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UNDERSTANDING FUNCTIONAL MOVEMENTS IN PATIENTS WITH ARTHRITIS – A NEUROMUSCULAR PERSPECTIVE
Key Points

1. Neuromuscular changes in OA cannot be attributed solely to normal aging
2. Neuromuscular changes in OA play a role in the development / progression of knee OA
3. Targeted rehabilitation can impact neuromuscular changes in OA
4. Implications for clinical research and practice
NEUROMUSCULAR CHANGES AND THEIR CONSEQUENCES
The Role of Proprioceptive Deficits

- Deficits in *proprioception* (joint position and joint motion) in patients with knee OA compared to age-matched control subjects
# Results:

<table>
<thead>
<tr>
<th>Threshold of detection (degrees)</th>
<th>Control Group* (N = 40)</th>
<th>Side Scheduled for Op.* (N = 117)</th>
<th>P Value†</th>
<th>Side Not Scheduled for Op.* (N = 93)</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension</td>
<td>1.42 (0.26-4.08)</td>
<td>2.25 (0-20.41)</td>
<td>0.054</td>
<td>2.74 (0.23-17.95)</td>
<td>0.003</td>
</tr>
<tr>
<td>Flexion</td>
<td>1.64 (0.61-4.43)</td>
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</table>

*The values are given as the mean, with the range in parentheses.†Compared with the control group.

- Proprioception in arthritic knees differed from proprioception in nonarthritic, age-matched, knees.
- Proprioception reduced in contralateral knee in severe OA

Effect of Impaired Proprioception on the Development / Progression of Knee OA

• The MOST study, assessed proprioception (joint position sense) in 2243 subjects, at baseline and at 30 month follow-up

Results:

- Confirmed previous relationship between poor proprioceptive acuity and worse pain and physical functioning.

<table>
<thead>
<tr>
<th>Table 2. Baseline proprioceptive acuity, pain, and physical functioning*</th>
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<tbody>
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<td>----------------</td>
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<tr>
<td>WOMAC scores†</td>
</tr>
<tr>
<td>Pain‡</td>
</tr>
<tr>
<td>Functioning‡</td>
</tr>
<tr>
<td>Knee pain†</td>
</tr>
<tr>
<td>Yes/no (%)</td>
</tr>
<tr>
<td>Adjusted OR (95% CI)§</td>
</tr>
<tr>
<td>Radiographic OA</td>
</tr>
<tr>
<td>Yes/no (%)</td>
</tr>
<tr>
<td>Adjusted OR (95% CI)§</td>
</tr>
</tbody>
</table>
Results (cont’d):

- **Modest trend** between (greater) proprioceptive deficits and (increased) risk of deteriorating physical function and more severe pain.
The Role of Muscle Weakness

Cross sectional studies:

1. Evidence of quadriceps weakness in patients with knee OA
   
   Slemenda, C., K. D. Brandt, et al. (1997)

2. Evidence of quadriceps weakness in patients post-meniscectomy, “pre-OA”
   
The Role of Quadriceps Weakness in the Progression of Knee OA

• In women, knee extensor strength (adjusted for body weight) - 18% lower at baseline among subjects who developed incident knee OA than among age matched controls at 32 month follow-up (P = 0.053).

In contrast

Data from the MOST study

Neither higher knee extensor strength nor normal H:Q balance is protective against the development of incident radiographic tibiofemoral OA.

However, for women, being in the highest tertile of knee extensor strength appeared protective against development of incident symptomatic whole knee OA.

(Segal, Torner et al. 2009)
Mechanisms of Quadriceps Weakness

• Arthrogenic Muscle Inhibition
  – Quadriceps weakness in the presence of pain
    
    (Palmieri-Smith and Thomas 2009)

• Quadriceps Activation Failure
  – Quadriceps weakness in the absence of pain
  – Decreased MVC quads torque compared with (MVC + twitch superimposition) quads torque
    
    QAF appears to moderate the relationship between quadriceps strength and physical function
    
    (Fitzgerald, Piva et al. 2004)
The Role of Instability

• Sensation of shifting, buckling, giving way
• Prevalent in medial knee OA
• Affects muscle activation strategies
• But limited evidence that instability influences self-reported function

(Schmitt, Fitzgerald et al. 2008)
The role of neuromuscular changes on Functional Activity Performance

