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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

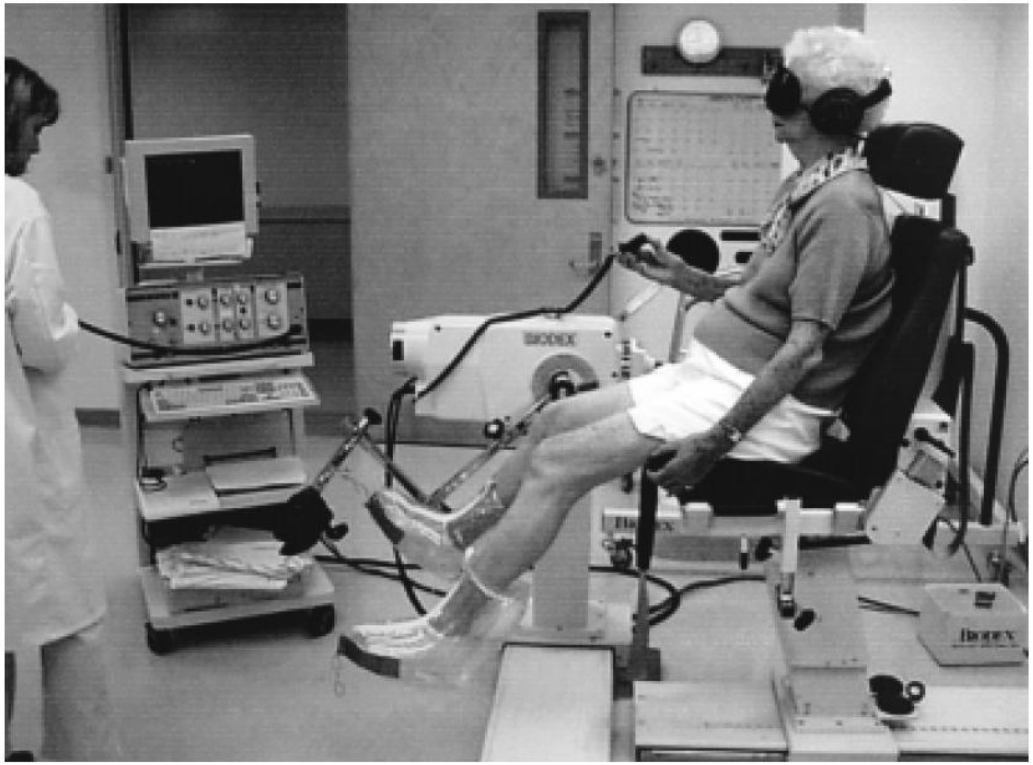


FIG. 1

# Results:

COMPARISONS OF THRESHOLDS TO DETECTION OF PASSIVE MOTION BETWEEN STUDY GROUPS

| | | Arthritic Group | | | |
|---|---|---|---|---|---|
| | Control Group* (N = 40) | Side Scheduled for Op.* (N = 117) | P Value† | Side Not Scheduled for Op.* (N = 93) | P Value† |
| Threshold of detection *(degrees)* | | | | | |
| Extension | 1.42 (0.26-4.08) | | | 2.25 (0-20.41) | 0.054 |
| Flexion | 1.64 (0.61-4.43) | | | 2.74 (0.23-17.95) | 0.003 |

*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

*Koralewicz, L. M. and G. A. Engh (2000)*

# 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

*Felson, D. T., K. D. Gross, et al. (2009)*

# Results:

Table 2. Baseline proprioceptive acuity, pain, and physical functioning*

| | Quartile 1 (worst) | Quartile 2 | Quartile 3 | Quartile 4 (best) | *P* for trend |
|---|---|---|---|---|---|
| WOMAC scores† | | | | | |
| Pain‡ | 3.8 | 3.4 | 3.2 | 3.0 | < 0.001 |
| Functioning‡ | 15.1 | 14.5 | 14.0 | 13.6 | 0.03 |
| Knee pain† | | | | | |
| Yes/no (%) | 156/495 (31.5) | 216/717 (30.1) | 167/607 (27.5) | 157/621 (25.3) | |
| Adjusted OR (95% CI)§ | 1.33 (0.99–1.78) | 1.32 (1.01–1.73) | 1.18 (0.89–1.56) | 1 (referent) | 0.03 |
| Radiographic OA | | | | | |
| Yes/no (%) | 191/495 (38.6) | 271/717 (37.8) | 237/607 (39.0) | 267/621 (43.0) | |
| Adjusted OR (95% CI)§ | 0.87 (0.67–1.12) | 0.79 (0.63–1.00) | 0.79 (0.62–1.01) | 1 (referent) | 0.22 |

