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

World Health Organization

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)

Woolf et al 2003, Lawrence et al 2008, Vos et al 2012, Sharif et al 2016
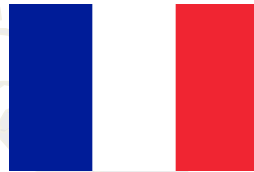
Unsustainable Trends

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)

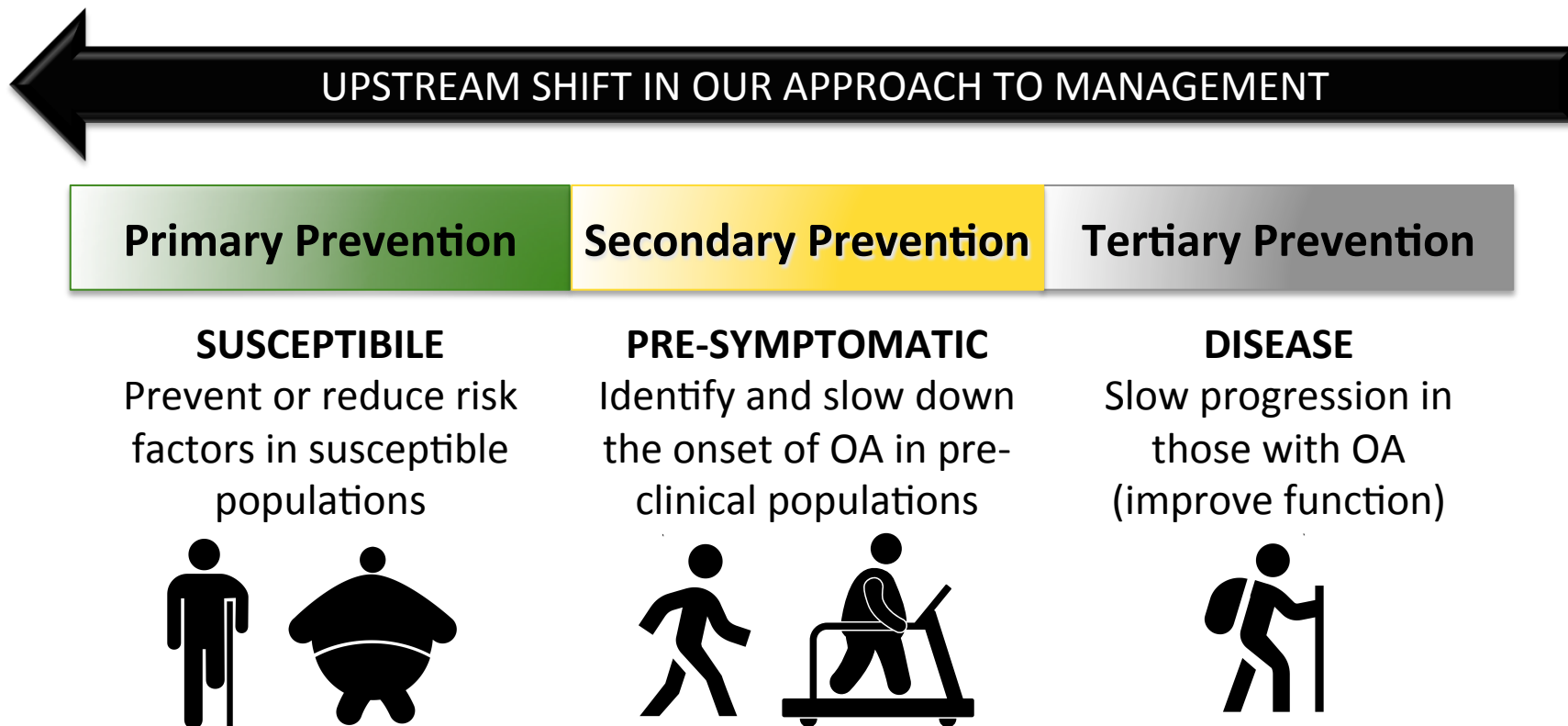54% increase in direct medical costs between 1993 and 2002

