Is there a link between Injury and Ground Conditions?

A Case Study in Australian Football

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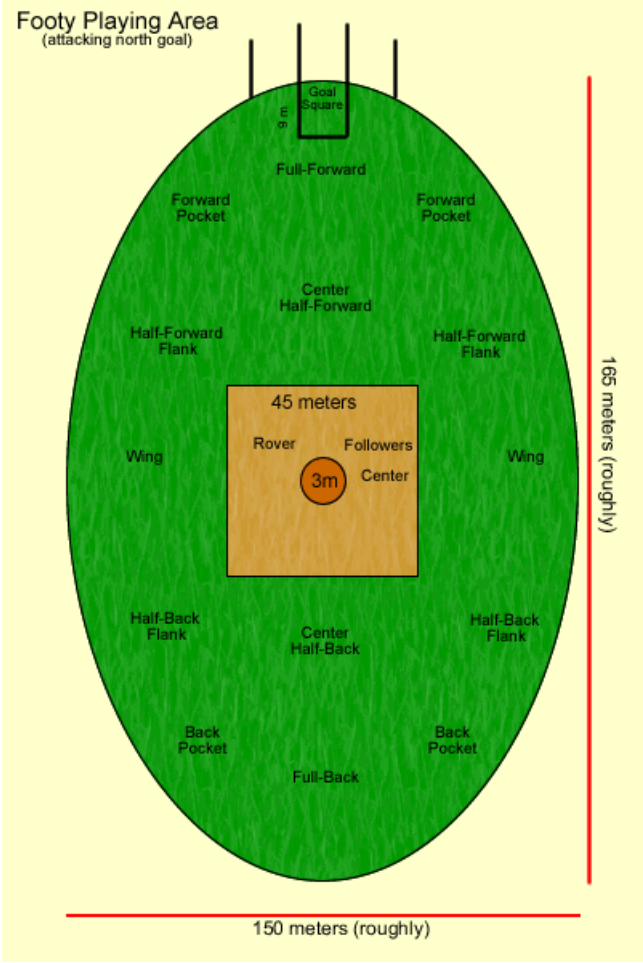
A glance at Australian football

- 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…



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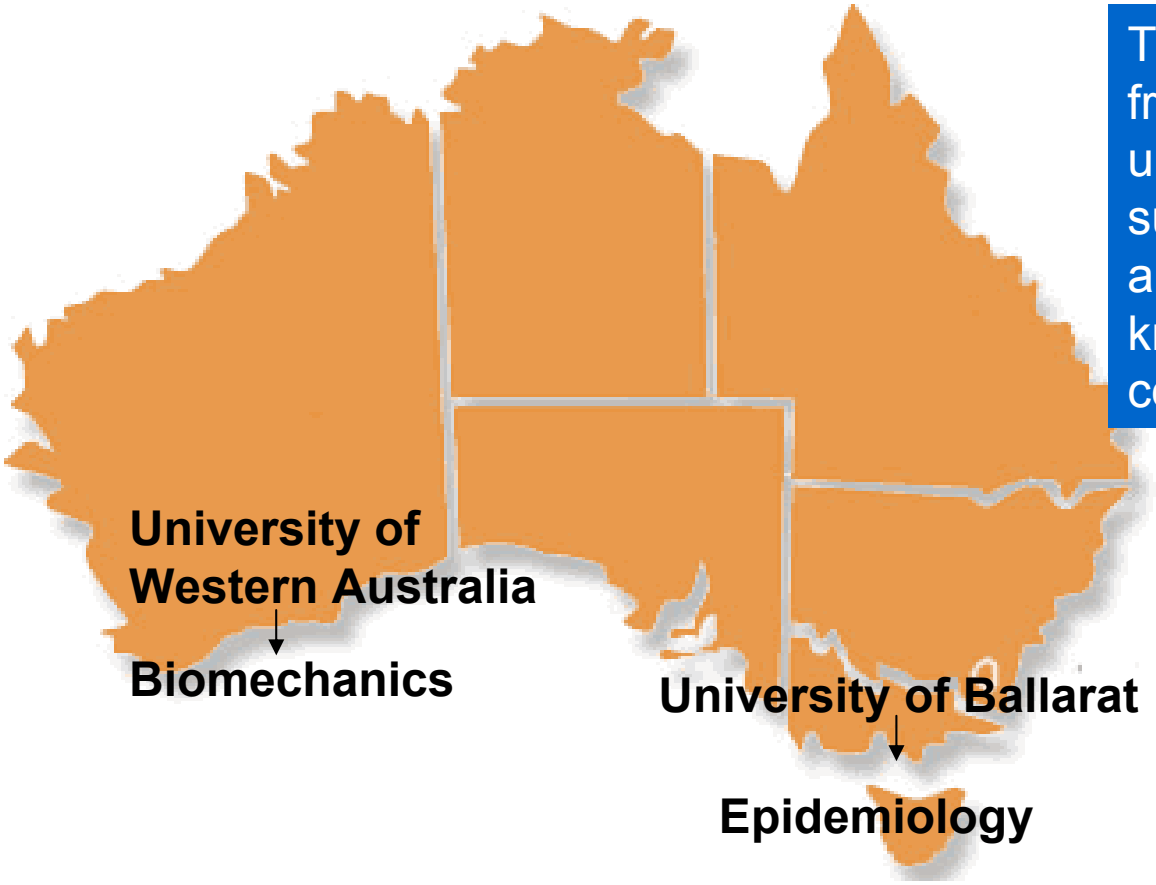
Large Scale Study Needed so….

