The Consequences of Youth Sport-Related Knee Injury
Implications for Secondary Prevention of Osteoarthritis

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The Growing Burden of Osteoarthritis

Significance

OA is expected to become the 4th leading cause of disability worldwide by 2020

Increase in prevalence from 12.5% (2010) to 25% (2040)

Increase in prevalence from 26.6% (2012) to 29.5% (2032)

Increase in prevalence from 12% (2008) to 25 (2030)

Unsustainable Trends
Significance

OA is the fastest growing disease globally based on Years Lived with Disability

Increase in direct costs from $2.9 billion (2010) to $5.8 billion (2040)

54% increase in direct medical costs between 1993 and 2002

37% and 48% increase in hip and knee replacements between 2015 and 2020

Prevention of Osteoarthritis
Epidemiological Model

UPSTREAM SHIFT IN OUR APPROACH TO MANAGEMENT

Primary Prevention
SUSCEPTIBLE
Prevent or reduce risk factors in susceptible populations

Secondary Prevention
PRE-SYMPTOMATIC
Identify and slow down the onset of OA in pre-clinical populations

Tertiary Prevention
DISEASE
Slow progression in those with OA (improve function)
Prevention of Post-Traumatic Osteoarthritis

Timeline of Events & Interventions

**Primary Prevention**
- Prior to Injury
- Prevent Injuries
  - Injury prevention programs in sport populations

**Secondary Prevention**
- Joint injury to PTOA (10-15 years)
- Delay/Halt OA Onset
- Therapy aimed at improved function
  - (exercise, weight control, arthroplasty)

**Tertiary Prevention**
- After PTOA diagnosis
- Improve Function
  - Therapy aimed at improved function
  - (exercise, weight control, arthroplasty)

??
Prevention of Post-Traumatic Osteoarthritis
Timeline of Events & Interventions

**Primary Prevention**
Prior to Injury

**Secondary Prevention**
Joint injury to PTOA (10-15 years)

**Tertiary Prevention**
After PTOA diagnosis

**Improved understanding will Inform the development, evaluation & implementation of;**

1. Screening Programs = Identify Risk Factors for OA
2. Interventions = Underlying Mechanisms
Alberta Youth PrE-OA Study
Ongoing Longitudinal Cohort Study

Secondary Prevention – Knee PTOA

0-3 yrs post-injury

3-10 yrs post-injury

n=400

100 = sport-related knee injury, ≤18 yrs, 3-10 years earlier
100 = age, sex and sport matched controls

+ 100 = sport-related knee injury, ≤18 yrs, in the last 3 months
100 = age, sex, and sport matched controls

Followed annually on a diverse set of outcomes for 3 yrs.
Outcomes
PrE-OA Study

1° MRI-defined OA*
KL radiographic grade
Trunk, hip & knee muscle size (USI)

2° Serum biomarkers*
sCOMP expression
Estimated VO$_2$max
Adiposity (BMI | DEXA)

2° KOOS*
Clinical exam (IKDC)
Knee pain (NPRS | ICOAP)
Return to Sport
Kinesiophobia

*included in sample size calculation

2° Physical Activity*
Nutrition (3 day recall)
Depression (PHQ-9)
Health Status (EQ-5D)
Athletic Identity (AIMS)
Exercise Identity (EIS)
Quality of Life
Locus of Control (SRLC)
Semi-structure 1:1 Interviews
Healthcare use

2° Strength*
(Knee Extensor/Flexor, Hip Abd/Add)
Physical Performance
(TSLH | SEBT | UPDB)
Kinematic measures
(SLS | VDJ | single leg balance)

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## Participant Characteristics

**PrE-OA Study**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Uninjured n=100</th>
<th>Injured n=100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (% female)</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Age (yrs; median, range)</td>
<td>22 (15-26)</td>
<td>22 (16-26)</td>
</tr>
<tr>
<td>Age at Injury (yrs; median, range)</td>
<td>-</td>
<td>16 (9-18)</td>
</tr>
<tr>
<td>Injury to Follow-up 1 (yrs; median, range)</td>
<td>-</td>
<td>6.9 (3-10)</td>
</tr>
<tr>
<td># Index Knee Surgeries</td>
<td>0</td>
<td>63*</td>
</tr>
<tr>
<td># Contralateral Knee Injuries</td>
<td>0</td>
<td>23§</td>
</tr>
<tr>
<td># Contralateral Knee Surgeries</td>
<td>0</td>
<td>15ϕ</td>
</tr>
<tr>
<td># Index Lower Limb Injuries</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td># Contralateral Lower Limb Injuries</td>
<td>13</td>
<td>16</td>
</tr>
</tbody>
</table>

*54 ACL reconstructions, §ϕ11 of these were ACL reconstructions

_Whittaker et al 2015, 2017, 2018_
Injury Definition
PrE-OA Study

**KNEE INJURY**

- Ligament, meniscal or other intra-articular tibio or patello-femoral injury requiring both MEDICAL CONSULTATION & DISRUPTED SPORT PARTICIPATION

- ACL Tear, 54%*
- PFJ Sublux/Dislocation, 17%
- Fracture, 1%
- Other Ligament, 13%
- Isolated Medical Injury, 15% *

*all under went ACL reconstruction, 36 had concomitant meniscal injuries

*7 of these had arthroscopic surgery

`Whittaker et al 2015, 2107`
MRI-Defined OA
Surrogate Structural Outcome of Early PTOA

