Preventing knee ligament (ACL) injuries in sport

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Time to add a new priority target for child injury prevention? The case for an excess burden associated with sport and exercise injury: population-based study

Caroline F Finch,1 Anna Wong Shee,2 Angelica Clasper2

ABSTRACT

Objective: To determine the population-level burden of sports injuries compared with that for road traffic injury for children aged <15 years in Victoria, Australia.

Design: Retrospective observational study.

Setting: Analysis of routinely collected data relating to non-fatal hospital-treated sports injury and road traffic injury cases for children aged <15 years in Victoria, Australia, over 2004–2010, inclusive.

Participants: 75,143 non-fatal hospital-treated sports injury and road traffic injury cases in children aged <15 years. Data included all Victorian public and private hospital hospitalisations, using the International Classification of Diseases and Related Problems 10th Revision, Australian Modification (ICD-10-AM) activity codes to identify sports-related cases and ICD-10-AM sport and location codes to identify road traffic injuries and injury presentations to 38 Victorian public hospital emergency departments, using a combination of activity, cause and location codes.

Main outcome measures: Trends in injury frequency and mild were analysed by log-linear Poisson regression and the population-level injury burden was estimated in terms of years lived with disability (YLD), hospital bed-days and direct hospital costs.

Results: Over the 7-year period, the annual frequency of non-fatal hospital-treated sports injury increased significantly by 29% (from 2.14 to 2.60, p < 0.001) but the frequency of non-fatal hospital-treated road traffic injury decreased by 26% (from 1.50 to 1.12, p < 0.001). Sports injury accounted for a larger population health burden than did road traffic injury at all ages. 3.3% of the total burden of disease (2265.6 to 2432.3) was attributable to non-fatal hospital-treated sports injury (23.9% of 13.88 and 2.6 times the direct hospital costs $314.0 million vs $422.7 million). Conclusion: The significant 7-year increase in the frequency of hospital-treated sports injury and the substantial higher injury population health burden (direct hospital costs, bed-day usage and YLD impacts) for sports injury compared with road traffic injury for children aged <15 years indicates an urgent need to prioritise sports injury prevention at this age group.

INTRODUCTION

Injury, particularly due to road trauma and transport accidents, is a recognised global health problem.1 In the past, injuries have been regarded as random events and often considered inevitable. More recently a better understanding of the nature of injuries has developed, and unintentional and intentional injuries are now viewed as largely preventable.1 As a result of the growing acceptance of injuries as a preventable public health problem, there has been increasing demand for effective injury prevention policies worldwide.1,2 Measurement of the health burden of injuries for understanding the magnitude and impact of the problem is the crucial first step in the planning and development of health policy. Non-fatal hospitalised outcomes from diseases and injuries are increasingly recognised as being critical to the prevention

- Over 7 years 2004 – 2010
- Sports injury greater population health burden than road traffic injury
- 5.4 times as many hospital-treated child sports injury cases than road traffic injury cases
- Annual injury frequency of non-fatal hospital-treated sports injuries increased significantly by 29% where non-fatal hospital-treated road traffic injury decreased by 26%
High incidence and costs for anterior cruciate ligament reconstructions performed in Australia from 2003–2004 to 2007–2008: time for an anterior cruciate ligament register by Scandinavian model?

K. W. Jansson¹, J. W. Orchard², T. R. Driscoll³, W. van Mechelen⁴
Increase in ACL injuries 5-14 year olds
Hospital Admissions in Victoria, Australia

High incidence of Osteoarthritis after ACL Rupture
Knee Osteoarthritis: Prevention is better than cure

- Joint injury → knee osteoarthritis
  - primary preventable cause in men,
  - second to obesity in women (Hunter, 2011)

- Evidence based prevention needs to (Finch et al, 2011)
  1) Target established causes (Donnelly et al 2012)
  2) Use appropriate translation (Finch et al, 2011)
Cadaveric Studies Reveal Crucial External Knee Loads ↑ ACL loading

= perfect storm of loading for the ACL
Characteristics of ACL Injuries in AFL

- 32% Full-contact
- 12% Partial-contact
- 56% Non-contact

42% Sidestep
- 29% Land
- 13% Land & Sidestep

Knee gave-way
- Valgus
- Internal rot’n

Valgus Only
- Valgus + Internal Rot’n

Visual-Perception-Action and ACL Injuries

Perception = Opponent approaching
Action = Sidestepping
Outcome = ACL injury

Preparatory Action = Kicking
Knee Loading in Sidestepping & Landing in the Laboratory

Planned Sidestepping to 45° in the laboratory: Arrow-planned (AP)

Arrow-planned
Unplanned Sidestepping to 45° in the laboratory: Arrow-unplanned (AUNP)

Arrow-Unplanned (AUNP)

Sidestepping to 45° in the laboratory:
1 Defender Scenario (1DS)

1-Defender Scenario (1DS)

