Is there a link between Injury and Ground Conditions?

A Case Study in Australian Football

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A glance at Australian football

- Consists of 18 players per team
- Played on an oval shaped ground
- The game is a fast-paced combination of speed, athleticism, skill and physical toughness
- Players, kick, tackle, jump to mark, handpass, and run...
Large Scale Study Needed

so....

Where can we get the funding???
The combination of skills from these two universities joined to submit a grant application in reducing knee injuries in community level football.

Assoc Professor David Lloyd & Professor Bruce Elliot

& Professor Caroline Finch
PAFIX Project

- Preventing Australian Football Injuries through Exercise (PAFIX) (Finch et al., 2009)

- Australian National Health & Medical Research Council funded project ($1.06m)

- Examining the effectiveness of special training programs on reducing lower limb injuries in community level football players
Study Design

- 4 year project with 2 years data collection (2007 & 2008)
- 40 teams participating
- Two training programs
Study Plan

VICTORIA
20 teams

WESTERN AUSTRALIA
20 teams

5 clubs
(Senior + Reserve)

5 clubs
(Senior + Reserve)

5 clubs
(Senior + Reserve)

5 clubs
(Senior + Reserve)

TRAINING PROGRAM 1

TRAINING PROGRAM 2

TRAINING PROGRAM 1

TRAINING PROGRAM 2

Project Manager
Data Collected

- Field & Laboratory Data
- Player & Coach Knowledge & Attitude Surveys
- Ground Hardness (Penetrometer)
- Subjective Ground Condition Data
- Game & Training Exposure
- Training Exposure
- Game & Training Injury Data
- Lower Limb Taping
- PAFIX Project
• Opportunity for a small grant scheme at the University of Ballarat ($10K)

• Interest from Sport & Recreation Victoria (State Government Department) ($26K)
Drought and injuries
What does the evidence say about ground conditions and injury?
AFL Injury Reports - 15 years

The 2008 & 2006 reports had no grounds data included. But 2002 included it.

- The 2002 AFL injury report, 11 years data at AFL level. Five years prior to 2002 hardness measures were recorded using a penetrometer.

- The only injury they found which had significantly higher rates on harder grounds were AC joint sprains.

- More facial fractures on softer grounds.

- No difference in hamstring injuries, quad strains, knee injuries, or ankle injuries on harder grounds.

- The variable more likely to be responsible for differences is shoe-surface traction.
Existing Evidence

Relationship between ground hardness and game speed → increase collision impact forces
(Norton et al., 2001)

Non significant association in elite level rugby union players
(Takemura et al., 2007)

Increase in game injuries but not training in rugby league
(Gabbett et al., 2006)

Anterior Cruciate Ligament (ACL) injuries have been associated with increased traction
(Orchard et al., 2005)

Increase in clavicular fractures in rugby union
(Davidson, 1987)

Increase in fractures in junior Australian football
(McMahon et al., 1993)

Increase in fractures in junior Australian football
(McMahon et al., 1993)
Early Season Bias

- Early season bias towards injuries has been found in many studies and harder grounds at the beginning of seasons has been suggested as a reason.

- But the same has been found for some indoor sports where the ground conditions don’t change.
Early Season Bias Cont’d

- Orchard (2002) concluded that an early season bias was most certainly associated with ground conditions but it wasn’t sure if it was hardness traction, or grass type that was to blame.
Ground Injury Link Project
Aims of Project

- Develop, trial and validate an observational checklist for match ground safety
- Compare the reliability of observational and direct ground measures
- Identify the relationship between the various ground condition measurements and injury incidence
- Quantify relationships between the common measures for hardness, rotational traction and volumetric soil moisture
- To provide recommendations to community football about appropriate ground conditions for minimising injury risk in Australian Football

The red box above highlights what will be focussed on in this presentation
These were the only 3 questions on the ground playing area.
New checklist being validated

Included

• Surface Evenness
• Grass Cover
• Shock Absorbency
• Grip
• Other Hazards
• Ground Profile
Budget

- Equipment
- Transport to grounds
- Research Assistant
- Botanical Expertise/Training
- Uni Infrastructure

