Paediatric ACL injury

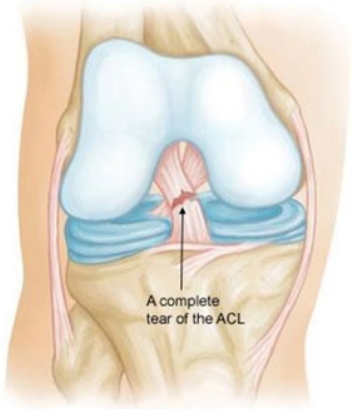
Why aren't we doing more?

Creation of Australia's first Paediatric ACL registry and summary of demographic data from our first 150 patients

Dr Sheanna Maine

Acknowledgement to Kylie Bradford and the QCH team

Queensland Government



No disclosures regarding this topic

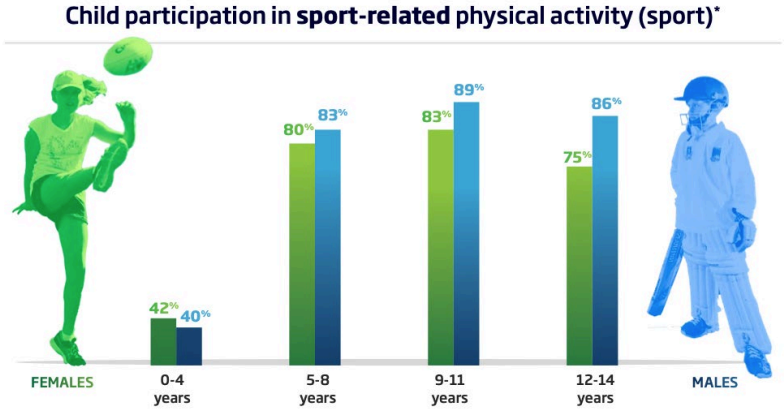
Introduction

- ACL rupture occurs more commonly in young people/adolescents than in
  (US data = x3, rises between 12-14yo, peaks between 15-18yo)

- **Australia**;
  - **highest incidence of ACL injuries in the world**
  - prevalence of ACLR is 52 per 100 000
- Treatment is different in children compared to adults;
  - challenges due to growth plates
  - higher rate of graft rupture has been reported
  - behavioural + developmental + neuromuscular issues

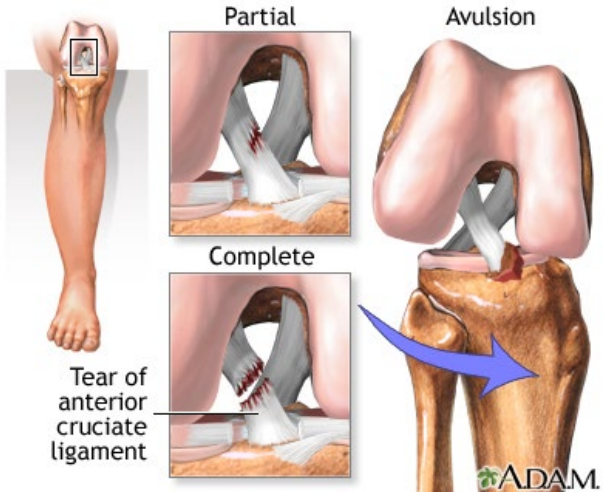
Reasons for ↑incidence?

- FEMALE PARTICIPATION
- ↑ clinical awareness / RADIOLOGY
- ↑ participation in organised and competitive sport
- lack of frequent multi-planar movement experiences in the developing pre-school neuromusculoskeletal system
- concurrent ↑in sedentary behavior and ↓physical activity
- earlier/pre-season sport specific training
- all year round participation
- ↑ BMI



Mechanism of Injury (MOI)	(eg) Sport
Pivoting injury (changing direction rapidly, side-stepping)	Union/league, AFL, soccer, touch
Sudden stop	Netball, soccer, touch, basketball
Hyperextension/landing from jump	AFL, basketball, long-jump
Direct collision	Multiple team ball sports

Injury	Management
Partial thickness ACL tear	Depends on amount of subjective instability and other symptoms
Tibial spine avulsion fracture	Bracing/cast in extension vs ORIF (depending on Grade)
Full thickness ACL tear	**Trend towards surgical over conservative management**



Full thickness ACL tears - Historical thinking

- Children are skeletally immature and have growth plates
- Risk of damage to open physes can potentially lead to leg length discrepancies or angular deformities
- Commence conservative management and delay surgery until they are skeletally mature
  1. Activity restriction/modification
  2. Physiotherapy
  3. Bracing - nil evidence to support prevention of an ACL injury and limited evidence to support

     returning to sport with bracing post-injury or post-ACLR *(Mall (2013), McConkey, 2011)*

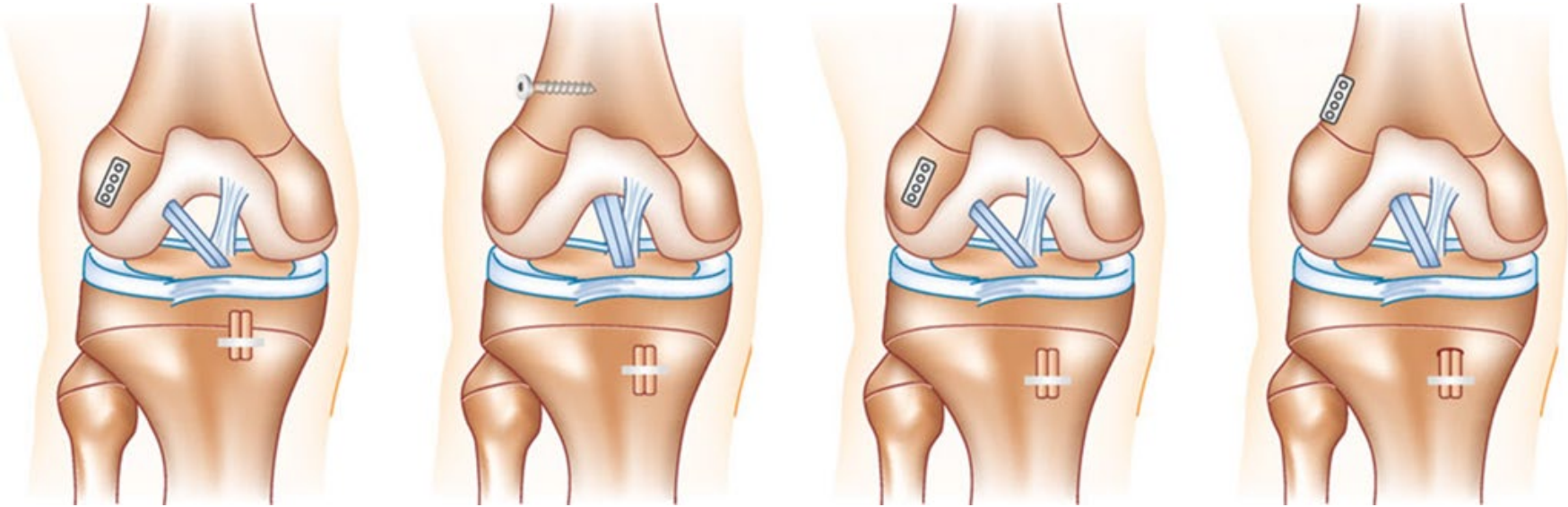
But, conservative management can lead to chronic instability and poorer outcomes with fewer athletes able to return to their sport at their previous level.

