Lower Extremity Movement Adaptations in the Presence of Pain and Clinically Useful Tools to Assess and Correct Movement

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Disclosures

- I have no disclosures.

Background

- Ohio State Sports Medicine
  - Endurance Medicine Team Member
  - Paper to Practice Team Member

OSU Sports Medicine
Objective

- Get patients better... Faster!
  - Examine motor control & pain literature
  - Review common movement adaptations
  - Discuss clinical skills and tools
  - Have thought-provoking discussion

17 Years ↓ 14% of research adopted into practice
(Westfall et al. 2007)

Movement Adaptation (Hodges & Smeets 2015)

- Chicken or the egg?
- Adaptation may be:
  1. Reaction to pain
  2. Reaction to threat of pain
  3. Due to tertiary factor that leads to pain
Why?

- Purposes of adaptations are to:
  - Protect, protect, protect
  - Sustain motor output (Hodges 2011)

- Adopted strategy is not always most obvious solution
  - More habitual than optimal (Dankaerts et al 2006)

Spectrum of Movement Change

- Major: Avoidance of Movement
- Guarded/protected movement
- SUBTLE: Redistributed activity between/within muscles

- Amount of movement decreases
- Movement assessment becomes more difficult

Spectrum of Movement Change

- Redistribute Muscle Activity Within/Between Muscles
- Guarded/Protective Movement
- Avoidance of Movement

- Modification of muscle activity coordination
- Subtle modification of force direction or stress
- Modification of loading at adjacent regions
- Adoption/maintenance of provocative movement/posture
- Reflex inhibition
- Enhanced or reduced movement variation
- Reduced force output
- Avoidance of function
- Activity and/or participation limitation
Pain and Motor Control (Tucker et al. 2009)

- Former Pain Theories
  - "vicious cycle," "pain adaptation," etc.
- New Theory: recruitment strategy reorganized
- Creates problems for using surface EMG

Downfalls of EMG (Hug et al. 2015)

- Force cannot be inferred from activation
- Electromechanical delay
- Role of high-frame-rate ultrasound
- New clinical methods are needed

Adaptation to Pain (Hodges 2011)

- “Link between current theories and rehabilitation is weak”
Clinical Conundrum

- Unseen motor adaptations

- Possible to show identical kinematics & ground reaction forces but vary muscle activation (Brandon et al. 2014)

- Individual-specific (van der Hoorn 2015)

Gluteal muscle activity and patellofemoral pain syndrome: a systematic review.
Christian J Barton, Simon Lack, Peter Malliaras, Dylan Morrissey

- Moderate-strong evidence of delayed/shorter duration glute medius activity

Unseen Motor Adaptations

- Reduced endurance and rapid activation (Pool-Goudzwaard AL et al. 2005)

- Activation is less task-specific and variable (Dieterich et al. 2016)

- No consistent order in muscle sequencing (Lehman et al. 2004)
Neural Adaptations to Strength Training
(Selvanayagam et al. 2011)

- Single isometric strength training session
  - 4x10
  - Significant shift in muscle twitch (lasted 25 minutes)
  - Strongest effect with combined ballistic and sustained contraction

- Think timing and duration

- Snapshot of future muscle function
  - Synchronization
  - Recruitment
  - Rate

Human Body is Resilient (van der Krogt 2012)

- Tolerate up to 40% generalized muscle weakness

- Gait most sensitive to plantarflexor/abductor weakness

- Compensations
Long-Term Consequences (Hodges & Smeets 2015)

- Adaptations which:
  - Persist too long
  - Exceed what is necessary
  - Are inappropriate for pain reduction

Common Movement Adaptations
Walking Gait

- Hip Pain (Allison et al. 2016)
  - ↓ hip extension
  - ↓ terminal knee extension
  - ↑ lumbar lordosis
  - ↑ hip adduction throughout stance
  - ↑ contralateral/ipsilateral trunk lean
  - ↑ pelvic drop
  - ↑ hip external rotation

Common Movement Adaptations
Walking Gait

- Knee Pain
  - ↓ terminal knee extension
    - Attenuated flexion-extension-flexion cycle
  - ↓ hip extension
  - Circumduction/vaulting pattern
  - ↓ stance time
    - ↑ step length
Common Movement Adaptations
Walking Gait