$35K

All injury data collected by PAFIX project
Injury Report Form

Game Details
Player Name: 
Club: 
Grade: 
Date: 
Venue: 
Training Game

In which quarter did the injury occur?
- Q1
- Q2
- Q3
- Q4
Position player at time of injury:
- Forward Line
- Back Line
- Midfield

Where on the field did the injury occur (Mark with X)?
- Forward Line
- Back Line
- Midfield

Body Region Injured
- Head & Neck
- Face (including mouth)
- Teeth/Mouth
- Shoulder
- Upper Arm
- Elbow
- Lower Arm
- Hands/Feet
- Chest
- Thigh/Abdomen
- Groin/Hip
- Back
- Backside/Buttocks
- Upper Leg
- Knee
- Lower Leg
- Ankle
- Foot/Tarsus
- Other

Nature of Injury
- Abnormal gait
- Cartilage injury
- Contusion
- Concussion
- Dislocation
- Fracture (not stress)
- Rupture
- Sprain (ankle/foot)
- Strain (muscles/tenons)
- Tearing or changing direction
- Other

Cause of Injury
- Contact:
  - Point of body contact
- Being tackled
- Collision with other player/team
- Collision with fixed object
- Fall/hit slip on same level during or after contact
- Struck by ball
- Struck with/while attacking
- Struck whilst defending
- Tasks another player
- Non-contact:
  - Aggravation of previous injury
  - Fall/hit slip on same level
  - Kicking the ball
  - Landing from jump/mark
  - Overspeed/overreach
  - Overreached
  - Rapid change in speed (acceleration/deceleration)
  - Side stepping/going
turning or changing direction
  - Other

Injury Details
Give a description of what occurred at the time of injury. Please include details on how many players were involved, form of contact, if any, and specific movement of injured player. Continue overleaf if needed:

Other Details
Did the injured player leave the field as a result of the injury?
- Yes
- No

Did the injured player return to the field after receiving medical assistance at the ground?
- Yes
- No

If yes, specify medical attendants:
- Doctor
- Sports Trainer
- Physio
- Other:

Was the injured player advised to seek off-field medical advice?
- Yes
- No

Was the injured player taken to hospital?
- Yes
- No

Primary Data Recorder Details
PDC Name: 
PDC: 
Signature: 
Date: 

Office Use Only
ID: ________  Today's date: ___/___/___
Where on the field did the injury occur? (Mark with an X).
Hardness Measures

Penetrometer

- 9 kg weight
- dropped from 0.5 m pushing the conical shaped head into the surface of the ground
- the depth of penetration was measured in centimetres after each drop and
- three consecutive penetrometer drops

Clegg Hammer

- 2.25 kg Clegg hammer
- dropped from 45 cm through a guide tube
- deceleration on impact was recorded in gravities (g)
- a single drop method
Rotational Traction
Studded Boot

- 40 kg circular weight at the end of a steel pole
- six 16mm football studs arranged in a circular pattern on the base.
- the device was lifted vertically and dropped from 150 mm onto the turf
- a torque wrench inserted into the handle at 90 degrees was used to record the amount of torque (in Newton metres) required to rotate the studs in the ground
Sampling Plan

- A purposive sampling plan based on PAFIX teams

- 2007 football season- 18 weeks

- Eight community level Australian football grounds in Victoria

- Each ground 4-8 times, each PAFIX team 8-9 times→ total of 41 ground assessments
Measurement Procedure

- All measures are taken in each of the nine positions below (1-9) (Orchard, J. 2001; Otago et al., 2007)

- Four repetitions of each piece of equipment at each site

- Botanical information at each site
Number of Measures

- The total number of readings differed for the three devices (excluding the soil moisture) since not all were completed on every occasion due to adverse weather conditions or loss of daylight.

- Clegg hammer = 324 sites
- Penetrometer = 369 sites
- Studded boot apparatus = 297 sites
Results

- A total of **130** injuries

- The overall injury rate was 38.4 injuries per 1000 player hours (95%CI 31.9 – 44.8).