Foundation of the Project



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

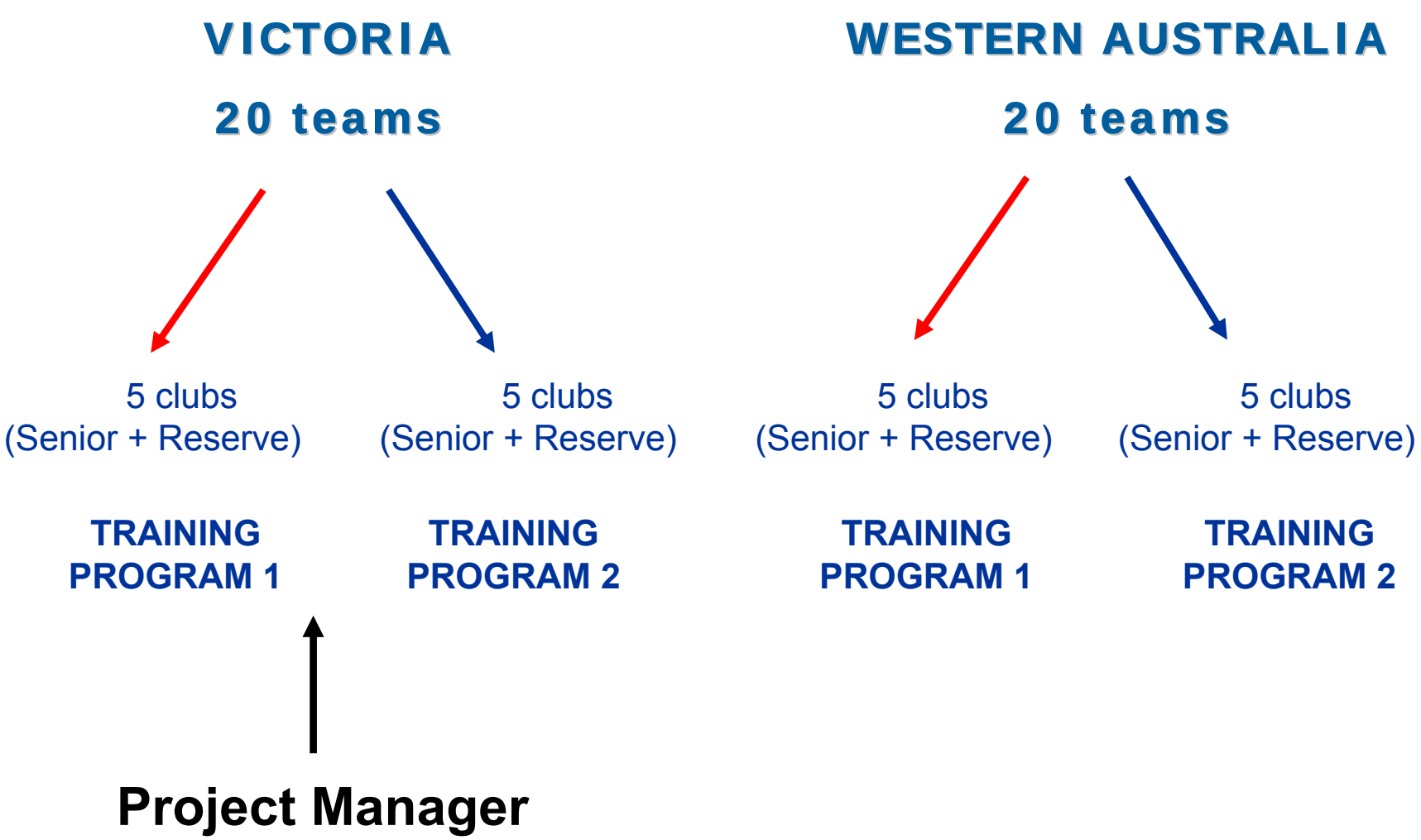
PAFIX
PREVENTING AUSTRALIAN FOOTBALL INJURIES THROUGH EXERCISE

THE UNIVERSITY OF WESTERN AUSTRALIA

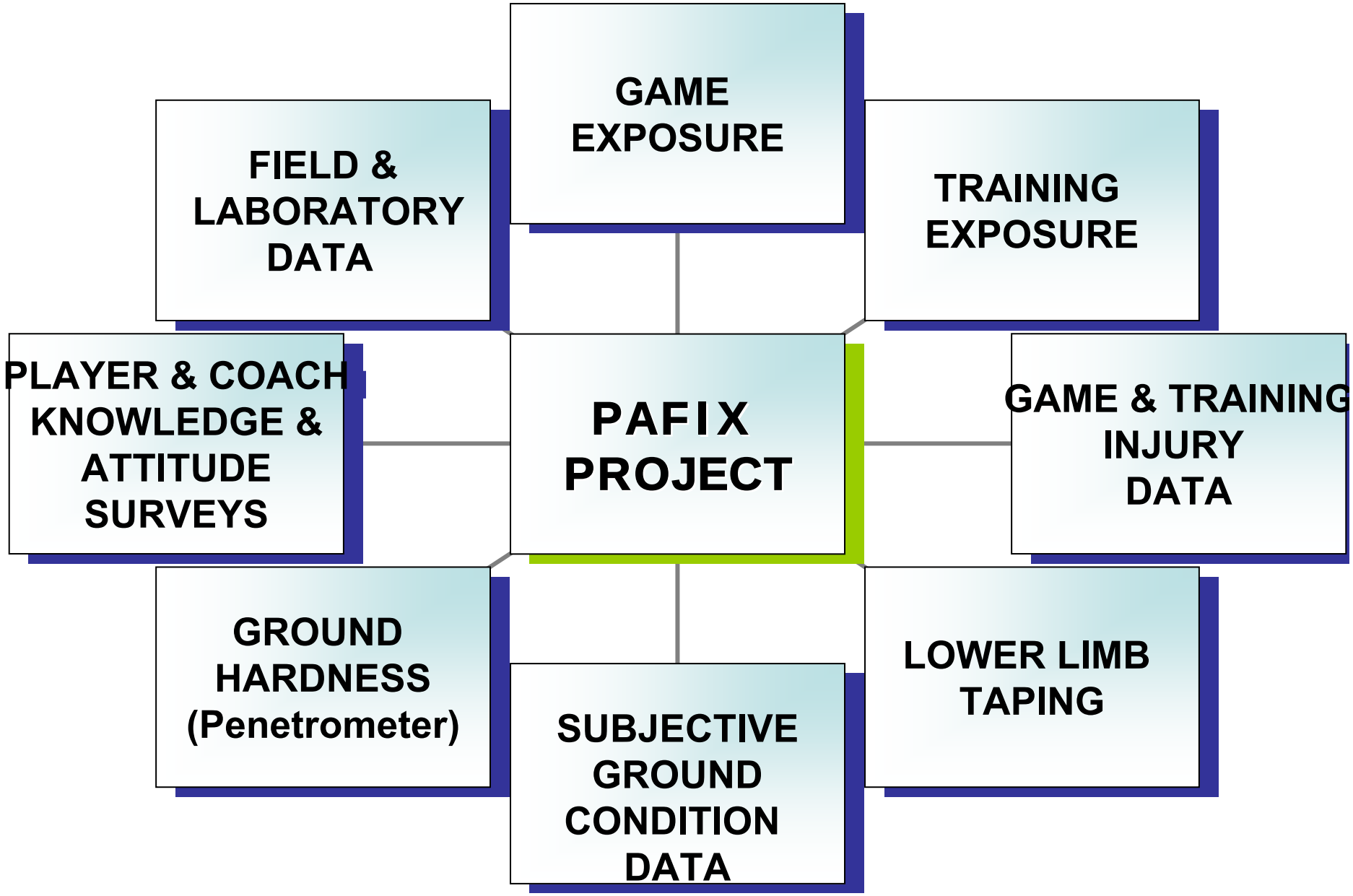
Study Design

- 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



- Opportunity for a small grant scheme at the University of Ballarat ($10K)

- Interest from Sport & Recreation Victoria (State Government Department) ($26K)

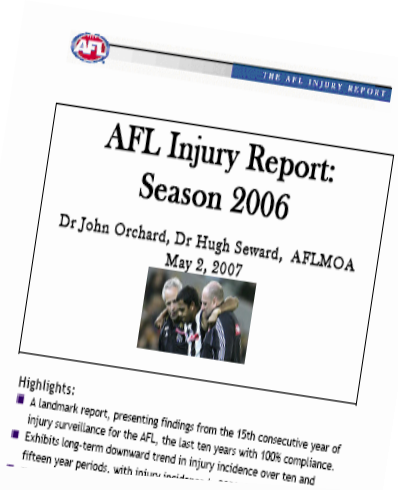
Drought and injuries

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


THE AFL INJURY REPORT

AFL Injury Report: Season 2006

Dr John Orchard, Dr Hugh Seward, AFLMOA
May 2, 2007

Highlights:
- A landmark report, presenting findings from the 15th consecutive year of injury surveillance for the AFL, the last ten years with 100% compliance.
- Exhibits long-term downward trend in injury incidence over ten and fifteen year periods, with injury