MRI Defined OA
Bilateral clinical series (1.5 Tesla): axial, coronal & sagittal proton density, proton density fat saturation
MOAKS rating by radiologist blinded to injury

MRI defined OA Criteria:
Osteophyte AND full-thickness cartilage loss
OR
1 of the above plus 2 of the following;
Sub-chondral bone marrow lesion
Meniscal disruption
Partial thickness cartilage loss

Hunter et al 2011
MRI-Defined OA
Surrogate Structural Outcome of Early PTOA

Structural MRI

- Structural changes consistent with OA are not unique to ACL tears or damaged menisci

Clinical

- The odds of MRI defined OA 3-10 years after knee injury vary by injury history, injury type and surgery

Functional


Physiological


Behavioural Beliefs

Whittaker et al 2017

<table>
<thead>
<tr>
<th>Surgery / Injury Type</th>
<th>Odds of MRI-defined OA (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee Injury</td>
<td>10.0 (2.3,42.8)*</td>
</tr>
<tr>
<td>Grade I-III MCL or LCL</td>
<td>2.0 (0.18,22.1)</td>
</tr>
<tr>
<td>3° ACL</td>
<td>11.5 (1.4,85.2)*</td>
</tr>
<tr>
<td>Knee Surgery</td>
<td>13.5 (1.7,99.4)*</td>
</tr>
<tr>
<td>3° ACL &amp;/or meniscal injury</td>
<td>14.5 (1.8,106.5)*</td>
</tr>
</tbody>
</table>
Clinical Symptomology (KOOS)
Knee Injury and OA Outcome Score – Modifiable Risk Factor

Previously injured participants score lower on all 5 KOOS subscales compared to matched-controls.

Whittaker et al 2015, 2017, 2018
Knee Extensor Strength
Dynamometer – Modifiable Risk Factor

Previously injured participants have weaker KNEE EXTENSORS and this varies by sex & time since injury

*Whittaker et al 2015, 2017, 2018*
Knee Flexor Strength
Dynamometer – Modifiable Risk Factor

Previously injured participants have weaker KNEE FLEXORS and this varies by sex & time since injury

Whittaker et al 2015, 2017, 2018
Previously injured participants have poorer DYNAMIC BALANCE and this varies by sex & time since injury.

Whittaker et al 2015, 2017, 2018
Adiposity
Dual X-ray Absorptiometry - Modifiable Risk Factor

Physiological Adiposity

Previously injured participants are 4.4 (OR 95%CI 1.6, 12.3) times more likely to be in the upper quartile of FMI

Toomey et al 2017, Whittaker et al 2015, 2017, 2018
Physical Activity (self-reported)

Godin Leisure Time Questionnaire - Modifiable Risk Factor

Previously injured participants are 2.1 (OR 95%CI 1.1,4.0) times more likely to be in the lowest ¼ of physical activity

Toomey et al 2017, Whittaker et al 2015, 2017, 2018
Beliefs re: Sport, Injury and OA
Behavioral; Semi-structured Interviews (n=19, purposive sample)

**Dominant themes:**

**Acceptance**
Varying & often unrealistic degrees of acceptance about the impact of injury on sporting ability & future PTOA

**Resiliency & Determination**
Highly motivated to recover & meet injury with resiliency – do not pace well

**Knee Confidence**
Knee requires ongoing protection

**Evolving Athletic Identity**
Influenced by injury & shifting life priorities

*Ezzat et al 2018*
Joint Injury
3-10 years Previously

- Reduced or Disengaged from Physical Activity
- Elevated BMI Adiposity
- Weak Knee Muscles Poor Dynamic Balance
- Pain / Stiffness Reduced Knee Confidence
- Not Realistic
- Poor Pacing

OSTEOARTHRITIS
AT RISK

ACL Tear ± Meniscus Osteochondral Lesion

Lacking Info.

Elevated BMI, Adiposity

Reduced or Disengaged from Physical Activity

Insufficient Rehabilitation Pain / Stiffness Reduce Knee Confidence

Frequent Flare-ups

Weak Knee Muscles Poor Dynamic Balance

Vitamin D, K, Deficient

Poor Pacing

No RTS Criteria

Reduced or Disengaged from Physical Activity

Frequent Flare-ups

Weak Knee Muscles Poor Dynamic Balance

Vitamin D, K, Deficient

Lacking Info.

Elevated BMI, Adiposity

Reduced or Disengaged from Physical Activity

Insufficient Rehabilitation Pain / Stiffness Reduce Knee Confidence

Frequent Flare-ups

Weak Knee Muscles Poor Dynamic Balance

Vitamin D, K, Deficient

AT RISK
## Implications
### Future Directions

<table>
<thead>
<tr>
<th>Pre-existing Risk Factors</th>
<th>Do injured youth have ↑adiposity, ↓strength or participate in less physical activity at the time of injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanisms</td>
<td>What is contributing to changes in ↑adiposity and ↓strength? (Diet, activity, psychosocial factors, inaccurate beliefs, etc.)</td>
</tr>
<tr>
<td>Sub-groups</td>
<td>Are there different phenotypes / sub-groups of at risk individuals (i.e., OA phenotypes.)</td>
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</tbody>
</table>
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Registration Open

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