Hip and Knee Osteoarthritis: The influence of physical activity, alignment and FAI

MPAP Interdisciplinary Staff Day
June 5, 2008

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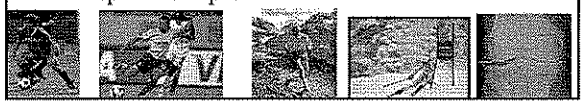
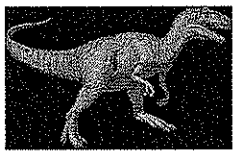
Objectives

- *Be aware of*...the ***risk factors*** for the development of hip and knee OA
- *Be aware of*..... the evidence for the role of ***physical activity and alignment*** in the development and progression of hip and knee OA
- *Understand*...the ***Physical Activity and Joint Health*** cohort project at ARC
- *Understand*.....the potential importance of the role of ***femoro-acetabular impingement (FAI)*** in the development of hip OA

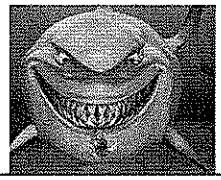


History – Cartilage and Bone

- OA occurred in ancient animals, fish, dinosaurs and other animals

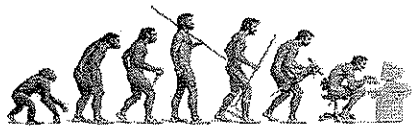


- No evidence for OA in cartilaginous animals such as sharks



Evolution and Osteoarthritis

Evolution

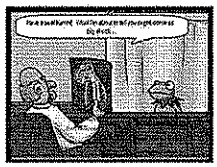


(or is it?)

OA – What is it?

Discordance between X-rays, structural change and symptoms

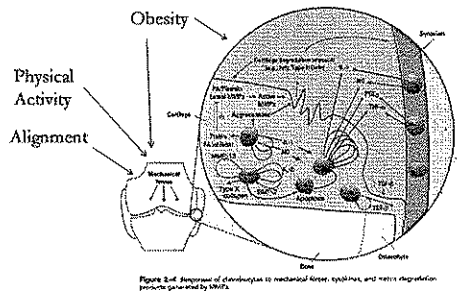
- *Hannan 2000* – substantial discordance between *radiographic* OA (ROA) and *symptomatic* OA
  - Of those with moderate to advanced ROA, only 47% had pain



- *Cibere 2006*
  - plain radiography has limited ability to detect osteoarthritic features at an early stage of disease

OA – What is it?

Molecular pathology or Altered Biomechanics?



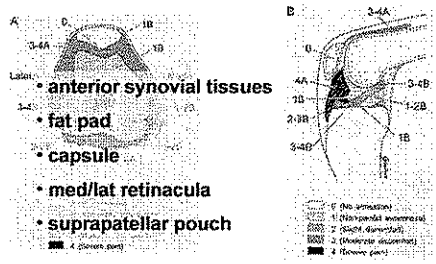
Poole et al, 2007, in Moskowitz R, Altman R, et al. Eds. Osteoarthritis. 4th ed. Philadelphia: W.B. Saunders; 2007.

OA - why does it hurt?

Candidate Structures

- capsule
- ligament
- outer meniscus
- periosteal and subchondral bone
- synovium
- soft tissue including fat and deep pat tendon
  - fat pad (hoffa's fat pad) highly innervated
  - v often involved in OA (usually on side of compartment involved)

Why does it Hurt?



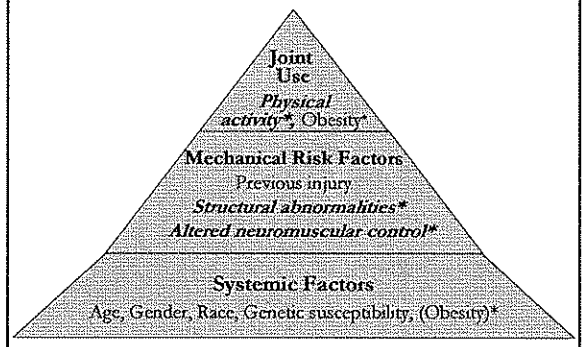
A=accurately localized; B=poorly localized