Full thickness ACL tears - Current thinking

- Trend towards early surgical management,
- Reasoning and evidence towards early vs delayed surgery due to increased risk of developing secondary associated injuries (if TTS > 6/52) with minimal short-term complications;
  - ↑ severity/irreparable meniscal injuries (↑↑ 4/12 > initial ACL injury)

    (meniscal involvement is the greatest risk factor in the development of degenerative/OA changes)
  - ↑chondral injuries
  - ↑instability symptoms
- Children are more likely to participate in risk taking behaviours and less like to modify activity

1. Physeal-Sparing (intra-articular) 2. Partial transphyseal 3. Partial transphyseal 4. Complete transphyseal



Partial transphyseal approach spare the femoral physis but cross the tibial physis

(McConkey, 2011)

Graft Rupture

- increased risk of paediatric/adolescent cf adult ACLR re-rupturing, especially within the first 12 months.

  Proposed risk factors;
  - ✓ risk taking behaviour
  - ✓ returning to activity too early
  - ✓ unrealistic expectations
  - ✓ surgical techniques
  - ✓ rehabilitation

  Evidenced risk factors;
  - ✓ young age
  - ✓ return to pivot sport
  - ✓ allograft use

- Risk of ipsilateral and/or contralateral rupture
- literature quotes 25% risk of ACL graft rupture or contralateral ACL rupture within 15 years of initial surgery (all ages)

Complications After Pediatric ACL Reconstruction: A Meta-analysis

Stephanie E. Wong, MD, Brian T. Feeley, MD, and Nirav K. Pandya, MD

Published in JPO 2019

- RERUPTURE (160 studies)
  - 8.7% rerupture rate (115 of 1329 pts)
  - Contralateral knee injury
- DEFORMITY (45 studies)
  - LLD – both Shortening and Overgrowth (2.49cm to 1.65cm respectively)
  - ANGULAR DEFORMITY – Mainly Valgus, also Varus, Flexion and Recurvatum
  - 18 patients
- No consensus on surgical technique

Meniscal Injury

Earlier anterior cruciate ligament reconstruction is associated with a decreased risk of medial meniscal and articular cartilage damage in children and adolescents: a systematic review and meta-analysis

Jeffrey Kay[1] · Muzammil Memon[1] · Ajay Shah[2] · Yi-Meng Yen[3] · Kristian Samuelsson[4] · Devin Peterson[1] · Nicole Simunovic[5] · Helene Flageole[6] · Olufemi R. Ayeni[1]

Received: 29 March 2018 / Accepted: 1 June 2018 / Published online: 6 June 2018

- 9 studies 1353 paediatric patients (mean 14yo)
- MRI at diagnosis compared with intra-op findings
- Significantly decreased risk of Medial Meniscal injury with early reconstruction
- Significantly decreased rate of chondral injury (medial and lateral femoral condyle)

2018 International Olympic Committee consensus statement on prevention, diagnosis and management of paediatric anterior cruciate ligament (ACL) injuries

Clare L. Ardern[1,2] · Guri Ekås[3,4,5] · Hege Grindem[6] · Håvard Moksnes[4] · Allen Anderson · Franck Chotel[7] · Moises Cohen[8] · Magnus Forssblad[9] · Theodore J. Ganley[10] · Julian A. Feller[11,12] · Jón Karlsson[13] · Mininder S. Kocher[14,15] · Robert F. LaPrade[16,17] · Mike McNamee[18] · Bert Mandelbaum[19] · Lyle Micheli[14,15,20] · Nicholas Mohtadi[21] · Bruce Reider[22] · Justin Roe[23] · Romain Seil[24,25] · Rainer Siebold[26,27] · Holly J. Silvers-Granelli[28] · Torbjørn Soligard[29,30] · Erik Witvrouw[31] · Lars Engebretsen[3,4,5,29]

Ardern CL, *et al*. *Br J Sports Med* 2018;**0**:1–17. doi:10.1136/bjsports-2018-099060

1. Prospective **injury surveillance** studies
2. Prospective research on **outcomes** after surgical and non-surgical treatment.
3. Efficacy of **different surgical techniques**.
4. Multicentre and registry studies should be prioritised.

LONGITUDINAL MULTIDISCIPLINARY PROSPECTIVE PAEDIATRIC ANTERIOR CRUCIATE LIGAMENT REGISTRY

Other benefits of clinical registries

Quality

AUSTRALIAN COMMISSION ON SAFETY AND QUALITY IN HEALTH CARE

Cost-effective:

Impact on care

AOANJRR Australian Orthopaedic Association National Joint Replacement Registry

Registry Aims and Objectives

1. Compare clinical, functional, and radiographic parameters
2. Obtain high-quality long-term data to influence and inform protocols and practice
3. Comparatively analyse surgical treatment outcomes
4. Examine the long-term outcome of ACL injury in the development of OA
5. Determine the timeline for patients to return to full physical function and at what level/intensity
6. Guide and standardise best practice management for surgery and rehabilitation

Inclusion criteria

- confirmed diagnosis of ACL rupture on MRI
- receive follow-up at participating centre
- Maximum age = 16, no minimum age (youngest age at injury = 6)
- concomitant injuries (ipsi- or contra-lateral)
- *patients who had surgery prior to commencement of registry may be included so retrospective diagnostic and treatment data can be collected*

Exclusion criteria

- no definitive diagnosis of ACL rupture
- patients who are not intending to have f/u at a participating centre
- congenital absence eg. fibula hemimelia

?DATA?

What data are we collecting?

1. Patient factors
2. Treatment factors
3. Complications
4. Medium → long-term outcomes *(functional + joint health/OA + PROMs)*

What main questions do we want answered?

1. Predictors of injury
2. Predictors of graft re-rupture
3. Predictors of joint health/OA
4. Predictors of outcomes at 6 + 12 months

Multidisciplinary data collection with 5 minimum data sets;

1. Medical imaging
2. Patient Reported Outcome Measures (PROMs)
3. Surgical findings and technique
4. Knee AP laxity (using GNRB)
5. Physical/functional outcome measures

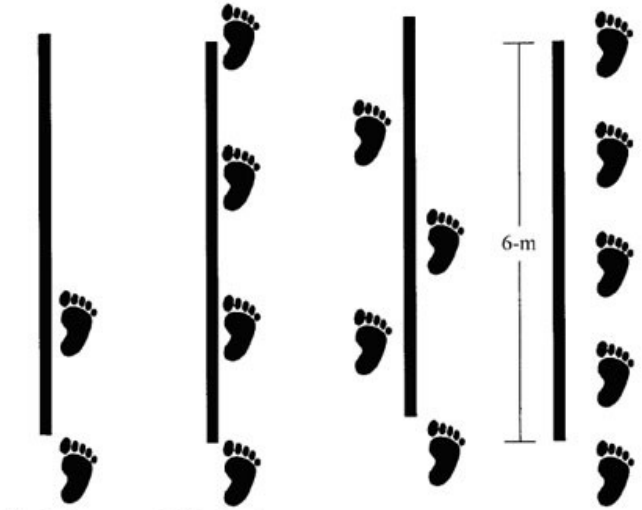
Data collected at the following timepoints

- Pre-operative
- Peri-operative
- 6 months post-op
- 12 months post-op
- 3 and 5 years post-op (MRI and clinical review only)

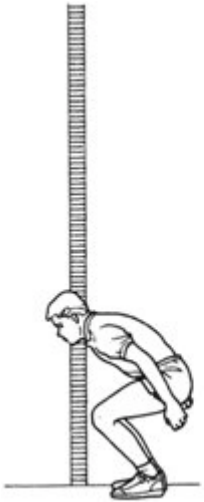
For any registry to be valid, 80% of data needs to be collected