Lee et al, Proc SPIE, 2010; Lee et al, J Motor Behav, 2013; Lee et al, MSSE, 2013;
Sidestepping to 45° in the laboratory:
2 Defender Scenario (2DS)
Different Visual-Perception Tasks Imposed Time Constraints

- Arrow Planned (AP)
- 1 Defender (1DS)
- 2 Defender (2DS)
- Arrow Uplanned (AUNP)

- EASIEST
  Most Preparation Time

- MOST DIFFICULT
  Least Preparation Time

External Knee Moments in Sidestepping in Weight Acceptance
Knee Joint Compression Force

Medial TF Contact Force (BW)

Lateral TF Contact Force (BW)

Total TF Contact Force (BW)

(Saxby et al, *Gait Posture*, 2016)
Sidestepping is the Perfect Storm of Loading for ACL
Hams & Quads Co-contraction Index

Resultant Ground Reaction Force

Visual-perception difficulty makes it worse...

**Trunk lateral flexion (deg)**

- AP
- 1DS
- 2DS
- AUNP

**Peak valgus moments**

- Weight acceptance (Nm/kg)

* AP < 1DS
* AP < 2DS
* AP < AUNP
† AUNP > 1DS
† AUNP > 2DS

Most upright in AP

⬆ 4° in other conditions

Lowest in AP

⬆ 40% in defender scenarios
† 70% in AUNP
Skill Level Affects Peak Valgus Moments

Across all Visual-Perception Scenarios

- High Level Players
- Low Level Players

Peak Valgus Moments (Nm/kg)

Two Defender (2DS) Visual-Perception Scenario

- High Level Players
- Low Level Players

Peak Valgus Moments (Nm/kg)

• Significant Skill x Visual Perception Condition (p<0.036)

• Post Hoc revealed only 2DS Visual Perception Condition (p<0.004)

Bad sidestepping techniques

Sidestepping techniques that
- peak valgus moments
- peak internal rotation moments

↑ Trunk Lateral Flexion
↑ Trunk External Rotation
↑ Foot Width
↑ Ankle Dorsiflexion

Ball carried on plant side

Bad Sidestep Techniques → ACL Injury

- Foot Wide
- Trunk Lateral Rot’n
- Trunk External Rot’n
- Ankle Dorsiflexed
- Arm Constrained
- Ball carried on plant side
Peak Valgus Knee Moment Landing From Mark

Decrease Ligament Loading

- Decrease external joint load
- Decrease muscular loading of ligaments
- Increase muscle support of ligaments

Plyometric training

- Technique training
- Balance & Control training
- Plyometric training
- Visual-Perception training

Reducing Risk of ACL Injuries
6 Weeks of Good Technique Training

- **Trunk Lateral Flexion**
  - Pre-training: Planned, Unplanned
  - Post-training: Planned, Unplanned
  - Foot from Pelvis Midline (cm)
  - *p* < 0.01

- **Trunk External Rotation**
  - Pre-training: Planned, Unplanned
  - Post-training: Planned, Unplanned
  - *p* = 0.034

- **Knee Flexion**
  - Pre-training: Planned, Unplanned
  - Post-training: Planned, Unplanned

- **Foot distance from Pelvis Midline**
  - Pre-training: Planned, Unplanned
  - Post-training: Planned, Unplanned
  - *p* < 0.01

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Dempsey et al, MSSE, 2007; Dempsey et al, AJSM, 2009
12 weeks of...

Machine
Weights
Training

Free
Weights
Training

Balance
Training

Cochrane et al, MSSE, 2010; Cochrane et al, MSEE, Submitted
% Change in Peak Valgus Moment in Sidestepping

<table>
<thead>
<tr>
<th>Training Groups</th>
<th>% Change</th>
<th>Valgus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls</td>
<td></td>
<td>☓</td>
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<tr>
<td>Free Weights</td>
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<td>Machine Weights</td>
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<tr>
<td>Balance</td>
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* Significant difference from before to after training.

Resultant Ground Reaction Force

Cochrane et al, *MSSE*, 2010;
% Change in Hams-Quads Co-contraction

% Change

Resultant Ground Reaction Force

Cochrane et al, MSSE, Submitted
Good Techniques

- Reduce Cut Angle
- Slow Running Speed
  - Create Time
    - Move COM early to COD
  - Narrow Foot Placement Width
  - No Lower Limb Valgus
    - Neutral Hip Rotation
    - Less Hip Flexion
    - Less Knee Flexion
    - Neutral Ankle In-Eversion
  - Knee
    - Flexed
    - Facing direction of travel
  - Trunk
    - Upright and Straight ahead
    - Lean and Turn into COD
  - Foot
    - Plantar Flexed
    - Straight Ahead

- No Lower Limb Valgus
  - Neutral Hip Rotation
  - Less Hip Flexion
  - Less Knee Flexion
  - Neutral Ankle In-Eversion
- Knee
  - Flexed
  - Facing direction of travel
- Trunk
  - Medial Flexion - away from landing leg
  - Facing direction of travel
- Foot
  - Plantar Flexed
  - Facing direction of travel
Can We Reduce In-game Injuries?