Dye et al., Conscious neurosensory mapping of the internal structures of the human knee without intraarticular anesthesia. Am J Sports Med 1998;26(6):773-7

OA – Why does it hurt? Recent evidence from MRI

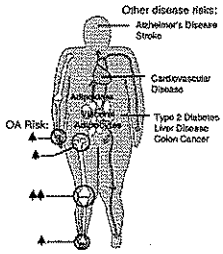
- Synovitis / Synovial Thickening (Hill et al., 2007, 2001; Torres 2006)
  - Change in synovitis was correlated with change in knee pain, but not loss of cartilage
  - Hoffa's fat pad
- Bone Marrow Lesions (Felson, Hunter, Hernandez - 2001, 2003. 2006, 2007, 2008, Torres 2006)
  - appear in areas joint is highly loaded
  - ACL enthesis
- Bone Attrition (Hernandez et al., 2007, Torres 2006)
  - flattening or depression of subchondral bone
- Effusions (Moderate to Large) (Hernandez et al., 2007, Torres 2006, Biesma-Zeinstra 2006)

A Model for the Development of Osteoarthritis



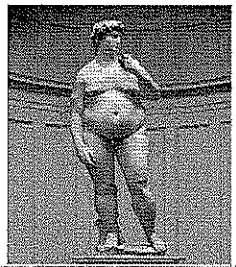
Adapted from Felson (2004) **modifiable or correctable*

Obesity and OA



Guilak, F et al. Ex Sport Sc 2005

- ***Adipocytokines***



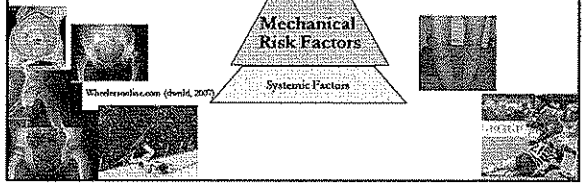
OA – Biomechanical Risk Factors

HIP

- *DDH, SCFE, LCPD, Joint injury*
- *FAI → spectrum leading to OA*
  - *Structural change*
  - *Subtle changes in F-A mechanics*
  - *Neuromuscular control ?*

KNEE

- *Meniscal / ACL injury*
- *Alignment*
  - *Static*
  - *Dynamic - Adduction moment*
- *↓ proprioception*



Previous Injury and Hip/Knee OA

- ACL injury (Roos, Lohmander 2003,2004, 2007, 2008)
  - Up to 3-10x increase in knee OA
  - Irrespective if repaired or conservative treatment
- Mensical injury (Hunter et al, 2006)
  - Almost ubiquitous in knee OA – chicken and egg
  - SI subluxation during movement ↑ un-coverage between femoral and tibial hyaline cartilage
- SKIP study at ARC
  - moderate joint injury cohort in young athletes– MRI


Physical Activity and Hip / Knee OA

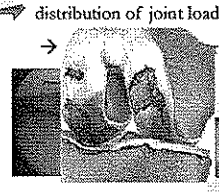
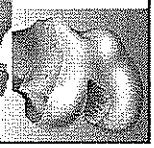
Physical Activity and Hip / Knee OA

PA necessary for joint health

Can too much activity damage joints?

Under normal physiological conditions, [illegible] ...eady frictionless ...or transmission and distribution of joint loads

→ ... decades of use

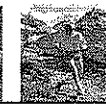
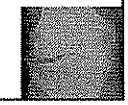



Physical Activity and Hip / Knee OA Longitudinal Studies

Increased Risk of OA	No Effect on OA	Protects Against OA
McAlindon 1999	Hannan 1993	White 1993
Spector 1996	Lane 1998	Rogers 2002
Lane 1999	Hootman 2003	Foley 2007
Cheng 2000	Felson 2007	Racunica 2007
Szoeke 2006		
Foley 2007		

Also check Urquhart 2007 (PA gd or bad?, and 2008; Minor Editorial)



Physical Activity and Hip/Knee OA

Cheng et al. *J Clin Epi* 2000

Increased risk of OA

- High levels of physical activity (running 20 or more miles per week) associated with OA among men under age 50

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n= 16,961 prospective cohort - 10 year follow up

