• Golgi tendon organ activation results in direct inhibition of agonist muscles
• A reflexive reciprocal inhibition occurs at the antagonistic muscles
• As the patient relaxes, agonist and antagonist muscles remain inhibited allowing the joint to be moved further into the restricted range of motion.

Muscle Energy

• Applications:
  – To lengthen a shortened muscle
  – To mobilize an articulation with restricted mobility
    • Release an entrapped meniscoid
  – To strengthen a physiologically weakened muscle
  – To reduce localized edema and passive congestion
Muscle Energy

• Subjects with non-specific low back pain
• Immediate decrease in pain level
• But when used without other interventions, it is a transient effect


Muscle Energy

• MET
• Neuro re-ed
• Resistance training
• = decreased pain and increased function

Muscle Energy

– Increased cervical ROM (7 visits)
– Increased lumbar ROM (8 visits)

• Shenk
• J of Manipulative Therapy
• 1994 (2) and 1997 (5)

Muscle Energy

• J of Osteopathic Medicine
• 2003 (6) Lenehan
  – Increased thoracic mobility

• 2004 (7) Freyer
  – Increased OA mobility
Joint Mobilization/Manual therapy

Therapeutic touch was first documented in Western medicine by Hippocrates (c. 400 B.C.)

• About 500 yrs. Earlier in Eastern medicine

An Introduction to Manual Therapy

• In Europe and North America, the practice of ‘bone-setters’ or lay people skilled in manual therapy evolved into 3 dominant schools of thought:
  • Osteopathy (1872)
  • Chiropractic
  • Manual Physical Therapy (1950’s)
Joint Restrictions/Interdependence

- Joints should have a normal end feel and position

- Joint mobilization:
  - Passive movements of a joint performed to have a mechanical AND neurological effect.
  - These techniques can be performed as a sustained stretch or with an oscillatory movement
  - Afferent input = impact TONE and DYSFUNCTION

So how does it work?

- MT is believed to have impact on at least 3 levels:
  - Biomechanical
  - Neurophysiological
  - Psychophysiological
Biomechanical Considerations

• What about the Concave – Convex Rule?
• “...the physiotherapist should not mobilize a pathological joint according to a rule, but treat clinical findings, which are in correlation with the patient’s complaints.”
• Schomacher 2009

Neurophysiological

• MT has a profound but transient impact upon neurophysiology. This can be divided into 3 components:
  • Peripheral
  • Spinal
  • Supraspinal
Peripheral Neurophysiological Effects

• MT stimulates cutaneous and articular mechanoreceptors which can modulate muscle tone and pain.
• MT has been shown to impact the local tissue environment via its impact upon nociceptor function.

Spinal Neurophysiological Processes

• MT is associated with decreased Dorsal Horn sensitization =
  • Alteration in muscle tone
  • Alteration in motor neuron pool activity
  • Alteration in afferent discharge
  • Alteration in fluid dynamics
Neurophysiological

- The presence or absence of positional faults has yet to be determined by the literature
- Perhaps there is not a lasting change in bone position
- However, we are providing input into the CNS
- Non-opiod pain control “Hypoalgesia”
- Mediated by the Endogenous Descending Pain Inhibitory System (DPIS)

Supraspinal Mechanisms

- MT has been shown to impact supraspinal descending pain inhibition
- JOSPT May 2013
- Reduced activation and
- Cerebral blood flow in the insular cortex after
- Thoracic manipulation
Psychophysiological Effects

• Expectation of outcome impacts effectiveness of MT.

• Articular MT has also been shown to positively impact psychological outcomes.

• Placebo Effect

In conclusion...

• Manual Therapy appears to work at various levels rather than just mechanically.

• Evidence is steadily accumulating to support its utilization in a variety of disorders.
More References


References

• Maitland GD. Peripheral Manipulation 5th ed. 1986
Applying the same concepts

• To lengthen muscles?

Static Stretching

• Medicine and Science in Sports and Exercise, 2004 (Power, K)
• Passive stretch
  – decreases strength,
  – vertical jump height and
  – explosiveness
Static Stretching

- J of Strength and Conditioning Research 19(3)
- Aug. 2005

- Static stretch of 30 sec or no stretching
  - No change in leg extension performance
- Dynamic stretch
  - Leg extension power was greater (.001)

Static Stretching?

- J of Strength and Conditioning Research 17(3)
  - Aug. 2003
  - Used EMG and mechanomyography

- Static stretch of 30 sec. (3 positions)
  - Decreased torque production in the bicep brachii
- Greater production of torque w/o stretching
  - Due to musculotendinous stiffness
  - Not number of motor units activated
Static Stretching

- Canadian J of Applied Physiology 26(3), 2001

- Static stretching
  - Quadriceps showed decreased force production
  - 12% decrease in max voluntary contraction
  - Muscle inactivation increased by 20% (iEMG)
  - Twitch force decreased by 11.7%
  - They don’t think it is an elasticity issue, though

Static Stretching??

- J of Strength and Conditioning Research 18(2)
  - 2004

- 3 static stretches on only 1 limb
  - Leg extensor strength decreased on both sides

- Perhaps the response is mediated by the central nervous system
Stretching

• Dynamic stretching is beneficial before running or an athletic event
• J Strength and Conditioning, April 2006
• Roundtable discussion on flexibility training
  **Incorporate dynamic training for neuro re-education**
• Lab: Dynamic stretches

• Essentials of Strength Training and Conditioning NSCA best reference

---

Stretching

• IF THE PATIENT LOVES TO STRETCH
• See if you can change them to contract/relax
• Check their form
• Hold time – decrease to 15 sec or less
• Use them after running!
Hypertonicity

– Our best influence on muscle length is by addressing TONE

– Is the muscle in a relaxed state when it should be?