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

Levy et al 1993, Woolf et al 2003, Pen et al 2005, Vos et al 2012, Sharif et al 2016, Hunter & Bowden 2017
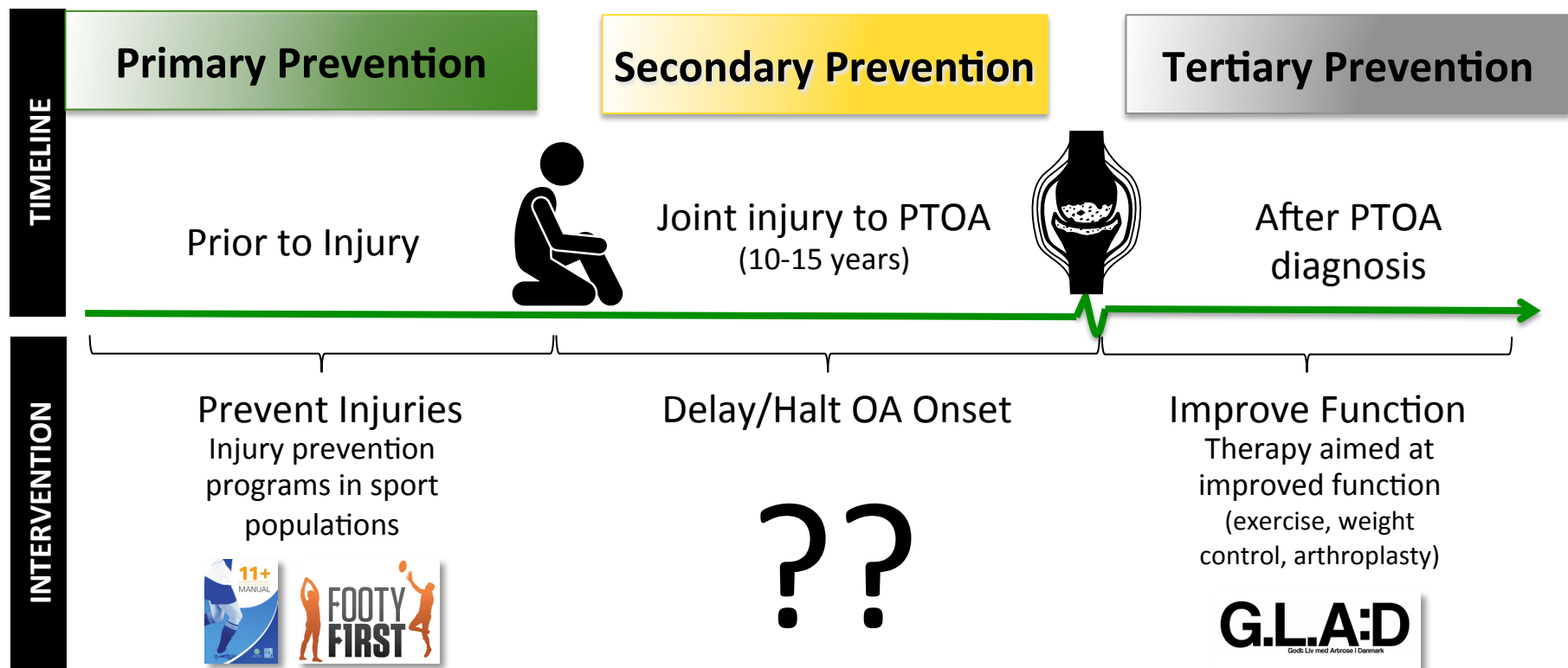
Prevention of Osteoarthritis
Epidemiological Model

← **UPSTREAM SHIFT IN OUR APPROACH TO MANAGEMENT**

Primary Prevention	Secondary Prevention	Tertiary Prevention
SUSCEPTIBILE	**PRE-SYMPTOMATIC**	**DISEASE**
Prevent or reduce risk factors in susceptible populations	Identify and slow down the onset of OA in pre-clinical populations	Slow progression in those with OA (improve function)

Prevention of Post-Traumatic Osteoarthritis

Timeline of Events & Interventions

	Primary Prevention	**Secondary Prevention**	**Tertiary Prevention**
TIMELINE	Prior to Injury	Joint injury to PTOA (10-15 years)	After PTOA diagnosis
INTERVENTION	Prevent Injuries Injury prevention programs in sport populations	Delay/Halt OA Onset ??	Improve Function Therapy aimed at improved function (exercise, weight control, arthroplasty)

Prevention of Post-Traumatic Osteoarthritis

Timeline of Events & Interventions

Primary Prevention

Secondary Prevention

Tertiary Prevention

TIMELINE

Prior to Injury

Joint injury to PTOA
(10-15 years)

After PTOA
diagnosis

INTERVENTION

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

TIMELINE

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

Structure

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

Physiology

2º Serum biomarkers*
sCOMP expression
Estimated VO_2max
Adiposity (BMI | DEXA)

Clinical

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

*included in sample size calculation

Function

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

Behavior

2º 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

Early Knee
PTOA

Participant Characteristics

PrE-OA Study

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

*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

PFJ Sublux/Dislocation, 17%

Fracture, 1%

Other Ligament, 13%

Isolated Medical Injury, 15%[φ]

ACL Tear, 54%*
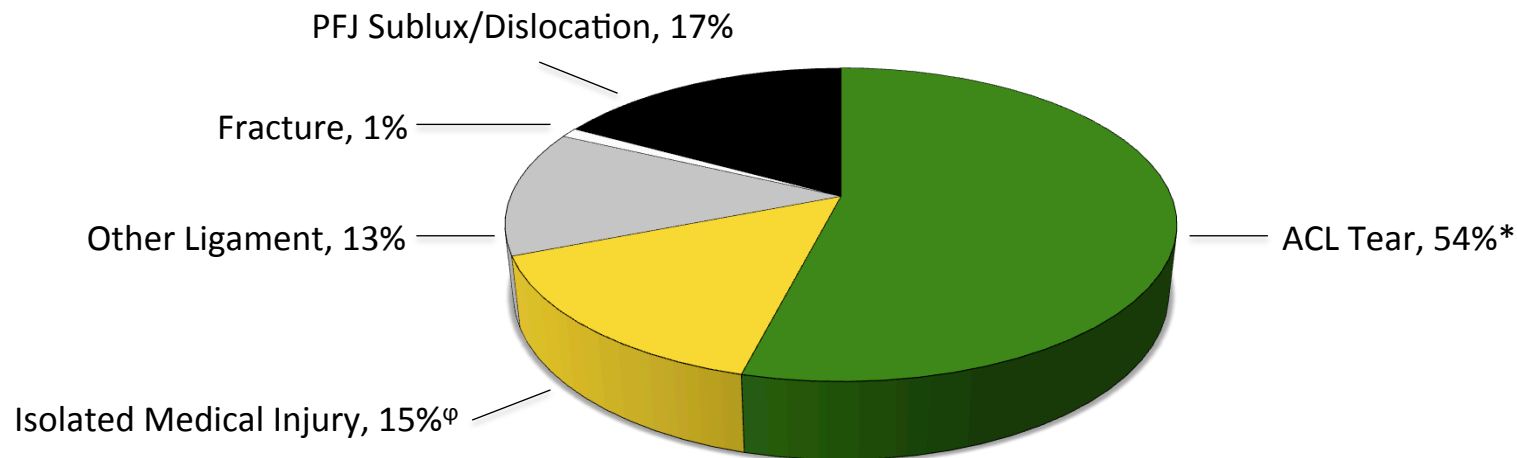
*all under went ACL reconstruction, 36 had concomitant meniscal injuries
[φ]7 of these had arthroscopic surgery