PA **questionnaire** – assessed at baseline by ***current level of PA*** – walking and jogging only

Physical Activity and Hip/Knee OA

Rogers et al. *Osteo Cart* **2002**

Protective Effect on OA

- no association between hip/knee OA and low joint stress
- moderate/high joint stress was associated with reduced risk of hip/knee OA in men and women
- all levels of PA associated with reduced risk in women

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n= 2,410; Nested case-control study (part of 20 yr cohort)

PA **questionnaire** – assessed at baseline by ***past 3 months activity*** – based on 'level of joint stress'

Physical Activity and Hip/Knee OA

Felson et al *Arthritis & Rheum*, 2007 (Framingham off-spring cohort)

No risk or protective effect on OA

- Walking and other recreational activities in older persons *does not increase risk of developing knee OA*
- *No measurable protective effect* of recommended weight-bearing exercise on OA

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n= 1,279, prospective cohort - 9 year follow up

PA **questionnaire** – recent/current PA (average over ***past week)*** taken 1-2 years from last follow up

Sample had low PA levels in general, few runners

Studies measuring ***Lifetime*** PA

- No studies in OA
- Lifetime PA and other Health Outcomes
  - Cancer (breast, prostrate, renal, colon, rectal)
  - Bone Mineral Density
  - Bone Health

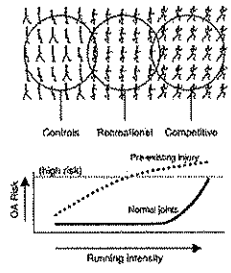
Physical Activity and OA: Possible ***Reasons for Conflicting Results***

- Subgroups of people differ in their response to PA
- PA (lo or hi) likely part of a multi-factorial causal pathway
- Methodological Issues
  - Measurement of PA
  - Many dimensions to PA – hard to capture, separate
  - Case Ascertainment **Also check March 1998 and Szoeke 2008 on OA case ascertainment in lg scale epi studies**
    - Self-report vs clinical
    - Radiographic OA vs Symptomatic OA

Physical Activity and OA Summary of Evidence

1. *PA necessary* for cartilage health
2. *High levels* / competitive sports associated with OA
3. Uncertain effect of *moderate levels*
4. *Subsets* of people may differ in their response
   - alignment, previous injury, NM control, BMI, age, gender
4. PA a broad construct with *many parameters*
   - freq, duration, intensity → *energy expenditure*
   - *joint load*
   - *threshold* concept
   - type load – *shear, compression, static*
   - *sport type*

Physical Activity and OA – Summary of Epidemiological Evidence



Griffin et al *Exerc Sport Sci Rev 33:195* (2005)

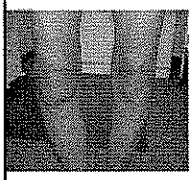
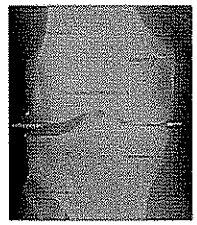
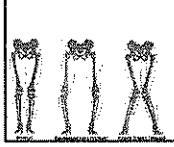
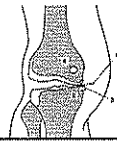
Physical Activity and Knee Osteoarthritis: Answers and Questions

" The cohort study (*Felson et al, 2007*) contains little information about individual subjects..... more informative if ...considered the contribution of potentially mediating factors such as ***knee alignment, laxity, and neuromuscular fitness***."

M. Minor, Editorial

Arthritis & Rheum (AC&R) **57:1, 2007**

Local Mechanical Factors: *Alignment*

Alignment and Knee OA – Recent Evidence from Longitudinal Studies

Progression of OA	No Risk for Incident OA	Risk Incident OA
Sharma 2001 Cerjelo 2002 Felson 2003 Hunter 2006	Hunter 2007 Zhai 2007	Brouwer 2007 Teichtahl 2008

*several x-sectional studies show dose-response ↑ compartment-specific cartilage loss in non-symptomatics



Also check Urquhart 2008; Sharma 2007 editorial

Malalignment and Compartment-specific OA Progression (2001)