- Out of the 41 individual ground testing sessions, there were five occasions when no injury was reported on the ground tested.
## Categorisation of Measures

<table>
<thead>
<tr>
<th>Grading</th>
<th>Unacceptably Low</th>
<th>Low/Normal Range</th>
<th>Preferred Range</th>
<th>Normal/High Range</th>
<th>Unacceptably High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clegg hammer</td>
<td>&lt;30g</td>
<td>31 – 69g</td>
<td>70 – 89g</td>
<td>90 – 119g</td>
<td>≥120</td>
</tr>
<tr>
<td>Studded boot apparatus</td>
<td>&lt;20Nm</td>
<td>21 – 39Nm</td>
<td>40 – 54Nm</td>
<td>55 – 74Nm</td>
<td>≥75Nm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grading</th>
<th>Soft/Heavy</th>
<th>Slow</th>
<th>Good/Firm</th>
<th>Fast/Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetrometer</td>
<td>≥ 10.5cm</td>
<td>7.3 – 10.4cm</td>
<td>5.7 – 7.2cm</td>
<td>≤5.6cm</td>
</tr>
</tbody>
</table>

(Chivers & Aldous, 2004; Otago et al., 2007)
## Measures & Injuries

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Injury Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clegg hammer</strong></td>
<td>28 – 164 g</td>
<td>55 – 134 g</td>
</tr>
<tr>
<td><strong>Penetrometer</strong></td>
<td>3.2 – 21.1 cm</td>
<td>5.5 – 13.8 cm</td>
</tr>
<tr>
<td><strong>Studded boot</strong></td>
<td>1.36 – 56.94 Nm</td>
<td>6.5 – 49.7 Nm</td>
</tr>
</tbody>
</table>

It is important to note here that the injuries did not occur on the sites with extreme values.
Relationships Between Properties

Clegg Hammer vs Penetrometer

\[ y = -0.0851x + 15.871 \]

\[ R^2 = 0.5096 \]

Penetrometer (cm) vs Clegg Hammer (g)

Clegg Hammer vs Studded Boot

\[ y = 0.037x + 14.938 \]

\[ R^2 = 0.0051 \]

Studded Boot (Nm) vs Clegg Hammer (g)

Penetrometer vs Studded Boot

\[ y = -0.3217x + 20.776 \]

\[ R^2 = 0.0055 \]

Studded Boot (Nm) vs Penetrometer (cm)

Relationships:

- Moderate Relationship
- Poor Relationship
### Injuries per Category
*number with % in brackets*

<table>
<thead>
<tr>
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<th>Preferred Range</th>
<th>Normal/High</th>
<th>Unacceptably High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clegg hammer (g) (n=130)</td>
<td>0(0)</td>
<td>50(38.5)</td>
<td>40(30.8)</td>
<td>36(27.7)</td>
<td>4(3.1)</td>
</tr>
<tr>
<td>Studded boot (Nm) (n=105)</td>
<td>53(50.5)</td>
<td>51(48.6)</td>
<td>1(1.0)</td>
<td>0(0)</td>
<td>0(0)</td>
</tr>
</tbody>
</table>

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<tr>
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<th>Good/Firm</th>
<th>Fast/Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetrometer (cm) (n=124)</td>
<td>44(35.5)</td>
<td>60(48.4)</td>
<td>19(15.3)</td>
<td>1(0.8)</td>
</tr>
</tbody>
</table>

The red boxes highlight the categories where the majority of injuries occurred.
Injuries

Most common natures:
- Strain 23.1%
- Sprain/rupture 22.3%
- Cork/bruise 16.2%
- Fracture/dislocation 9.2%
- Concussion 6.2%
- Abrasion/cut/laceration 3.8%
- Other/Unsure 19.2%

Most common body region:
- Upper limbs 10.8%
- Head/neck/face 15.4%
- Torso/back 9.2%
- Lower limbs 64.6%

29/03/2010
Cause of Injury

- Contact 59.3%
- Non-Contact 33%
- Other/Unknown 7.7%

(Collision with another player was the most common injury 22%)

For a full list of causes refer to the injury form on slide 21
Injury Severity - Clegg hammer

The majority of players left the field and didn’t return.