Whittaker et al 2015, 2107

MRI-Defined OA
Surrogate Structural Outcome of Early PTOA
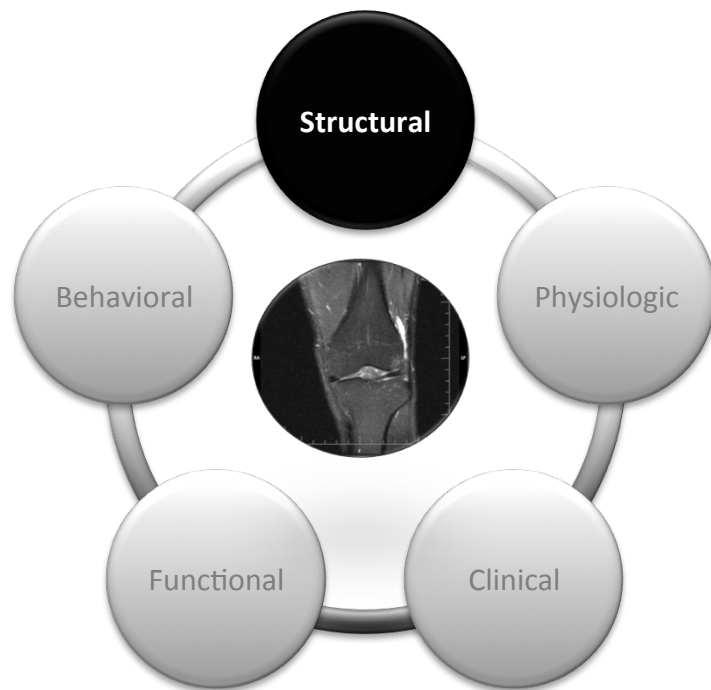
MRI Defined OA

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
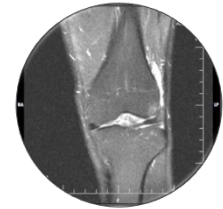
Structural MRI

Clinical

Functional

Physiological

Behavioural Beliefs

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

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

Surgery / Injury Type	Odds of MRI-defined OA (95%CI)
Knee Injury	10.0 (2.3,42.8)*
Grade I-III MCL or LCL	2.0 (0.18,22.1)
3° ACL$^{\varphi}$	11.5 (1.4,85.2)*
Knee Surgery	13.5 (1.7,99.4)*
3° ACL &/or meniscal injury	14.5 (1.8,106.5)*

Whittaker et al 2017

Clinical Symptomology (KOOS)
Knee Injury and OA Outcome Score – Modifiable Risk Factor

| Structural |
| Clinical KOOS |
| Functional |
| Physiological |
| Behavioural Beliefs |

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

Legend:
- Uninjured Males (solid black line)
- Injured Males (dotted black line)
- Uninjured Females (solid green line)
- Injured Females (dotted green line)

Y-axis: KOOS Symptoms (75, 80, 85, 90, 95)
X-axis: Time Since Injury (years) (2, 4, 6, 8, 10)
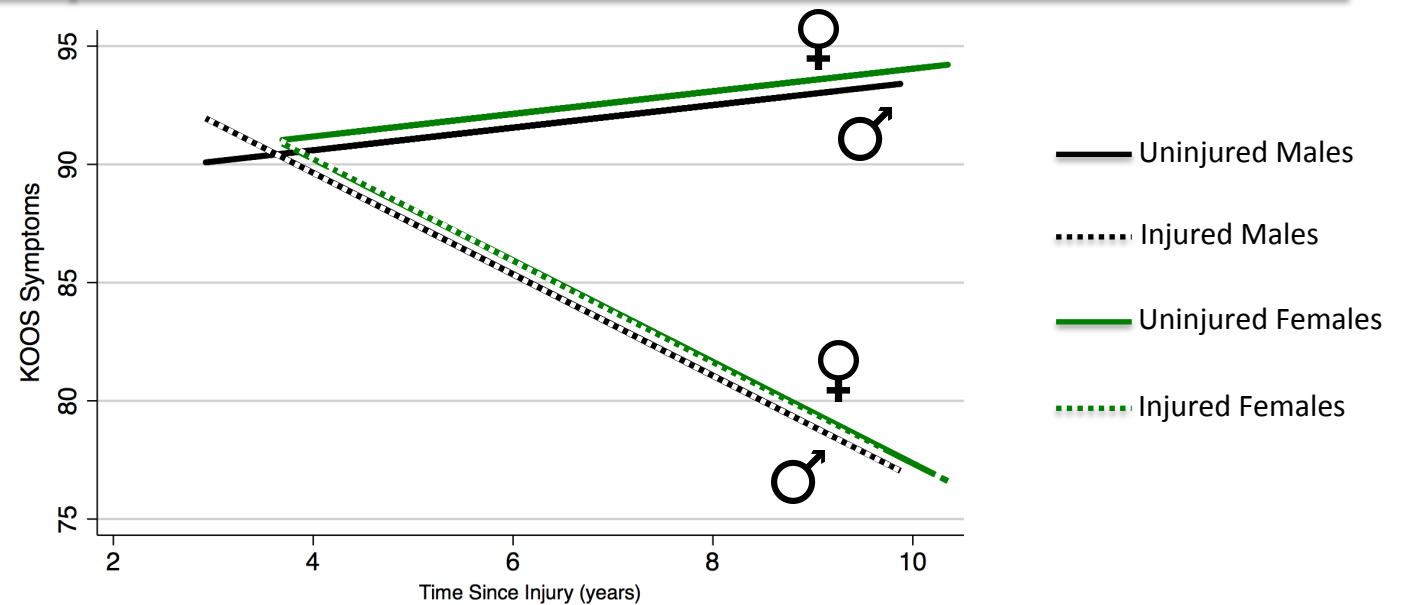
Whittaker et al 2015, 2017, 2018