- 1st report of compartment specific JSN progression, pain

Table 2. Odds Ratios for Medial and Lateral Progression*

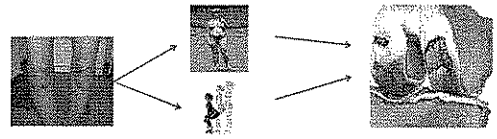
	Odds Ratio (95% Confidence Interval)	
	Unadjusted	Adjusted†
Varus Alignment and Medial Progression		
Nonvarus	1.00	1.00
Varus	5.00 (2.77–9.02)	4.09 (2.20–7.62)
Neutral/mild valgus	1.00	1.00
Varus	3.54 (1.85–6.77)	2.98 (1.51–5.89)
Valgus Alignment and Lateral Progression		
Nonvalgus	1.00	1.00
Valgus	3.88 (1.62–8.24)	4.89 (2.13–11.20)
Neutral/mild varus	1.00	1.00
Valgus	3.23 (1.30–8.05)	3.42 (1.31–8.96)

Key Findings:
- varus alignment increases risk of medial OA progression
- valgus alignment increases risk of lateral OA progression
- that burden of malalignment predicts decline in physical function

Sharma et al. JAMA 2001

Alignment as Mediator (2000, 2003, 2004)

1. Sharma L et al. The mechanism of the effect of obesity in knee osteoarthritis: the mediating role of malalignment. *Arthritis Rheum 2000*
2. Sharma L et al. Quadriceps strength and osteoarthritis progression in malaligned and lax knees. *Ann Intern Med 2003*
3. Felson DT et al. The effect of body weight on progression of knee osteoarthritis is dependent on alignment. *Arthritis Rheum 2004*



Malalignment and BML Progression in Medial Compartment (2006)

T2-weighted, fat suppressed MRI

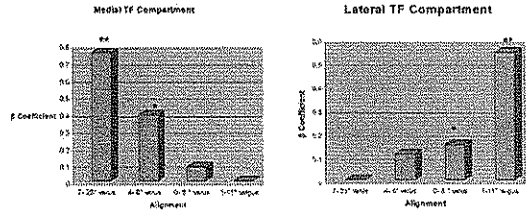
Baseline 30 months

- Medial BML associated with varus
- Lateral BML associated with valgus
- BML a potent risk factor for structural deterioration

Felson et al. Ann Intern Med 2003 Hunter, DJ et al. Arth Rheum 2006

Malalignment and BML Progression (2006)

Change in BML score and mechanical alignment, by compartment



P = .003 vs most valgus quartile, adjusted for age, sex and BMI

P = .008 vs most varus quartile, adjusted for age, sex and BMI

"Dose-response"

Hunter, DJ et al.Arth Rheum 2006

Alignment and Knee OA
(Hunter, 2007)

Alignment does not ↑ risk incident OA

Is a marker for disease severity and/or progression

Hunter et al. 2007 Arth Rheum 2007

n= 466 knees; Case-control study – mean fu – 8.75 years
Alignment measure – femoro-tibial angle on radiographs at baseline

Alignment and Knee OA
(Brouwer, 2007)

First report alignment ↑ risk incident OA

1st report of relationship between a local mechanical factor and incident knee OA

Confirmation malalignment influences OA progression, especially in overweight

Brouwer et al. Arth Rheum 2007

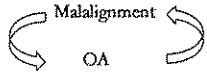
n= 1501, 2664 knees; Longitudinal – mean fu – 6.6 years
Alignment measure – femoro-tibial angle on radiographs at baseline

Alignment and OA: Possible ***Reasons for Conflicting Results***

- Measurement of varus and valgus
- Definitions of varus and valgus (i.e., cut-points)
- Differing populations (e.g., by BMI)
- Power of studies (sample sizes)

Alignment and Knee OA – Summary of Evidence

1. Plays a role in ***progression*** of OA - may set up a 'vicious circle'



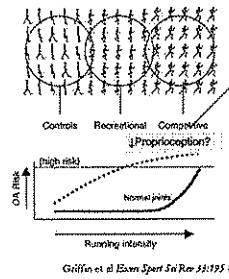
2. Influences ***load distribution***
   - direct effect on cartilage via altered load bearing
   - stress on other joint structures - bone, menisci, ligaments