• Quadriceps avoidance gait
• Stiffening strategy
  \(\text{(Brechter and Powers 2002)}\)
• Learned Disuse
  \(\text{(Winter and Eng 1995)}\)

70/F, post TKR
The role of neuromuscular changes on Functional Activity Performance

- Learned Disuse

Increasing trunk lean in more severe knee OA

(Asay, Mundermann et al. 2009)

**Table 2.** Mean (1 Standard Deviation) Moments and Angles during Stair Climbing for the Three Subject Groups

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Less Severe OA</th>
<th>More Severe OA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak trunk flexion angle (°)</td>
<td>13.4 (4.6)</td>
<td>15.6 (5.5)</td>
<td>19.7 (10.1)</td>
</tr>
<tr>
<td>Peak knee flexion moment (%Bw*Ht)</td>
<td>5.1 (1.2)</td>
<td>4.6 (1.5)</td>
<td>3.3 (1.22)</td>
</tr>
<tr>
<td>Peak hip flexion moment (%Bw*Ht)</td>
<td>4.9 (1.1)</td>
<td>5.0 (1.0)</td>
<td>6.1 (1.6)</td>
</tr>
<tr>
<td>Hip flexion angle at foot contact (°)</td>
<td>42.5 (11.1)</td>
<td>47.0 (8.7)</td>
<td>39.1 (13.1)</td>
</tr>
<tr>
<td>Knee flexion angle at foot contact (°)</td>
<td>63.7 (4.7)</td>
<td>62.3 (4.5)</td>
<td>60.5 (5.1)</td>
</tr>
</tbody>
</table>

Patients with less severe OA were defined as KL ≤ 2 for the more severe knee, and patients with more severe OA were defined as KL ≥ 3 for the more severe knee. Bold numbers indicate a significant difference from the control group (p < 0.05).
Neuromuscular changes co-exist and interact

- Pain, proprioception and strength are related in patients with knee OA

*(Shakoor, Furmanov et al. 2008)*
INNOVATIVE REHABILITATION STRATEGIES
Perturbation Training

- [Case Study: 73/F w/ OA]
- Physically active individual with knee OA (high functioning), presented w/ pain and instability.
- 6 weeks, 12 treatment sessions
  
  (Fitzgerald, Childs et al. 2002)

- Promising results at 2 year follow up in patients with ACL reconstruction

  (Risberg and Holm 2009)
Proprioceptive Training

- **Non-weightbearing Target Matching Foot Game**, 6 week

- Results (small RCT, n=49)
  - Enhanced accuracy of joint position sense, functional capacity, and walking speed.

  *(Jan, Tang et al. 2008)*
Transcranial Magnetic Stimulation

- [Experimental study]
  Significant effect of *TMS on MVC* when applied in synchrony with muscle contraction, and this persisted for at least 60 min beyond stimulation.

  *(Urbach, Berth et al. 2005)*
Whole Body Vibration

- [Small RCT, n=52]
- Knee muscle strength was significantly improved after training on a stable platform and proprioception improved significantly after training on a vibrating balance board.
- No effects on self-reported disease status were observed in either group compared to the control group.

(Trans, Aaboe et al. 2009)
A Place for “Pre”-hab?

• Perturbation training *prior to surgery* improves symmetry in non-copers

*(Hartigan, Axe et al. 2009)*
IMPLICATIONS FOR THE FOOT AND ANKLE
Arthritis of the Foot and Ankle

• Rheumatoid Arthritis
• Inflammatory Etiology
• Osteoarthritis
  – 1st MTP joint OA
    (46% of women and 32% of men at 60 years of age)
  – Ankle OA
    (Post traumatic, includes fractures and ligamentous injuries)
  – Midfoot OA
    (Post vehicular accidents, poor footwear choices)
Evidence

- Proprioceptive Deficits
- Muscle Weakness

- Ankle OA
  (Hubbard, Hicks-Little et al. 2009)

- Ankle OA
  (Valderrabano, Nigg et al. 2007)
Evidence

- Instability

- Midfoot OA
  (Rao, Baumhauer et al. 2009)

- Stiffening strategy during gait
- Inability to control 1st metatarsal ROM during step descent
Future Directions

- Relationship between impairments (muscle weakness, instability, proprioceptive deficits) and self-reported disability in individuals who have foot and ankle OA

- Interventions to decrease disability
  - Surgical
  - Orthoses and shoe inserts
  - Rehabilitation: Strength training
Thank You!