Injury Report 2008
Australian Football League

Released Wednesday 20 May 2009

Authors: Assoc Prof John Orchard
Adjunct Associate Professor, University of Sydney

Dr Hugh Seward
Executive Officer, AFL Medical Officers Association

Existing Evidence

Hard Ground & Injury Link

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

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

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

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

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

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

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

AFL

Match Day Checklist

Date:

Home Team: Away Team:

Ground:

	YES	NO
Has the ground surface and markings been prepared correctly for an Australian Football match?	☐	☐
Field of Play		
Is the surface free of debris? (free from glass, rocks, rubbish, etc)	☐	☐
Have weather conditions or water made the surface unsafe?	☐	☐

The red box above highlights what will be focussed on in this presentation

Sample Checklist

AFL

Administered by JLT Sport
(a division of Jardine Lloyd Thompson)

Match Day Checklist

Date: _____

Home Team: _____ Away Team: _____

Ground: _____

Has the ground s
for an Australian

Field of Play

Is the surface fre

Have weather co

Is the surface in

Are sprinkler cov

Is the perimeter f

Are the weather

Have goal and b

Are there any other factors which may be dangerous to the players? ☐ ☐

Is there a stretcher available for use in the event of a serious injury? ☐ ☐

Change Rooms & Toilet Safety

Are the rooms free of debris? (free from syringes, glass, rubbish, etc) ☐ ☐

Comments ***(particularly for any ticked shaded box)***

_____

_____

_____

Prior to the commencement of play, we, the undersigned, have undertaken the above inspection and agree that the playing environment is fit for play.