Parameter	Pre-operative	6/12 Post-operative	12/12 Post-operative
Baseline data	• Side (L)/(R)/bilateral • DOI • MOI (contact vs non-contact, sport vs non-sport, descriptive report) • dominant leg • Age, sex • Height/weight/BMI • Ethnicity • Menarche (month/year) • Sports Specialization (how many sports played, at what level) • Physical/functional/sports goals	• Height/weight/BMI • (Menarche) • Rehabilitation participation/ attendance/compliance • Rehab stage 1-5 and stage • Goals	• Height/weight/BMI • (Menarche) • Rehabilitation participation/ attendance/compliance • Rehab stage 1-5 and stage • Goals • Return to sport
Laxity	Lachman's (Grade 0-3) Pivot shift (Grade 0-3) GNRB™ laxometer (@134 + 150N)	Lachman's (Grade 0-3) Pivot shift (Grade 0-3) GNRB™ laxometer (@134N)	Lachman's (Grade 0-3) Pivot shift (Grade 0-3) GNRB™ laxometer (@134 + 150N)
Physical Ax	Hip/knee ROM Beighton's score	Hip/knee ROM	Hip/knee ROM
Functional Outcomes	Y Balance Test	Y Balance Test Forward step-down (FSD) test Double jump for distance Vertical Jump for height	(Y Balance Test) Forward step-down (FSD) test Single hop for distance Cross-over hop for distance
PROMs	KOOS-Child Pedi-IKDS HSS Pedi-FABS	XXXXXX	KOOS-Child Pedi-IKDS HSS Pedi-FABS
Medical Imaging	• AP bilateral long leg XR • Lateral knee XR • Bone age • MRI	XXXXXX	• AP bilateral long leg XR • Lateral knee XR • MRI (3T knee coil, 1mm slices) (muscle volume, graft morphology, menisci, and chondral surfaces)

Lower Limb Symmetry Index (from Ross, Langford, and Whelan, 2002 (3))

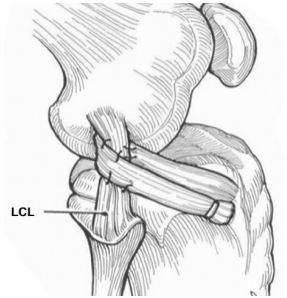


Single hop for distance | Triple hop for distance | Crossover hop for distance | 6-m hop for time



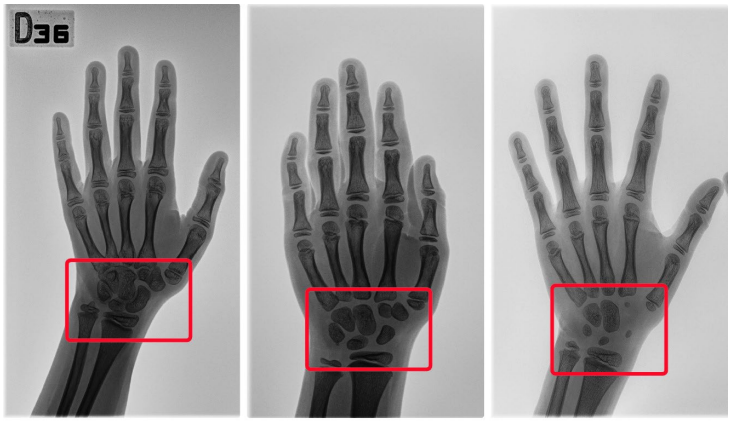
Peri-operative

EUA	• Knee ROM • Pivot shift test • Lachman's test
Chondral surfaces (grade 0-IV)	• Patella • Trochlea • LFC • MFC • Lateral tibial plateau • Medial tibial plateau
Meniscus (MM and LM) ➢ normal ➢ tear	• type of tear (parrot, bucket handled, radial, horizontal, vertical, complex, other) • Surgery (none, repair, debridement) • % remaining > debridement • repair technique (all inside, inside-out, outside-in)
Graft	• type (Semi-tendinosis, Semi-tendinosis/Gracilis, BTB, Quads, Allograft) • preparation (single, double, quads, quin, other) • diameter (mm) > preparation (proximal, middle, distal, 6-10mm)
Tunnels ➢ tibial ➢ femoral	• diameter • total length • reamed socket depth • fixation (screw, anchor, TLS, suspensory fixed loop, suspensory sliding loop) • screw type (metal, bioabsorbable)
Other	Intra-operative findings different to that expected from MRI? ie. wait list pathology Other concomitant surgery. eg. lateral tenodesis *Fluoroscopy time* TTS (time to surgery)



Reasoning for medical imaging protocol

Parameter	Reason Pre-op	Reason 12/12
Bone age	• different to chronological age, related to outcomes • wrist XR for ♂ < 11yo and ♀ < 10yo, otherwise elbow XR • influence on surgical technique? The higher the bone age, the less surgical interference to physis should occur? • esp important in pre-pubertal patients	—
AP long leg standing	Baseline; • coronal plane alignment/mechanical axis deviation (MAD) • lateral distal femoral angle (LDFA) • medial proximal tibial angle (MPTA) • leg length	Have changes to baseline measurements occurred during growth from physeal damage at time of surgery? Hardware and tunnel position
+/- Knee AP	• if done as part of standard knee injury series, otherwise long leg films • assess for other injuries	—
Knee lateral	• standard injury knee series • assess for other injuries • baseline posterior proximal tibia angle (PPTA) ('tibial slope'), sagittal plane alignment	• have changes to baseline PPTA occurred during growth from physeal damage at time of surgery? • hardware and tunnel position
MRI	• ACL rupture diagnosis • other internal knee pathology diagnosis • baseline menisci and chondral status • baseline hamstring tendon CSA?	• graft morphology/CSA • secondary meniscal and chondral changes • additional biomarkers of early OA? • hamstring CSA?