Alignment and Knee OA – Summary of Evidence

3. ***Mediator*** for other risk factors – BMI, quad strength
4. Likely plays some role in ***development*** of OA
   – either independently or as effect modifier
5. Worthwhile to pursue ***strategies*** to improve load distribution

OA – Potential Role Of Biomechanical Risk Factors

Epidemiological studies:
long-term distance running



Griffin et al *Exerc Sport Sci Rev* 33:195 (2005)

- modifiable mechanical risk factors →

important in the development and progression of hip osteoarthritis

Physical Activity and Joint Health

Research Questions:

- Is there a lifetime *threshold* or *dose-response* PA→OA?
- Is *energy expenditure* different than *joint force* from PA
- Are there *subgroups* that respond to PA differently?

Significance – public health recommendations – tailored guidelines for subsets of populations

Lifetime Physical Activity and *Local Joint Vulnerabilities* in the Development of Hip and Knee Osteoarthritis

Chuck Ratzlaff
PhD Thesis
Arthritis Research Centre of Canada

OBJECTIVE

To investigate the relationship of lifetime hip and knee joint load and local joint vulnerabilities with hip and knee osteoarthritis (OA)

Biomechanics and Hip OA

- Hip osteoarthritis is **prevalent** and disabling
- **correctable mechanical overload** is a major etiological factor in osteoarthritis
- relief of the mechanical overload can prevent or improve osteoarthritis

(Mills and Kim CORR 2002)

Hip OA – Biomechanical Risk Factors

HIP

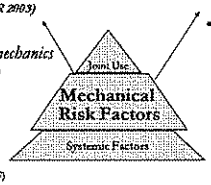
- *DDH, SCFE, LCPD, jt injury*
- ***FAI → spectrum leading to OA***

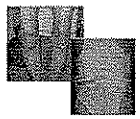
(McCarthy CORR 2003; Ganz CORR 2003)

- *Structural change*
- *Subtle changes in F-A mechanics*
- *Neuromuscular control ?*

Knee

- *Meniscal / ACL injur*
- *Alignment*
- *Adduction moment*
- *↓ proprioception*

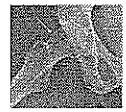




Idiopathic Osteoarthritis ?

Femoroacetabular Impingement – A Cause for Osteoarthritis of the Hip Ganz et al. 2003

- >600 cases, >10 years
- FAI is the "mechanism for development of early OA in most non-dysplastic hips"



The Role of Labral Lesions to Development of Early Degenerative Hip Disease McCarthy, 2001

- >430 cases, over 7 years
- 73% pts with labral tears had chondral lesions
- labral disruption and OA part of continuum of joint disease

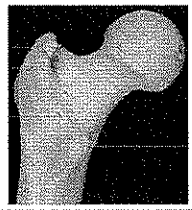
- Etiology of OA of the Hip Harris, 1986
  - >90% of "idiopathic" hip OA is secondary to mild deformities
  - subtle SCFE, LCPD, dysplasias, impinged labrum,

Clinical Presentation

- Usually active young adults
- Groin pain
- Slow onset, or after minor trauma
- Intermittent, exacerbated by high-demand activity or prolonged sitting

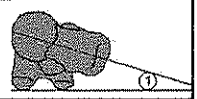
Brown T., Biomechanics of Hip Osteoarthritis: Research Opportunities and Challenges. Orthopaedic Research Societies, 2007

Femur – *CAM impingement*



- Inclination ~ 125°
  - coxa vara / valga
- Offset
- Centre edge angle (> 25-30°)
- Femoral torsion (~12°)

Lewis et al, 86: 110PhysTher 2006



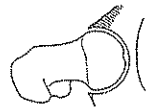
Bizzini et al. AJSM preview (2007)