No injuries on unacceptably hard ground were taken to hospital.
Injury Severity - Penetrometer

Similar to the Clegg hammer, the majority of players left the field and didn’t return.
Injury Severity – Studded Boot

And again, the majority of players left the field and didn’t return
Ground Condition Injury Risk (GCIR)

- All injuries were ranked as by two independent injury experts based on the narratives on the injury forms as
  - likely to be related,
  - possibly related,
  - unlikely to be related
  - unknown (due to insufficient details on the injury report forms)

- On the few occasions (4%) where a lack of agreement occurred, an additional rater was consulted and a consensus agreement was established.
GCIR Results

Of the 130 injuries,

- 12 were *likely to be related* to ground conditions
- 29 *possibly related*
- 75 *unlikely*
- 4 *unknown* due to incomplete details

- None of the injuries *likely to be related* to ground conditions were sustained on unacceptably high Clegg hammer readings, or hard/fast penetrometer readings.

- Six of the twelve injuries likely to be related to ground conditions occurred on grounds with unacceptably low traction readings and five injuries in the low/normal range.
Narrative Examples

- Graze to L thigh as a result from sliding on grate.

- Hit his head on ground after being knocked by opposition player

- During first quarter went to handball and was tackled. Foot stuck in the ground and went over on it. Had ankle taping on this ankle. Went over medial.

- He got slammed into the ground and his shoulder hit the ground first.

- During the first quarter the player slipped in a puddle and overstretched which placed pressure and strained the hamstring.

- Player tried to evade an opponent by changing direction but rolled his ankle in the mud. Player was able to walk and chose to sit out the rest of the game.
Injuries by Site

Of the twelve injuries identified as likely to be related to ground conditions, no particular site on the field resulted in a significantly larger number of injuries.

The blue boxes present the number of injuries that were likely to be related to ground conditions at the specific sites.
## Predictors of Injury

<table>
<thead>
<tr>
<th>Factor</th>
<th>Associated</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Player position</td>
<td>X</td>
<td>0.56</td>
</tr>
<tr>
<td>Body region</td>
<td>√</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nature of injury</td>
<td>√</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td>√</td>
<td>0.001</td>
</tr>
<tr>
<td>Clegg hammer hardness</td>
<td>√</td>
<td>0.002</td>
</tr>
<tr>
<td>Penetrometer hardness</td>
<td>X</td>
<td>0.45</td>
</tr>
<tr>
<td>Rotational traction</td>
<td>X</td>
<td>0.31</td>
</tr>
</tbody>
</table>

The results presented here are from a general estimating equation model and show that player position, penetrometer hardness and traction were not predictors of injury in this study.
Conclusions

- Majority of injuries occurred within acceptable hardness and low traction ranges.

- Only 9% of injuries could be confidently related to the ground.

- Unacceptably hard/soft and higher/lower traction were not significantly associated with injury.

- Lower limb was the body region, and sprains the nature of injury, most associated with ground conditions.
Conclusions Cont’d

- Both contact and non contact injuries were significantly associated with GCIR.

- More injuries were not sustained along the centre corridor.

- Grass type, predominantly rye grass, may have contributed to the low traction results and the insignificant association with injury risk.
Conclusions Cont’d

- Could it be that players adjust their behaviour on harder ground?

The preliminary findings from further research seems to suggest so!

- Is the test equipment valid to determine player safety?

Potentially not but needs lots of further work
Future Implications

- Future studies on a wider range with more in the harder categories – sampled on grounds
- The need to continue building the evidence base in this area of research
- Need to look at validity of testing equipment in terms of player safety
Other Current Work

- Two year hardness data in two states at community level Australian football
- Potential to get elite Australian football injury & ground condition data
- Junior Cricket Project
- Synthetic turf in Australian football and cricket
The Ground Injury Link project was funded by Sport & Recreation Victoria and the University of Ballarat

**Research Team:**
Assoc Professor Leonie Otago  
Professor Caroline Finch  
Assoc Professor John Orchard  
Dr Ian Chivers


• Orchard J, Seward H. *AFL Injury Report 2002*


• Orchard J, Seward H. *AFL Injury Report 2007*

• Orchard J, Sward H. *AFL Injury Report 2008*