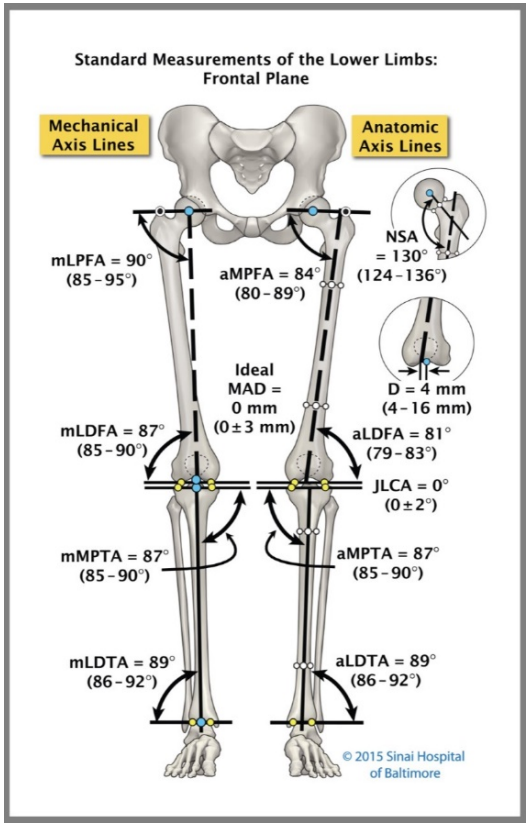

D36

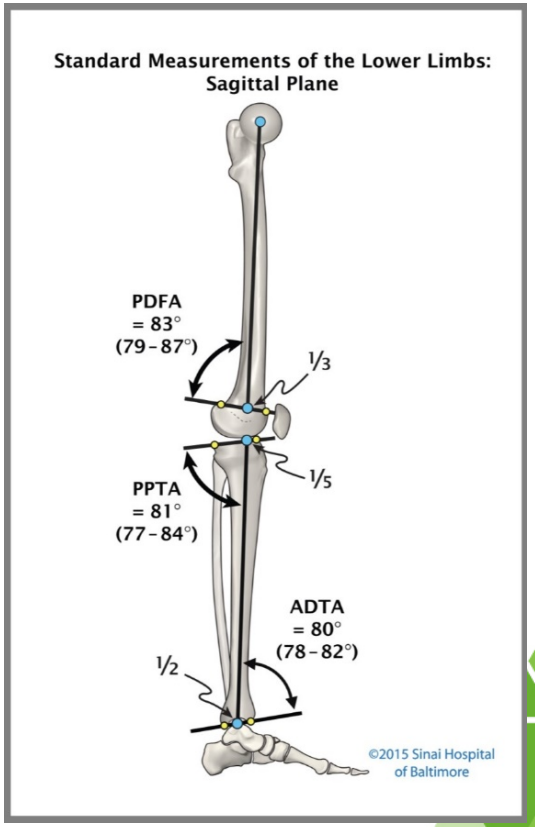

Olecranon
Internal Epicondyle
Ext Epicondyle
Capitulum
Trochlia
Radius


Weight Bearing

Quantifying Alignment

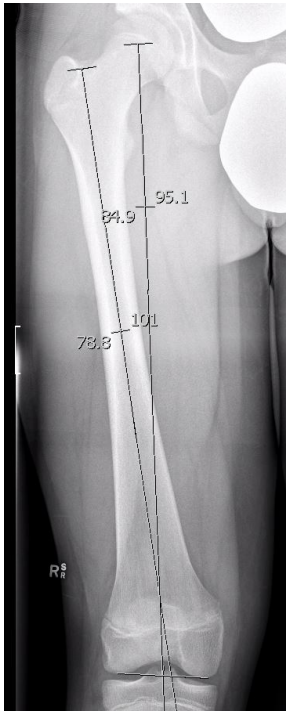
Standard measurement technique to obtain coronal and sagittal measurements





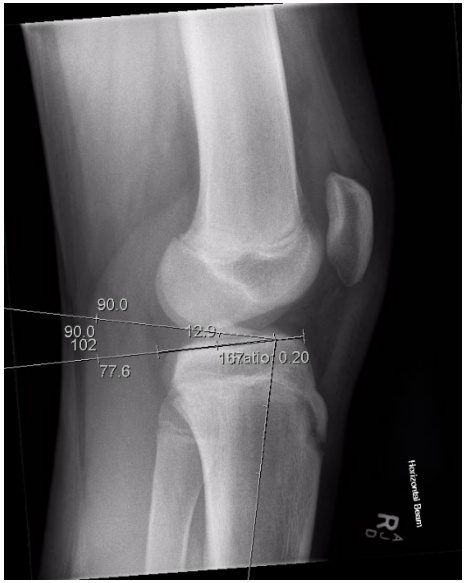
Mechanical axis

MAD



aLDFA/mLDFA

MPTA



PPTA

Complications and Secondary Events

- Wait list pathology
- Graft rupture (including time to rupture, complete vs partial, previously known partial tear?, location of failure, mode of failure)
- Contralateral rupture
- Meniscal pathology (progression of known pathology vs new)
- Hospital readmission (planned vs unplanned)
- Infection (superficial vs deep)
- Growth disturbance (leg length and alignment issues)
- Indicators of early onset OA
- Other (eg. FFD, ipsilateral hamstring tear, lax but intact graft)

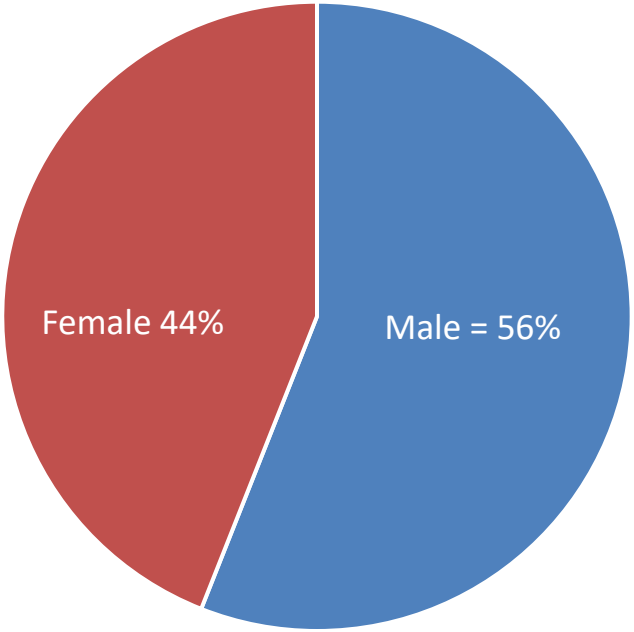
LONGITUDINAL MULTIDISCIPLINARY PROSPECTIVE PAEDIATRIC ANTERIOR CRUCIATE LIGAMENT REGISTRY

Baseline and Demographic data for the first 150 consecutive enrolments

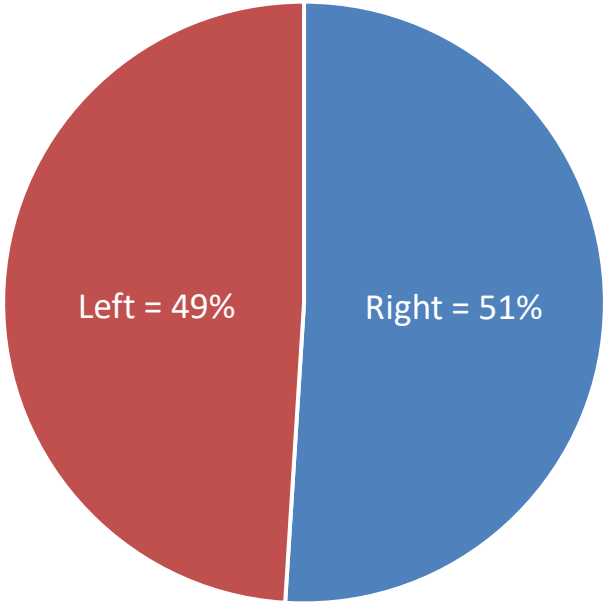
Data collected over a 31 month period from 18/9/18 - 8/4/21

Queensland Government

Sex



Side



Females post-menarche = 92%

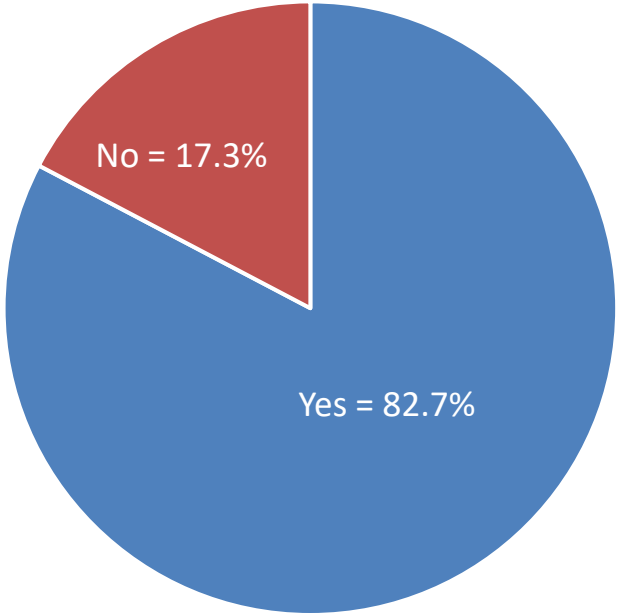
Bilateral ACLRs n = 1

Ethnicity

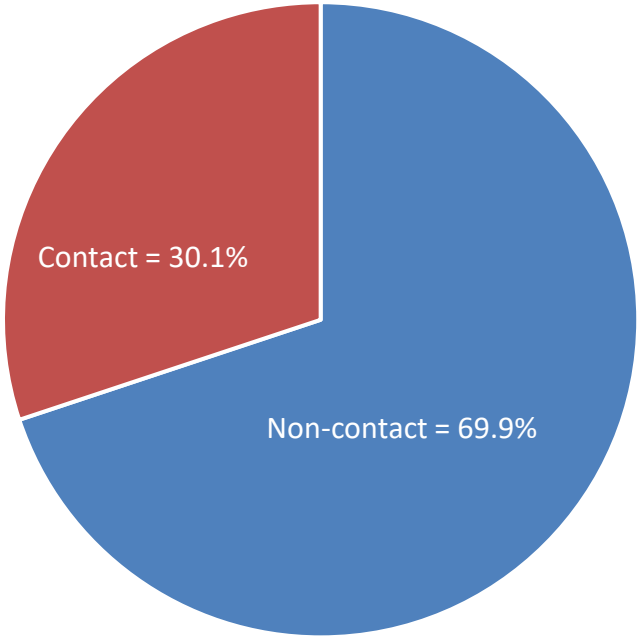
Aboriginal and/or Torres Strait Islander = 8.6%
Maori and/or Pacific Islander = 18.5%

	Age range	Average Age	Male %	Female %
MaPI	8.5 - 16.8	14.5	42.8	57.2
Indigenous	13.5 - 16.3	15.2	38.5	61.5
Other	8.4 - 17.6	14.1	60.9	39.1

Sporting Injury?