Knee Extensor Strength

Dynamometer – Modifiable Risk Factor

Structural

Clinical
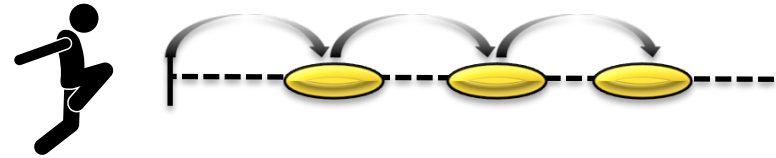
Functional Strength

Physiological

Behavioural Beliefs

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

Uninjured Males

Injured Males

Uninjured Females

Injured Females
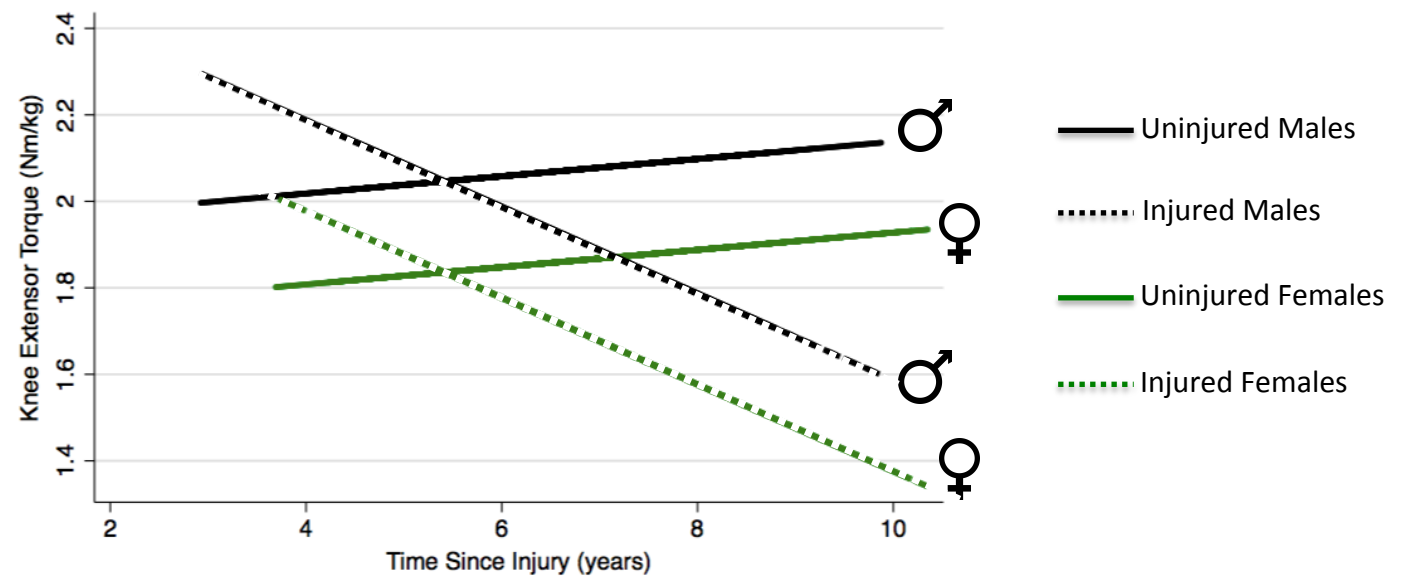
Whittaker et al 2015, 2017, 2018