Detonification

• When combined with a program of joint mobilization and strengthening, there can be lasting effects in muscle length
Does order matter?

- Joint mobilization
  - Can detonify a muscle
- Followed by detonification techniques
  - Takes less time to accomplish your goal

Lab: Detonification

- Lateral bending
  - Displace muscle laterally to fullest extent over 7 sec
- Passive pump
  - Apply pressure while lengthening the muscle
  - Ease pressure as the muscle lengthens
- Active pump
  - Apply pressure while asking the patient to gently contract the muscle
  - Ease pressure as the muscle shortens
Lumbar Spine

• Sidelying Rotations
• Lateral bending
• Passive pump
• Active pump
  – Erector spinae
  – Quadratus lumborum
• Prone rotations
• Lateral bending
• Passive pump
• Active pump
  – Hamstrings

Lumbar Spine

• Neuro re-ed
  – Sidelying upper trunk and lower trunk rotation
  – Kneeling upper trunk rotation
  – Prone ham curl (Light switch)
• Strength
  – Multifidi and oblique exercises
Lumbar spine **

- Psoas and Iliacus

- Strain Counterstrain
  - Prone opposite arm and leg raise

- SIJ Dysfunction
  - Isometric hip adduction/abduction

Hip

- SI and IS mobilizations
- Lateral bending
- Passive pump
- Active pump
  - Piriformis

- Seated or supine
  - Quadriceps
Hip

• Neuro re-ed
  – Prone hip IR/ER

• Strength
  – Clam shells
  – Theraband
  – Sidelying hip abduction

Knee

• Superior tib/fib joint
• Lateral bending
• Passive pump
• Active pump
  – Gastrocs
  – Peroneals
Knee

• Neuro re-ed
  – Quad sets
  – Progress to biomechanics of squatting, step downs, etc.

Ankle

• Subtalar joint mobes
• Talocrural joint mobes
• Midfoot/Navicular or cuboid mobes
• Distal Tib/Fib mobes
• Intermetatarsal mobes/ MPJ mobes
• Detonify
  – Peroneals
  – Anterior tibialis
  – Quadratus plantae
Ankle

• Neuro re-ed
  – Sidelying ankle inversion or eversion
  – Arch raises
  – FHL MPJ flexion without IP flexion

• Strength
  – Theraband
• (Proprioception)

Structure

• Biomechanical evaluation
• Rule of 3: 3x the forces, 3x faster, structural faults are 3x as significant
• Check leg length
• Check for tibial varum, rearfoot varum and forefoot varum = pronation
• Watch the runner in action
Shoewear

- Interaction of Arch Type and Footwear on Running Mechanics
- Motion control shoes control rearfoot motion better than cushion trainer shoes.
- Cushion trainer shoes attenuate shock better than motion control shoes do.
- The instantaneous loading rate was improved when a low-arched runner used a motion control shoe and when a high-arched runner used a cushion trainer shoe

Spectrum

Cushion  Stability  Motion Control
Mid Sole

- Part of shoe between upper and outersole
- Glued to shoe
- Most important part of running shoe

- Composed of different density materials:
  - EVA
  - polyurethane
  - multi / dual density
- Each material has specific purpose
Components

Mid Sole

Dual Density - has two layers: one for stability, one for cushioning
- Some extend to medial rearfoot, some to midfoot, some to metatarsals

*Darker color provides more stability
*Easy for patients to see/shop for

Components

Lastings

- CONSTRUCTION
- Component of shoe that is glued and / or stitched to inside of shoe on top of midsole
  BOARD
  CALIFORNIA
  COMBINATION
  SLIP
- Different materials used depending on degree of stability / cushioning desired
Components

Lastings

Board
- Fiberboard that runs the length of the shoe
- Adds stability and firmness but lacks flexibility
- Glued to midsole

Lastings

California
- Upper stitched to midsole around outer edge without fiberboard
- Used for cushioning and flexibility
Lastings

**Combination** - Fiberboard used in rearfoot and slip lasting used in forefoot
- Stability in the rearfoot and cushioning in the forefoot
*Also seeing fiberboard in the back and California in the front*

Lastings

**Slip**
- Slip lasting that has good flexibility
- Seam is centered in midsole
Components

Last

- SHAPE
- Shape from around which shoe is built
- Designed around a three-dimensional model
- Should be matched to the person’s foot shape
* Look at shape of sole of shoe

Determines which last fits: “Take the “wet foot” Test
**Components**

**Last**

**Straight** - Shape of foot that has little curve between rearfoot and forefoot
- Provides stability and controls pronation

**Semi-Curved** - In between straight and curved
- Allows some pronation and provides some cushioning
- Usually found in a stability shoe
Components

Last

Curved
- Curved inward from heel to toe
- Provides cushioning
- Good for a supinator with a high arch
- Usually found in a cushion shoe

Review

1. Motion Control
- Board lasting
- Or California last
- Very dense midsole (dual density)
- Shape of last is straight
- Can have rear and forefoot postings
- Used for pronators, heavy runners
2. Stability

- Combination lasting
- Dense midsole
- Shape of last is semi-curved
- Can have forefoot cushioning
- Rearfoot posting only
- Used for mild pronators, lighter runners

3. Cushion

- Slip lasting
- Soft midsole
- Shape of last is curved
- Cushioning in rear and forefoot
- No posting
- Used for supinators
Break