Home Team Representative Name ..... Away Team Representative Name .....

Signature ..... Signature .....

A copy of this form must be filed and kept by the HOME TEAM for each match conducted and be kept for

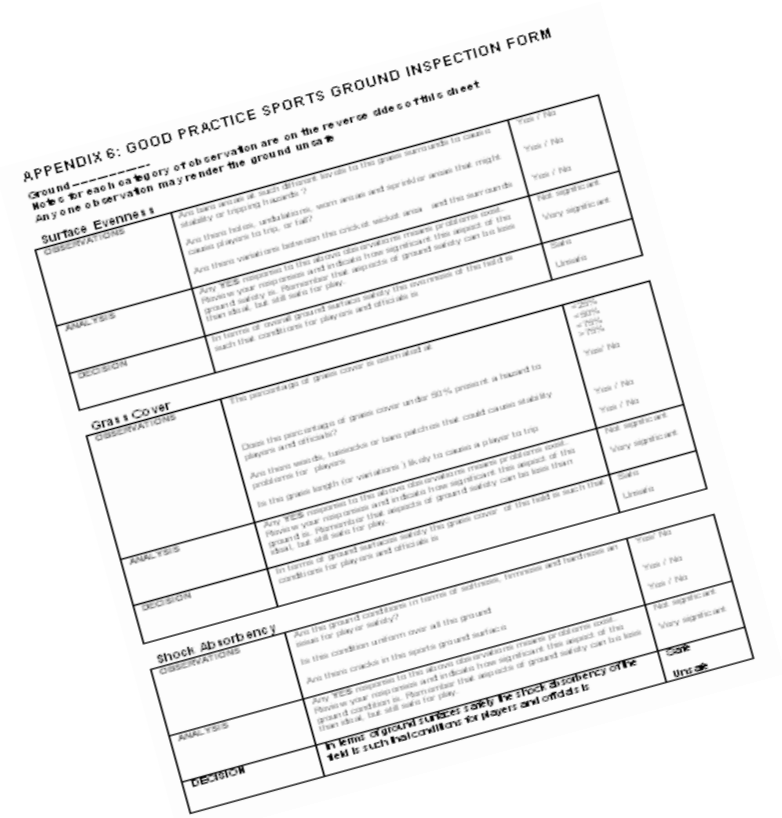
Is the surface free of debris? (free from glass, rocks, rubbish, etc) ☐ ☐

Have weather conditions or water made the surface unsafe? ☐ ☐

Is the surface in reasonable condition? (grass length, free of holes) ☐ ☐

These were the only 3 questions on the ground playing area.