Knee Flexor Strength
Dynamometer – Modifiable Risk Factor

Structural

Clinical

Functional Strength

Physiological

Behavioural Beliefs

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

Legend:
- Uninjured Males
- Injured Males
- Uninjured Females
- Injured Females
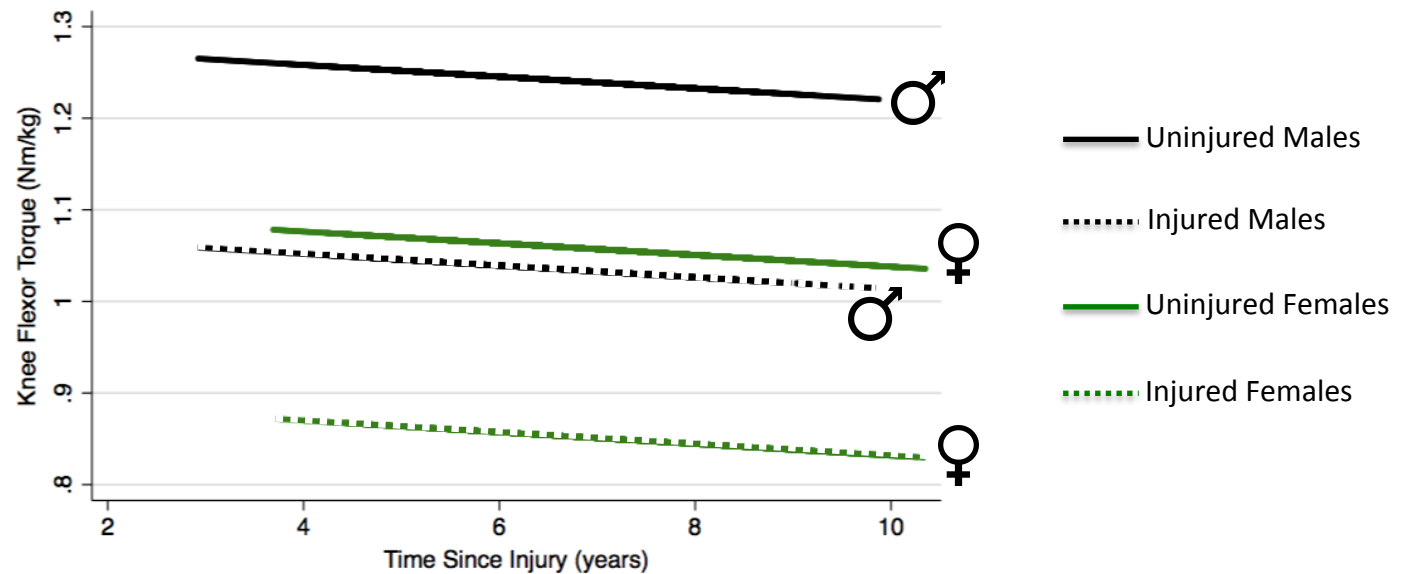
Whittaker et al 2015, 2017, 2018

Dynamic Balance
TSLH – Modifiable Risk Factor

Previously injured participants have poorer DYNAMIC BALANCE and this varies by sex & time since injury

Structural

Clinical

Functional Balance

Physiological

Behavioural Beliefs

Whittaker et al 2015, 2017, 2018

Legend:
- Uninjured Males (solid black line)
- Injured Males (dotted black line)
- Uninjured Females (solid green line)
- Injured Females (dotted green line)

Y-axis: TSLH Distance (% Leg Length)
X-axis: Time Since Injury (years)
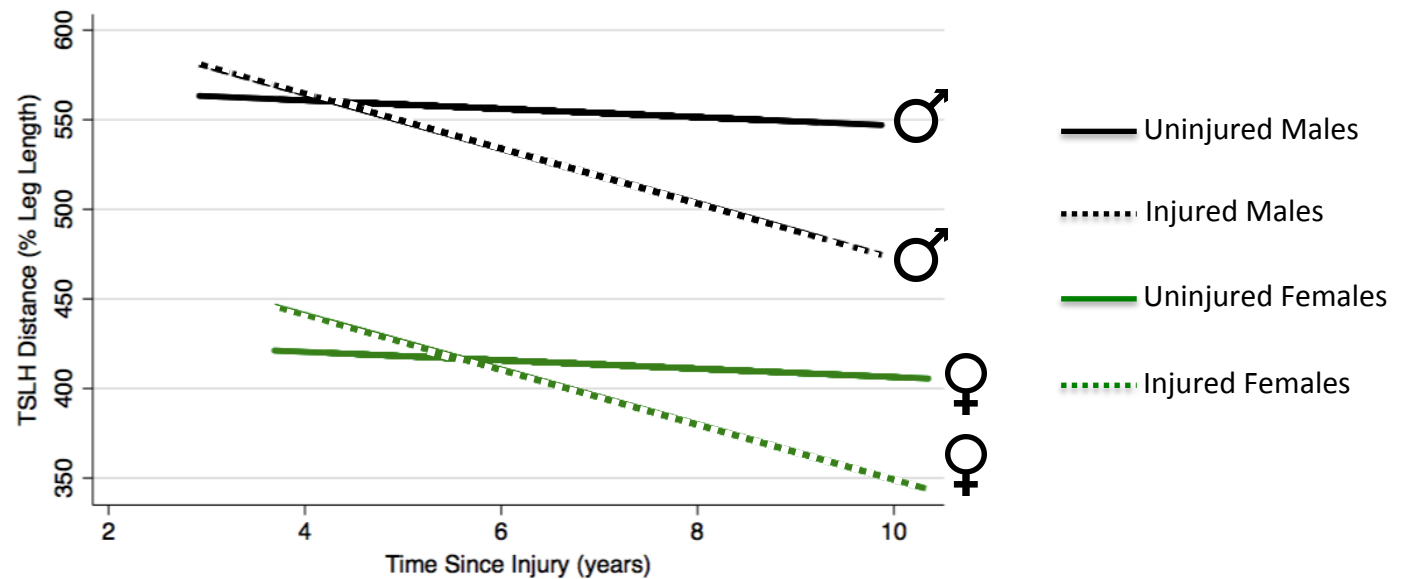
Adiposity
Dual X-ray Absorptiometry- Modifiable Risk Factor