Acetabulum – *Pincer impingement*

- Depth
  - » dysplasia
  - » coxa profunda
- Acetabular torsion

Philippon et al, AJSM 35(9): 1571 2007

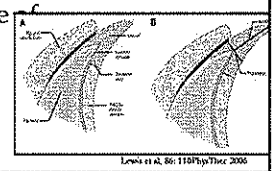
Anderson et al. Clin Orth Rel Res 2001



Lewis et al, 86: 110PhysTher 2006

Hip Anatomy - Labrum

- jt sealing/fluid pressure
- stability
- ↑ contact area
- ↓ contact stress
- reported high prevalence of pathology



Lewis et al, 86: 110PhysTher 2006

Physical Examination

Impingement Tests

7 FAI tests from the literature
- different aspects of hip
- done pre and post treatment

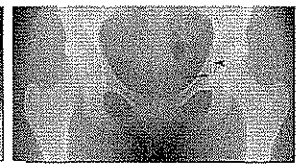
Parvizi et al. JAAOS 15: 561, 2007

Philippon et al. AJSM preview 2007

Radiography

Cam Impingement

Profunda (type of pincer)



Philippon et al, AJSM 35(9): 1571 2007

Parvizi et al. JAAOS 15: 561 (2007)

MR Arthrography

•Labral tear

T1-w fat suppressed

T2-w

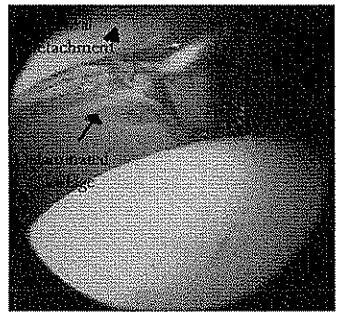
•Hypertrophied superior labrum, w/ extensive tear

•Intra- & para-labral cysts

Kassarjian et al. Europ. J. Radiol. 63: 29 (2007)

Brown T., Biomechanics of Hip Osteoarthritis: Research Opportunities and Challenges. Orthopaedic Research Societies, 2007

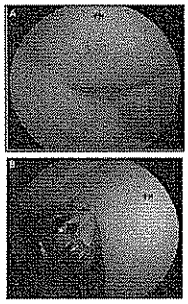
Arthroscopic Assessment

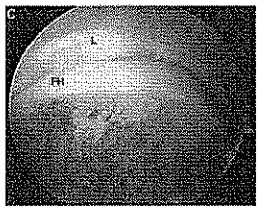


Gunther et al. JBJS 89A: 863 (2007)

Brown T., Biomechanics of Hip Osteoarthritis: Research Opportunities and Challenges. Orthopaedic Research Societies, 2007

Treatment – Arthroscopic Osteoplasty

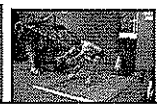




Philippon et al. AJSM 2007

Treatment: Conservative

- Loose body traction ***manipulation*** protocols
  - RCT proposal with surgical and conservative arms
- ***Manual therapy*** to 'centralize' femoral head
- ***Neuro-muscular re-training*** → decrease impingement
- ***Sport-specific*** motor re-training
- ***Occupation and ADL-specific*** re-training



Treating Pathomechanics – normalizing joint load

Abdominal (core) weakness Incr. LSp lordosis; Ant. rotated pelvis

Hip Flex/IR

Short Hip Flexors

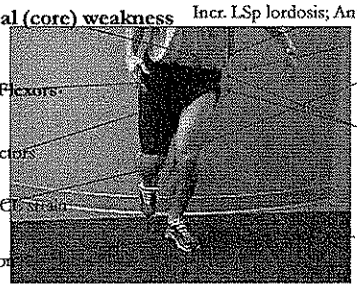
Short domina TFL/ITB and ↓ Hip Ext. Rota

Short Adductors

↓ Abductors

Valgus: MCL strain

↑ Pronation



Abnormal mechanics as a cause of OA

Take Home Messages - Management

1. Injury Prevention
   - ***Improving biomechanics***
   - Core strategies
2. Non-Pharm treatments – bracing, heel wedges, orthotics
   - ***Improve biomechanics***
3. Mechanical / Physical treatments

   Restore Mechanics
   - Manipulation protocols (entrapped LB, meniscus , labrum)
   - Mobilization / STT
   - Core-based rehabilitation
4. Exercise – NM fitness, biomechanics (hammer and nail)

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- Canadian Arthritis Network

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