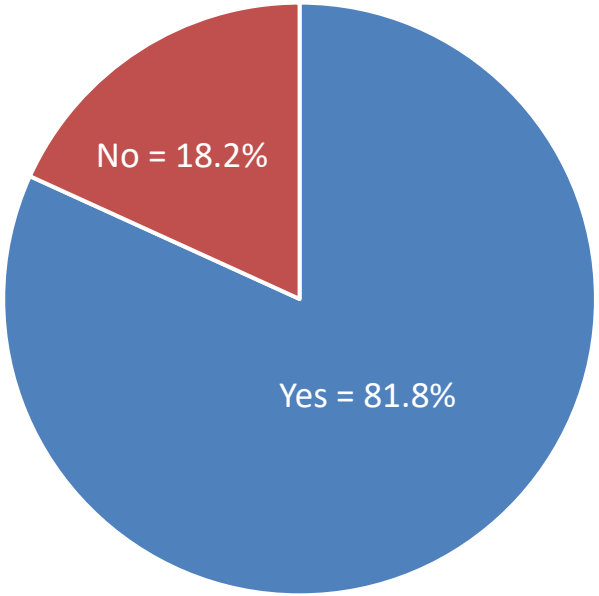


Contact vs Non-contact*

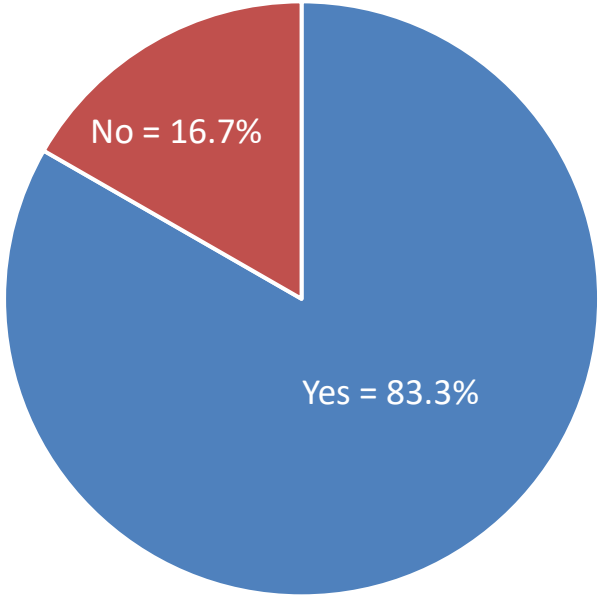


Sporting Injury (Yes/No) by Sex

Females

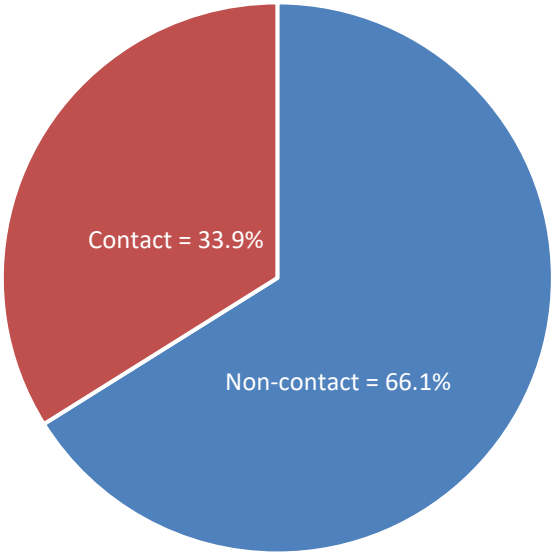


Males

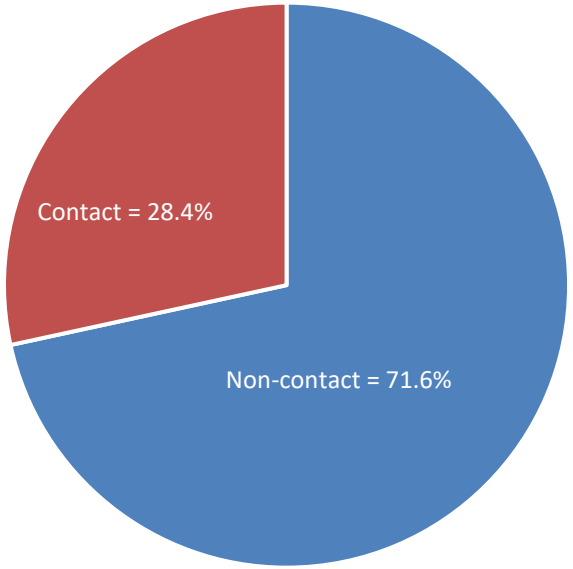


Contact vs Non-Contact by Sex

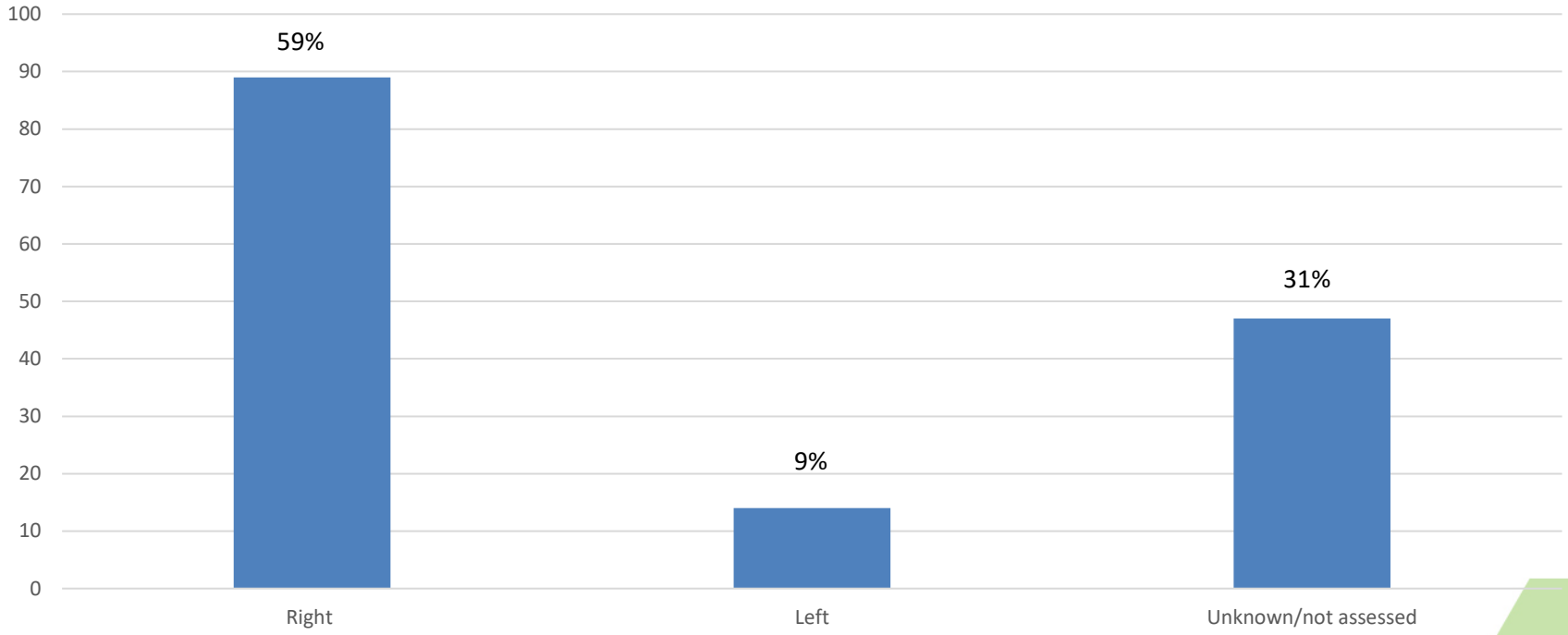
Females



Males

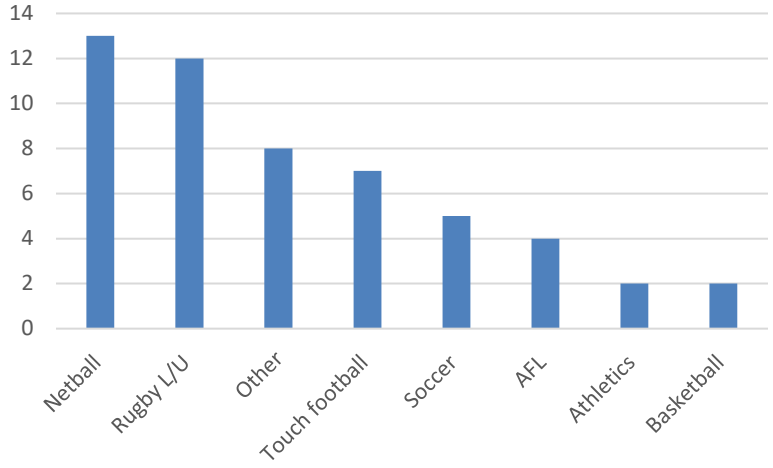


Foot Dominance



Causal Sport as MOI by Sex

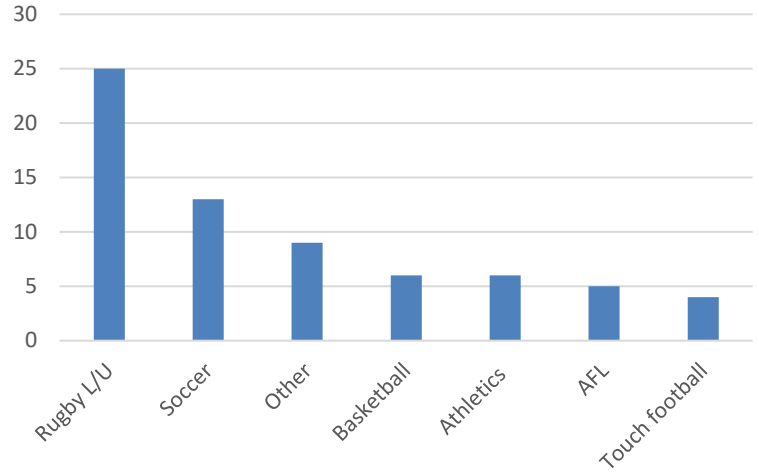
Females



Other

- volleyball x2
- ultimate disc
- indoor tag
- hockey
- handball
- gymnastics
- dance