Structural

Clinical

Functional

Physiological Adiposity

Behavioural Beliefs

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

Legend:
— Uninjured Males
······ Injured Males
— Uninjured Females
······ Injured Females

Y-axis: Fat Mass Index (kg/m2)
X-axis: Time Since Injury (years)
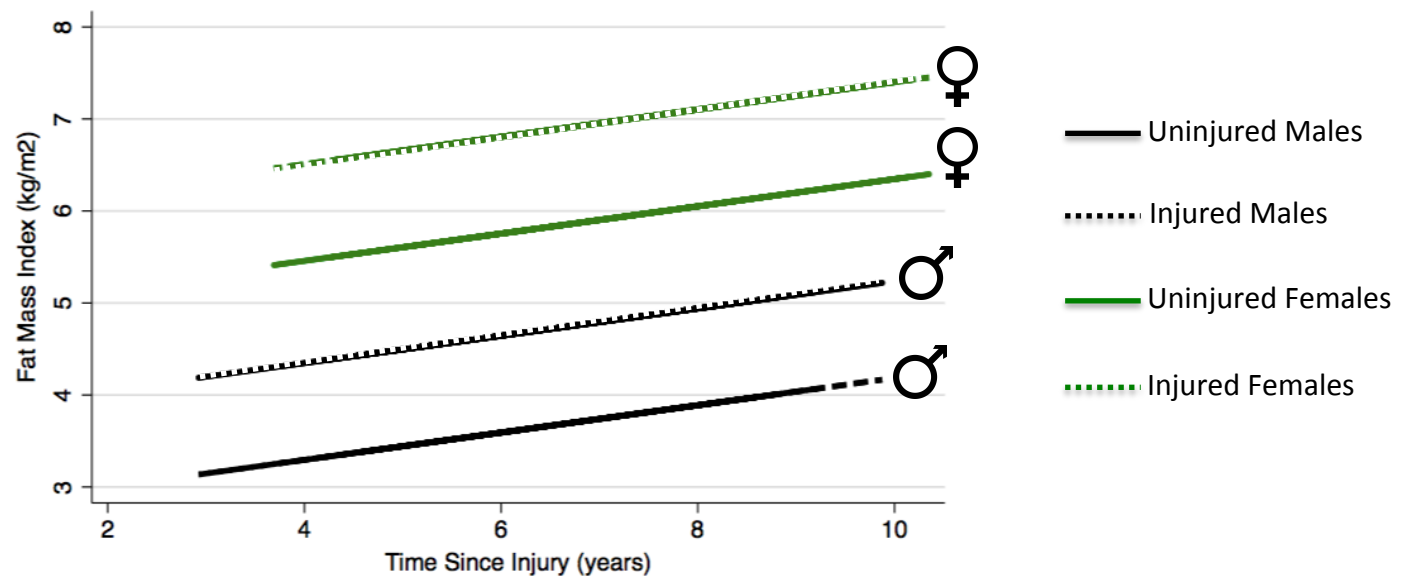
Toomey et al 2017, Whittaker et al 2015, 2017, 2018

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

Structural

Clinical

Functional

Physiological

Behavioural Activity

Legend:
- Uninjured Males (black solid)
- Injured Males (black dotted)
- Uninjured Females (green solid)
- Injured Females (green dotted)

Y-axis: Total Metaboic Equivalents (METS)
X-axis: Time Since Injury (years)
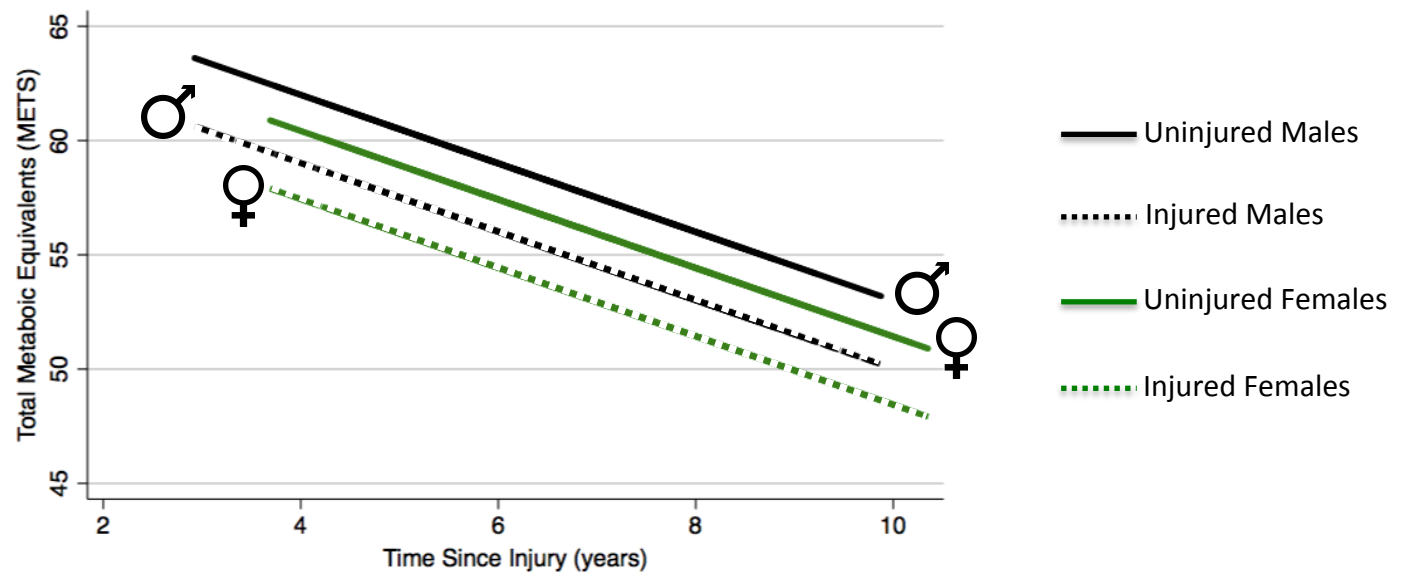
Toomey et al 2017, Whittaker et al 2015, 2017, 2018