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**Study protocol**

The Preventing Australian Football Injuries with Exercise (PAFIX) Study: a group randomised controlled trial

C Finch,¹ D Lloyd,² B Elliott²


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- PAFIX Injury prevention program

What do community football players think about different exercise-training programmes? Implications for the delivery of lower limb injury prevention programmes

Caroline F Finch,¹ Tim LA Doyle,²,³ Alasdair R Dempsey,⁴ Bruce C Elliott,³ Dara M Twomey,⁵ Peta E White,¹ Kathy Diamantopoulou,⁶ Warren Young,⁵ David G Lloyd²,³


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- Continued throughout playing season

50% reduction in the exposure-adjusted rate of in-game knee injuries

PAFIX vs Placebo
FOOTY FIRST
A training program to prevent leg injuries in community Australian Football

https://footyfirstaustralia.wordpress.com/
FootyFirst Manual
Are they really doing it right?

When ‘just doing it’ is not enough: Assessing the fidelity of player performance of an injury prevention exercise program

Lauren V. Fortington, Alex Donaldson, Tim Lathlean, Warren B. Young, Belinda J. Gabbe, David Lloyd, Caroline F. Finch

Who am I?  
What do I do?

Dr Jonathon Headrick: jonathon.headrick@griffith.edu.au

- Lecturer - School of Allied Health Sciences  
  » Exercise & Sport Psychology  
  » Motor Learning & Control

- Research Interest: Skill Acquisition

  Development of functional performer-environment relationships

- Worked with: AIS; APC; QAS; Cricket Australia; Schools; Clubs
Previous work

- Proximity-to-goal as a constraint on patterns of behaviour in attacker-defender dyads in team games
- Attunement to haptic information helps skilled performers select implements for striking a ball in cricket
- The dynamics of expertise acquisition in sport: The role of affective learning design
- Examination of the Optimal Equipment Modification and Game Formats for the Foundation Stage of the Australian Cricket Pathway
- A principled approach to equipment scaling for children's sport
My Role

- Build on existing knowledge around mechanisms of ACL injury
- Continue to develop programs such as *FootyFirst* to reduce incidence of injury – focus on ACL
  - Incorporate these foundation techniques into more elaborate tasks
- Enhance sport specific / general movement skills in junior – youth sport
  - Maintain participation
  - Increase enjoyment – engagement
  - Enhance development of skills
- Ideally at the same time!
Building on FootyFirst

Some key points:

- FootyFirst should be part of all training sessions. It should be completed at least twice a week.
- The warm-up should take about 5 minutes and the strength and conditioning exercises and jumping, landing and changing direction activities about 15 minutes.
- To get the full benefit of FootyFirst it is important to teach and reinforce proper technique.

To maximise the injury prevention and performance benefits of FootyFirst your players need to:

DO IT PROPERLY
DO IT CONSISTENTLY

FootyFirst Manual, p 4-5
Building on *FootyFirst*

**Questions / Problems:**

How can we incorporate key exercises from the *FootyFirst* program into all training sessions?

How can the critical actions of *jumping, landing, and changing direction* be effectively practiced?

Is there one “proper” or correct technique?

How should these critical technical skills be taught or incorporated to engage players?
How can we make practice Safe(er)?

What actions and movements are important to practice for reducing ACL injury?

» Jumping
» Landing
» Change of Direction

What age and skill level are we working with?

» Tailoring programs for individual needs
How can we make practice **Real(er)**?

How can we make practice more like a match/competition?

- Representative Learning Design
- Sampling information

What perceptual information to include in practice for players to attune to?

- Constraints
- Sport Specific
- Informational

**Pre-planned changing direction**

Teaches players to side-step and respond to external stimuli in a way that will lower the risk of knee and ankle injuries.

**RECOMMENDED EQUIPMENT**
Four cones, placed as shown in the diagram.
How can we make practice Fun(erer)?

How can we make practice more enjoyable and engaging for all abilities and ages?

» Beginners – Elite youth

How can we teach/coach safe technique without relying on overly repetitive drill based activities?

» Provide parameters
» Encourage exploration
What is the goal?

Move from prescriptive and planned to unanticipated and variable

Pre-planned changing direction

Teaches players to side-step and respond to external stimuli in a way that will lower the risk of knee and ankle injuries.

Vs

Unanticipated changing direction

Practising changing direction in response to an unpredictable cue using the correct, safe side-stepping technique will improve the neuromuscular control of side-stepping where the player is required to make ‘spur of the moment’ decisions. This will lower the risk of knee and ankle injuries.
Griffith University
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Thank You