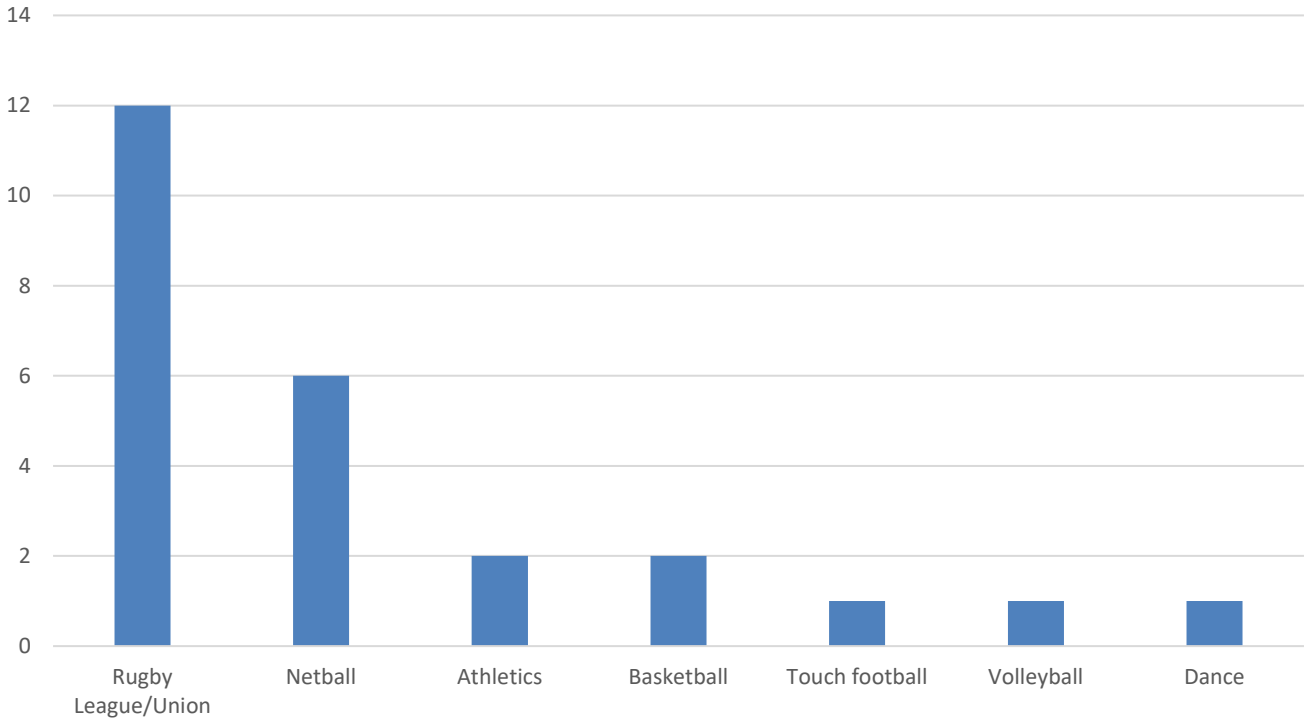
Males



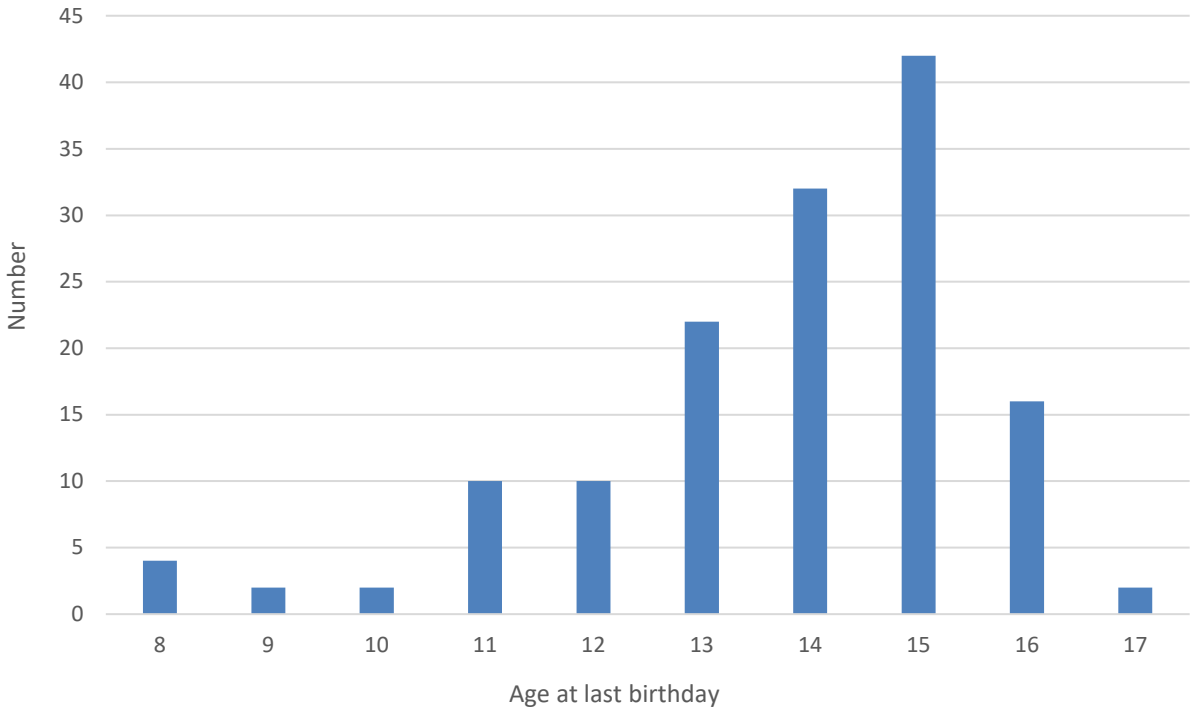
Other

- non-motorized vehicle competition;
  - dirtbike x3
  - BMX
  - scooter
- snowboarding
- competitive trampoline
- dodgeball (school HPE)

Causal Sport related to ethnicity - Maori and/or Pacific Islander (n = 25 representing the 90% that were sporting injuries)



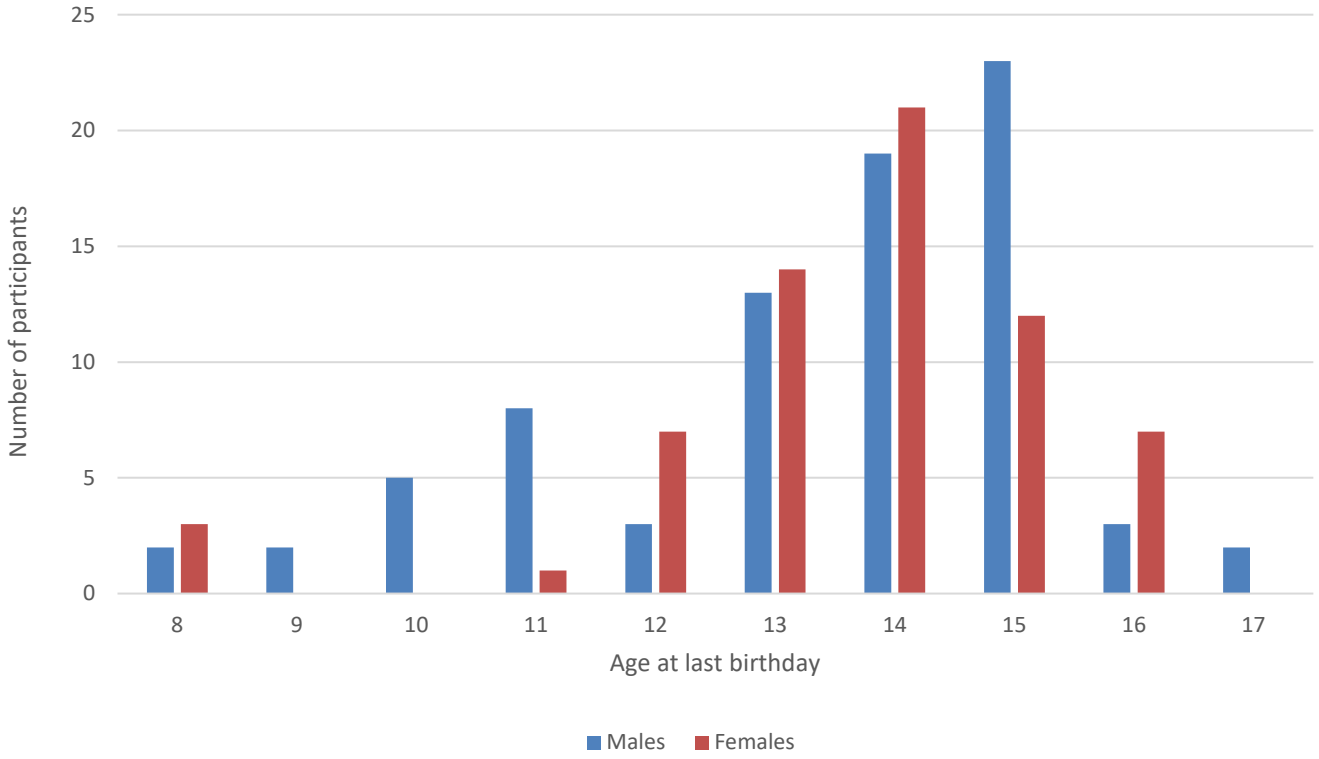
Age at Baseline*



Mean = 14.3
Median = 14.7
Range = 8.4 - 17.5
12.7% < 12 years of age

**Missing data for 8 private patients*

Age at injury by sex



80.8% of all injuries in children under the age of 12 occurred in males

Summary

- Aboriginal and/or Torres Strait Islander and Maori and/or Pacific Islander ethnic groups were more likely to rupture their ACL via a sporting injury. Rugby league/union then netball were the most common sports for both groups.
- Rugby league and union were the most common causal sporting injury
- no females sustained their injury by non-motorized vehicle accident; all 5 cases were males

- 150 kids in 31 months….

Challenges, Opportunities, and Future Directions

- Outcome measures;
  - are not paediatric specific
  - large age range (8 - 18yo) with very different physical abilities and developmental stages
  - are not sports specific so may not predict performance and risk of complications for the spectrum of physical activity this cohort participates in.
  - multiple other parameters *could* be assessed (eg. motion analysis, force platform, psychological readiness to return to sport.

Conclusions

- Analysis of a cohort of paediatric patients with ACL injuries has revealed preliminary trends in demographic and injury traits that may inform clinical practice and physical activity recommendations.

- Awareness, prevention, advocacy, and rehabilitation strategies for the concerning issue of paediatric ACL injuries should be specifically targeted according to age, sex, ethnicity, type of sports, and injury mechanism.

Cost of injuries – Burden on Society

AOA Joint Action Youth Injury Prevention Program

Almost 2/3rd of Australians aged 15 years & over participated in physical activities for recreation, exercise or sport at some time during 2011-12 [1]

36,000 people aged 15 years and over: were hospitalised in 2011/12 as the result of an injury sustained while playing sport, and spent a total of 79,000 days in hospital.[2]

Almost half of all hospitalised injuries for young people: (49% or 19,171 hospitalisations) occurred while engaged in sporting/leisure activities (2008). Of these, team ball sports injuries resulted in 9,820 cases (about half).[4]

526,000 Australians aged 15 years and over: had a current long-term condition that was a result of a sporting or exercise injury in 2007-08.