Beliefs re: Sport, Injury and OA

Behavioral; Semi-structured Interviews (n=19, purposive sample)

Structural

Clinical

Functional

Physiological

Behavioural Beliefs

Ezzat et al 2018
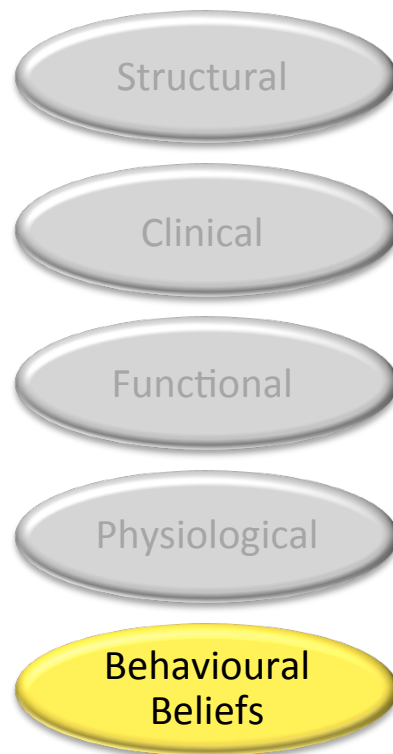
Dominant themes:

Acceptance

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

Resiliency & Determination

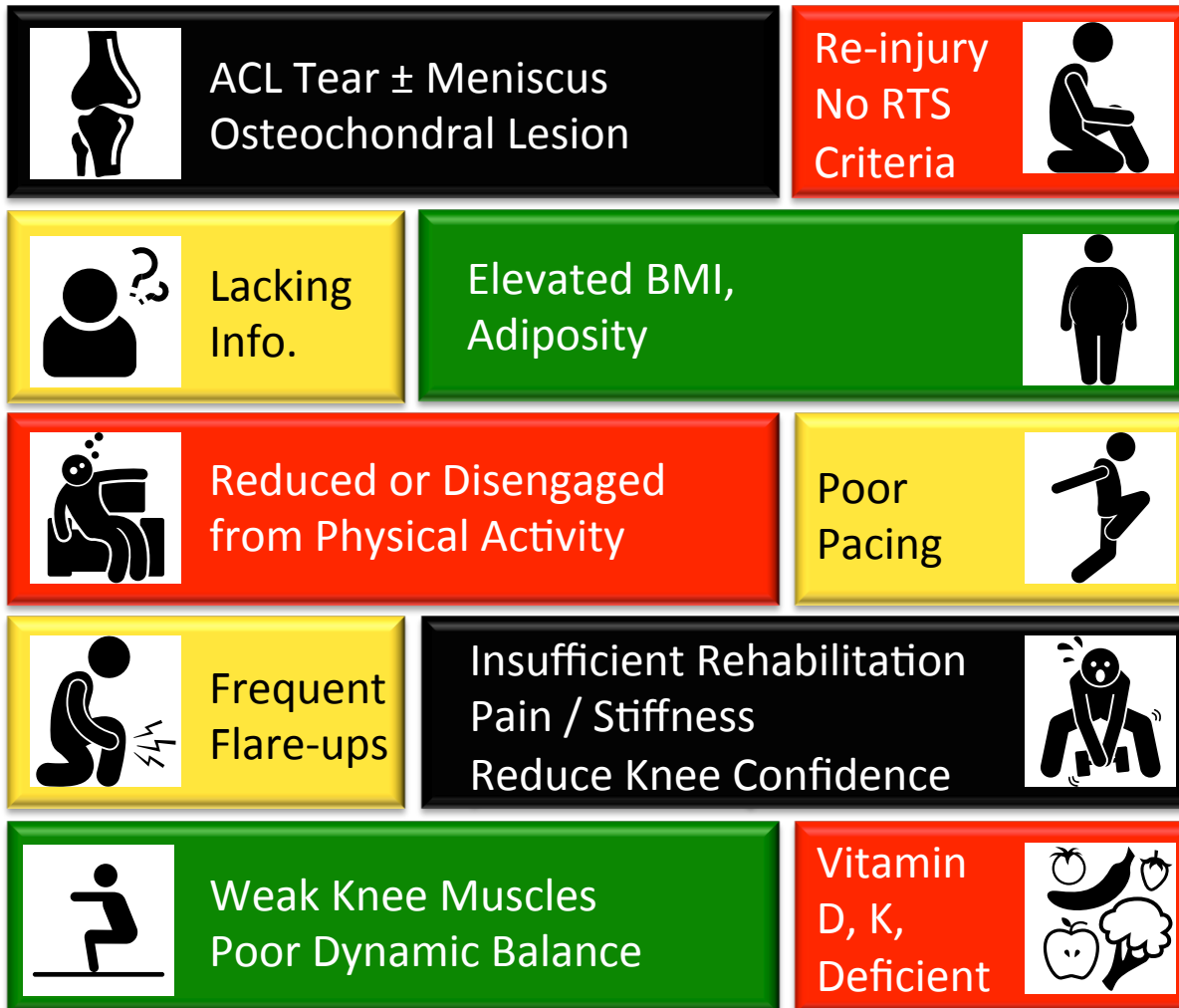Highly motivated to recover & meet injury with resiliency – do not pace well