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

# Results (cont'd):

Table 3. Proprioceptive acuity at baseline and development of new pain and change in WOMAC pain and physical functioning scores at the 30-month followup assessment*

| Proprioceptive acuity | Quartile 1 (worst) | Quartile 2 | Quartile 3 | Quartile 4 (best) | *P* for trend |
|---|---|---|---|---|---|
| Change in WOMAC scores at followup† | | | | | |
| Pain‡ | 0.47 (worse) | 0.38 | 0.19 | 0.15 | 0.05 |
| Functioning‡ | 1.50 (worse) | 1.08 | 0.67 | 0.16 | 0.02 |
| New knee pain at followup† | | | | | |
| Yes/no (%) | 33/222 (14.9) | 51/358 (14.3) | 43/296 (14.5) | 38/317 (12.0) | |
| Adjusted OR (95% CI)§ | 1.33 (0.78–2.26) | 1.22 (0.76–1.95) | 1.24 (0.75–2.04) | 1 (referent) | 0.31 |

- ***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"***

*Becker, R., A. Berth, et al. (2004)*

# 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).

*Slemenda, C., D. K. Heilman, et al. (1998)*

# In contrast

| | | |
|---|---|---|
| Women | | |
| Lowest tertile, 4–61 Nm (n = 647) | 96 (14.8) | 1.0 |
| Middle tertile, 62–83 Nm (n = 676) | 62 (9.2) | |
| Highest tertile, 84–206 Nm ( | | (0.5–0.7)§ |
| 1 SD | | 0.7 (0.6–0.9)§ |
| | | 0.0004 |

**Threshold Effect??**

- 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)*

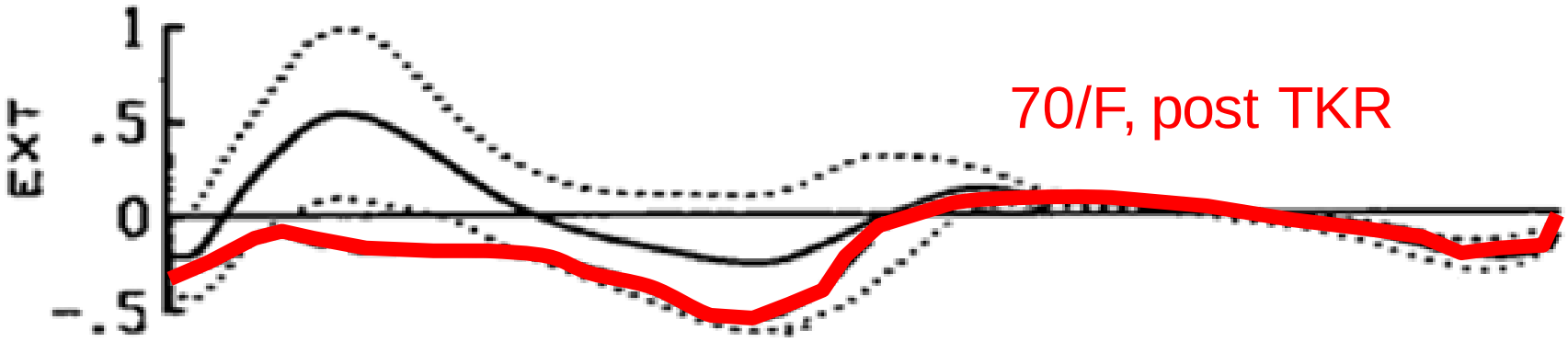
# The role of neuromuscular changes on Functional Activity Performance