$1.8 billion: the estimated annual sport injury health cost estimated by a 2004 study (Medibank Private 2004).[8]

Four times greater: the cost of sports related injuries in children under 15 to Victorian hospitals when compared with road traffic injury costs.[3]

6% growth: the estimated annual growth in Victorian hospital emergency department presentations relating to sports injury (meanwhile road related injuries have stabilised).[2]

30% to 40%: the estimated percentage of participants experiencing a major sports-related injury that will discontinue playing sport and/or will significantly reduce their physical activity levels.[2]

20,000: the estimated number of participants per year dropping out of sport in Victoria in 2020 due to a sports-related injury.[2]

545,000: the number of Australians reported to have a long-term health condition caused by a sport or exercise-related injury.[2]

Highest ACL Injury Rate : Australia has one of the highest CL Injury rates and subsequent reconstruction in the world.[8]

$1.65 billion and up to $2 billion: some recent estimates of the total burden each year of all sports injuries in Australia.[2]

AOA
AUSTRALIAN ORTHOPAEDIC ASSOCIATION

Meta-Analysis of Meta-Analyses of Anterior Cruciate Ligament Injury Reduction Training Programs

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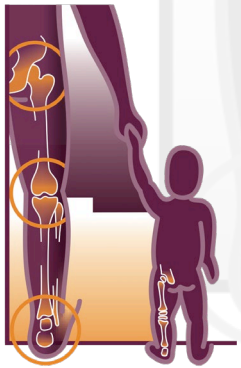

- "the overall finding of the analysis demonstrated that ACL injury reduction programs decrease the risk of all ACL injuries by half and non- contact ACL injuries in all athletes by two-thirds in female athletes."

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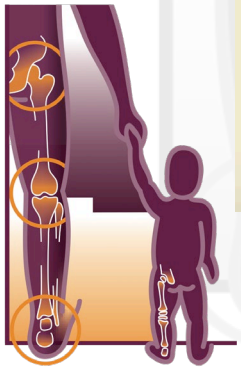
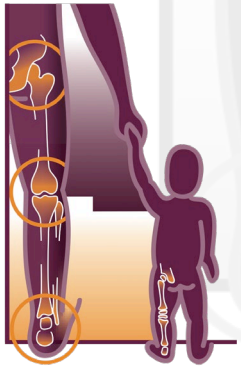
Exercise-Based Knee and Anterior Cruciate Ligament Injury Prevention

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Academy of Orthopaedic Physical Therapy and the American Academy of Sports Physical Therapy



Recommendations – Level 1 evidence

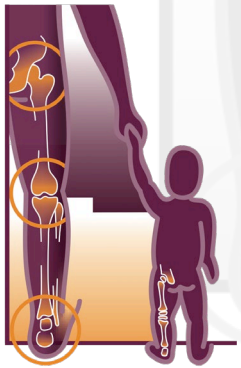
- Exercise-based knee injury prevention programs used for women should incorporate multiple components, proximal control exercises, and a combination of strength and plyometric exercises.
- Exercise-based knee injury prevention programs should involve training multiple times per week, training sessions that last longer than 20 minutes, and training volumes that are longer than 30 minutes per week.
- Clinicians, coaches, parents, and athletes should start exercise-based knee injury prevention programs in the preseason and continue performing the program throughout the regular season.
- Clinicians, coaches, parents, and athletes must ensure high compliance with exercise-based knee injury prevention programs, particularly in female athletes.



Recommendations

- Exercise-based knee injury prevention programs used for women should incorporate multiple components, proximal control exercises, and a combination of strength and plyometric exercises.

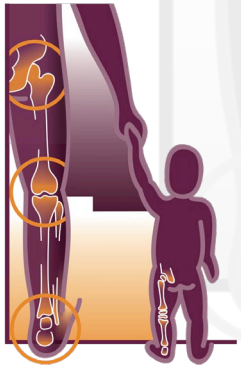
> **A** For the greatest reduction in future medical costs and prevention of ACL injuries, osteoarthritis, and total knee replacements, clinicians, coaches, parents, and athletes should encourage implementation of exercise-based ACL injury prevention programs in athletes 12 to 25 years of age and involved in sports with a high risk of ACL injury.

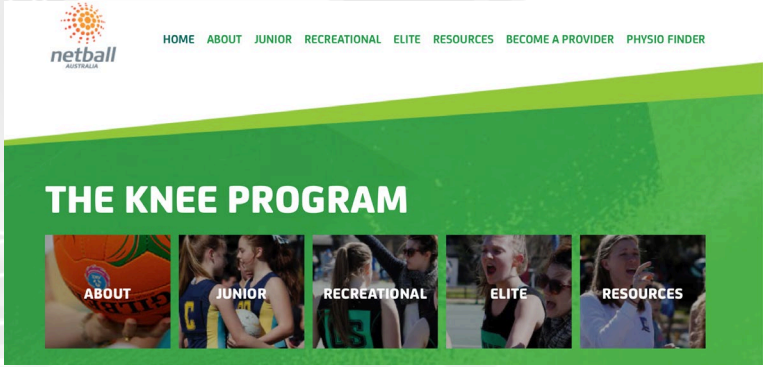


- Exercise-based knee injury prevention programs may not need to incorporate balance exercises, and balance should not be the sole component of a program.

In Australia

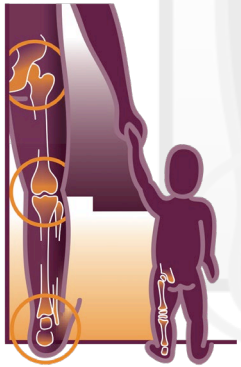
- No regulations exists to advocate for injury prevention
  - Netball Australia – Knee Program
  - AFL - Footy First
- Submission by Arthritis Australia and key stakeholders to develop National Sports Plan
- Assist all organisations responsible for youth sport to incorporate prevention into their training programs

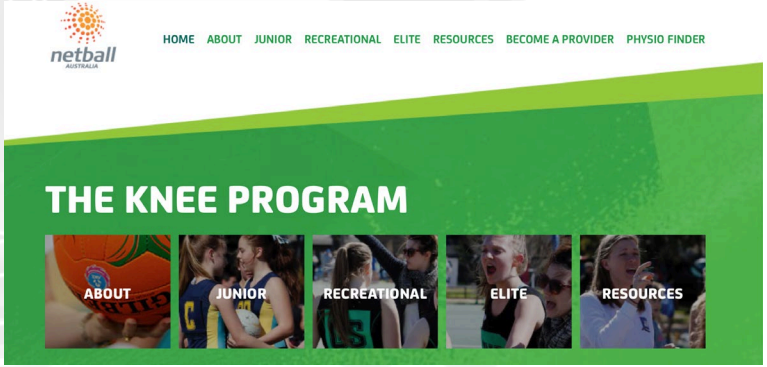




ACL injury prevention

- Still a work in (painfully slow) progress
- Needs adequate funding
- Needs support of community, sporting governing bodies, clubs, schools and families
- 150 kids in 31 months….





Thank you

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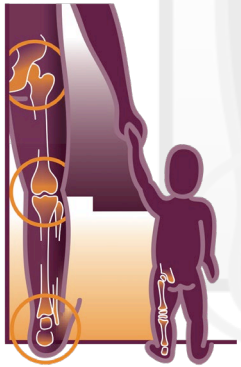

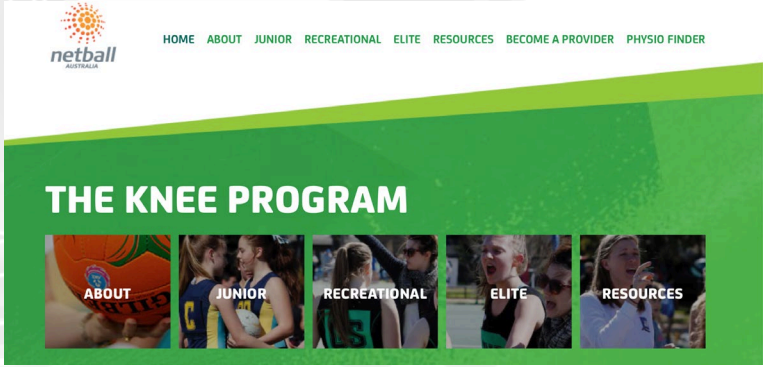

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