Knee Confidence

Knee requires ongoing protection

Evolving Athletic Identity

Influenced by injury & shifting life priorities

AT RISK

ACL Tear ± Meniscus Osteochondral Lesion	Re-injury No RTS Criteria
Lacking Info.	Elevated BMI, Adiposity
Reduced or Disengaged from Physical Activity	Poor Pacing
Frequent Flare-ups	Insufficient Rehabilitation Pain / Stiffness Reduce Knee Confidence
Weak Knee Muscles Poor Dynamic Balance	Vitamin D, K, Deficient
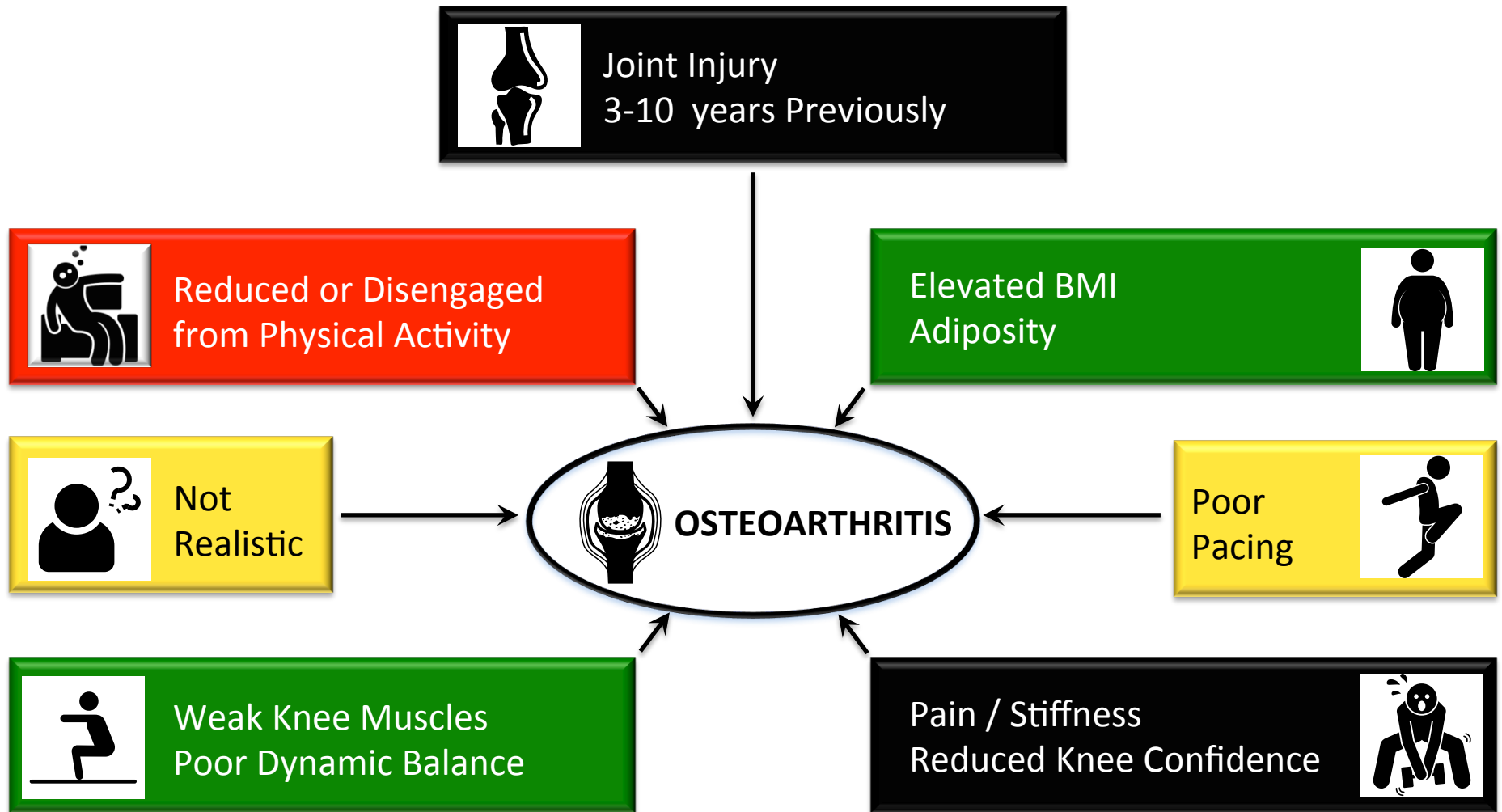
Implications
Future Directions

??

Pre-existing Risk Factors

Do injured youth have ↑adiposity, ↓strength or participate in less physical activity at the time of injury

Mechanisms

What is contributing to changes in↑adiposity and ↓strength?

(Diet, activity, psychosocial factors, inaccurate beliefs, etc.)

Sub-groups

Are there different phenotypes / sub-groups of at risk individuals

(i.e., OA phenotypes.)

Acknowledgements