- Foot/Ankle Pain
  - ↓ Ankle dorsiflexion
  - ↓ Great toe extension
    - ↑ weight bearing on lateral foot
  - ↑ Hip external rotation or circumduction
  - ↓ Stance phase
  - ↑ Increased rearfoot eversion
    - Excessive pronation

Common Movement Adaptations
Functional Squat/Jump (Hewitt et al. 2010)

- Movement Imbalances
  - Ligament dominance
  - Quadriceps dominance
  - Leg dominance
  - Core dominance

Quad  Trunk  Movement Imbalance

Leg  Ligament
Common Movement Adaptations
Running Gait

- Exaggerated patterns from walking gait
- Poor cadence
- Dissociation of UE/LE
- Vertical displacement

Barriers to Changing Movement (Hodges & Smeets 2015)

- Nervous system fails to return to pre-pain strategies
- Fear avoidance beliefs/behaviors
- Central/peripheral sensitization
- Secondary biomechanical/neurophysiological changes

Proposed Strategies (Hodges & Smeets 2015)

- Increase activity with dosage controlled \(\rightarrow\) optimization of motor control
- Train motor control to optimize tissue load \(\rightarrow\) augmenting activity
Implications for Rehab

- Conscious and precise motor control
- Activation ≠ temporal/spatial changes (Tsao & Hodges 2007)
- Variable, adaptive muscle activation
- Bottom line: Quality motor control training is effective!

Summary

- Movement adaptation is individual-specific
- Pain persists for many different reasons
- Similar movement, dissimilar activation
- Future research
  - How do we assess activation changes clinically?

BREAK
Movement Assessment/Correction

Spectrum of Movement Change

- **MAJOR**
  - Avoidance of Movement
  - Guarded/protected movement

- **SUBTLE**
  - Redistributed activity between/within muscles

Amount of movement decreases

Movement assessment becomes more difficult

2D Video (subtle adaptations present?)

Muscle timing &/or activation issues?

High quality motor training

Movement corrected with feedback?

Pain-reducing measures

Pain-Free Movement
Poor Movement?...We Can Help

- **Skills**
  - Traditional exam
  - Video analysis
  - Clinical reasoning
  - Manual clinical tests

- **Interventions**
  - Neuromuscular re-education
  - Motor control training
  - Strength/mobility

- **Tools**
  - Mirror
  - Technology
  - Exercises
  - EMG/Ultrasound
  - Taping

Walking Gait

- Observational Gait Analysis (OGA)
  - Fast, simple, and inexpensive
  - Little research on reliability in orthopedic population (Tat et al. 2015)
    - Poor to moderate validity and reliability for most kinematic assessments
    - Temporo-spatial parameters have high validity and reliability
  - Moderate reliability (Brunnekreff et al. 2005)
    - Subtle gait changes

Limitations of OGA

- Inconsistent changes in gait pattern
- Higher BMI
- Attire
- Transverse plane motion difficult to observe in 2D
Why Use Observation Tools… I Can See

- It’s not about YOU
  - Patients need movement education
- Paradigm shift for gait retraining
- Augmented feedback supports skill transfer (Meyer et al. 2013)
- Real-time feedback works

Benefits of 2D Video Analysis

- Inexpensive
- Time-efficient
- Research-supported (Dingenen et al. 2015)
- Educational… for clinicians and patients
- Observational power

Clinical Tools

- Tablets/Smartphones
- Real-time feedback (Noehren et al. 2011)
- Level belt
Augmented Feedback

- Knowledge of Results/Performance (Lauber & Keller 2014)
- Teach patient/Ask for their feedback
- Practice skill immediately
- Be precise with motor control
- Use test-retest

Keys to Consider

- When using technology to assess/correct movement:
  - Obtain patient consent
  - Use consistent setup
  - Have patient in appropriate attire
  - Use multiple angles

Broad Jump
Promoting Neural Drive to Muscle

Promoting Variable Muscle Activation

Patient Feedback

- “It’s as much a brain game as it is a muscle game.”
- “I feel like I have to think really hard about using that muscle.”
- “My muscle feels super activated.”
Special Considerations and Limitations

- Validation of clinical techniques to determine which adaptations require change (Hodges 2011)
- Transverse plane
- Adjunct to clinical reasoning

Summary

- Attempt to change movement efficiently
- Movement education for PATIENTS
- Create patient buy-in
- Relate movement changes to pain and function

Questions
References