- Quadriceps avoidance gait
- Stiffening strategy

*(Brechter and Powers 2002)*

- Learned Disuse

*(Winter and Eng 1995)*



# 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

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

Patients with less severe OA were defined as KL $\leq$2 for the more severe knee, and patients with more severe OA were defined as KL $\geq$3 for the more severe knee. Bold numbers indicate a significant difference from the control group ($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

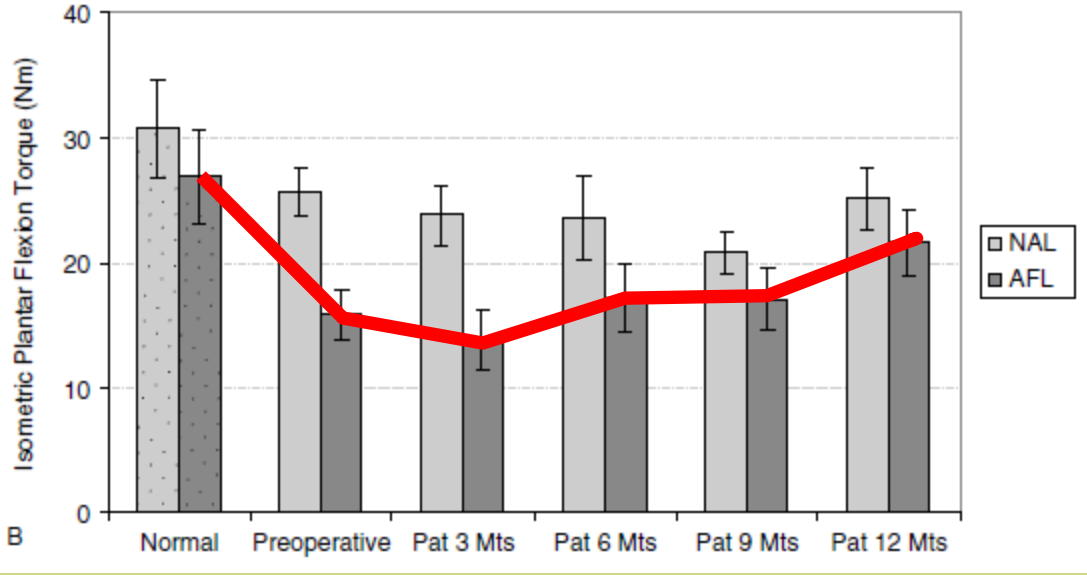
- Proprioceptive Deficits
- Muscle Weakness

- Ankle OA

  *(Hubbard, Hicks-Little et al. 2009)*

- Ankle OA

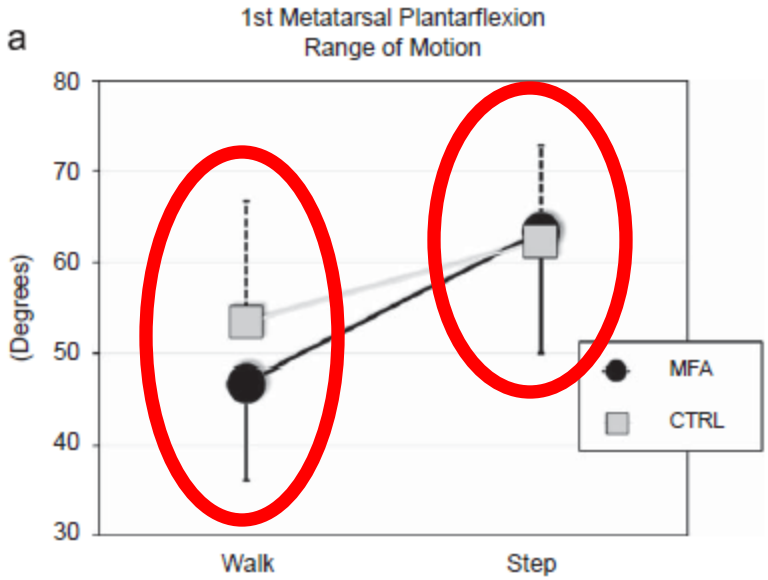
  *(Valderrabano, Nigg et al. 2007)*



# 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!