New checklist being validated


APPENDIX 6: GOOD PRACTICE SPORTS GROUND INSPECTION FORM

Ground _____

Note: for each category of observation are on the reverse side of this sheet

Any one observation may render the ground unsafe

Surface Evenness		
OBSERVATIONS	Are there areas of much difficult terrain to the grass surrounds to cause stability or tripping hazards ?	Yes / No
	Are there holes, undulations, worn areas and spring or areas that might cause players to trip, or fall?	Yes / No
	Are there variations between the cricket wicket area and the surrounds	Not significant
ANALYSIS	Any YES responses to the above observations mean problems exist. Review your responses and indicate how significant this aspect of the ground safety is. Remember that aspects of ground safety can be less than ideal, but still safe for play.	Very significant
DECISION	In terms of overall ground surface safety the evenness of the field is such that conditions for players and officials is	Safe / Unsafe
Grass Cover		
OBSERVATIONS	The percentage of grass cover is estimated at	<50% / <60% / <70% / >70%
	Does the percentage of grass cover under 50% present a hazard to players and officials?	Yes/ No
	Are there weeds, bareacks or bare patches that could cause stability problems for players	Yes / No
	Is the grass length (or variations) likely to cause a player to trip	Yes / No
ANALYSIS	Any YES responses to the above observations mean problems exist. Review your responses and indicate how significant this aspect of the ground is. Remember that aspects of ground safety can be less than ideal, but still safe for play.	Not significant / Very significant
DECISION	In terms of ground surfaces safety the grass cover of the field is such that conditions for players and officials is	Safe / Unsafe
Shock Absorbency		
OBSERVATIONS	Are the ground conditions in terms of softness, firmness and hardness an issue for player safety?	Yes/ No
	Is the condition uniform over all the ground	Yes / No
	Are there cracks in the sports ground surfaces	Not significant / Very significant
ANALYSIS	Any YES responses to the above observations mean problems exist. Review your responses and indicate how significant this aspect of the ground condition is. Remember that aspects of ground safety can be less than ideal, but still safe for play.	
DECISION	In terms of ground surfaces safety the shock absorbency of the field is such that conditions for players and officials is	Safe / Unsafe

Included

- Surface Evenness
- Grass Cover
- Shock Absorbency
- Grip
- Other Hazards
- Ground Profile

Budget

$35K

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

All injury data collected by PAFIX project

Injury Report Form

Injury Incident Report Form

Office Use Only
ID:_____ Today's date: ___/___/07

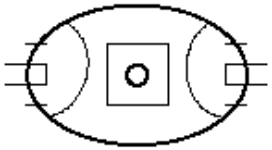
Game Details

Player Name
Club
Grade
Date
Venue
☐ Training ☐ Game

In which quarter did the injury occur?
☐ Q1 ☐ Q2 ☐ Q3 ☐ Q4

Position played at time of injury
☐ Forward Line
☐ Back Line
☐ Midfield

Where on the field did the injury occur?
(Mark with X). If during game, indicate where you were positioned using an asterisk.



Did the player sustain more than one injury during this injury event?
e.g. sprained ankle and knee abrasion
☐ Yes ☐ No

What was the intent of the injury?
☐ Within game rules ☐ Unsure
☐ Outside game rules ☐ Other

Body Region Injured

- ❒ Head & Neck
- ❒ Face (including mouth)
- ❒ Teeth/Mouth
- ❒ Shoulder
- ❒ Upper Arm
- ❒ Elbow
- ❒ Lower Arm
- ❒ Hand/Fingers
- ❒ Chest
- ❒ Trunk/Abdomen
- ❒ Groin/Hip
- ❒ Back
- ❒ Backside/Gluteals
- ❒ Upper Leg
- ❒ Knee
- ❒ Lower Leg
- ❒ Ankle
- ❒ Foot/Toes
- ❒ Other

Nature of Injury

- ❒ Abrasion/grazing
- ❒ Cartilage injury
- ❒ Cork/bruise
- ❒ Cut/laceration
- ❒ Concussion
- ❒ Dental
- ❒ Dislocation
- ❒ Fracture (not stress)
- ❒ Rupture
- ❒ Strain (muscle/tendon)
- ❒ Sprain (ligament/joint)
- ❒ Unsure
- ❒ Other

Cause of Injury

Contact

1st point of body contact

- ❒ Being tackled
- ❒ Collision with other player/umpire
- ❒ Collision with fixed object
- ❒ Fall/trip/slip on same level during or after contact
- ❒ Struck by ball
- ❒ Struck/hit whilst attacking
- ❒ Struck/hit whilst defending
- ❒ Tackling another player

Non-contact

- ❒ Aggravation of previous injury
- ❒ Fall/trip/slip on same level
- ❒ Kicking the ball
- ❒ Landing from jump/mark
- ❒ Overuse/gradual onset
- ❒ Overextended
- ❒ Rapid change in speed (acceleration/ deceleration)
- ❒ Side stepping/cutting
- ❒ Twisting or changing direction
- ❒ Other

Primary Data Recorder Details

PDC Name
PDC Signature
Date

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

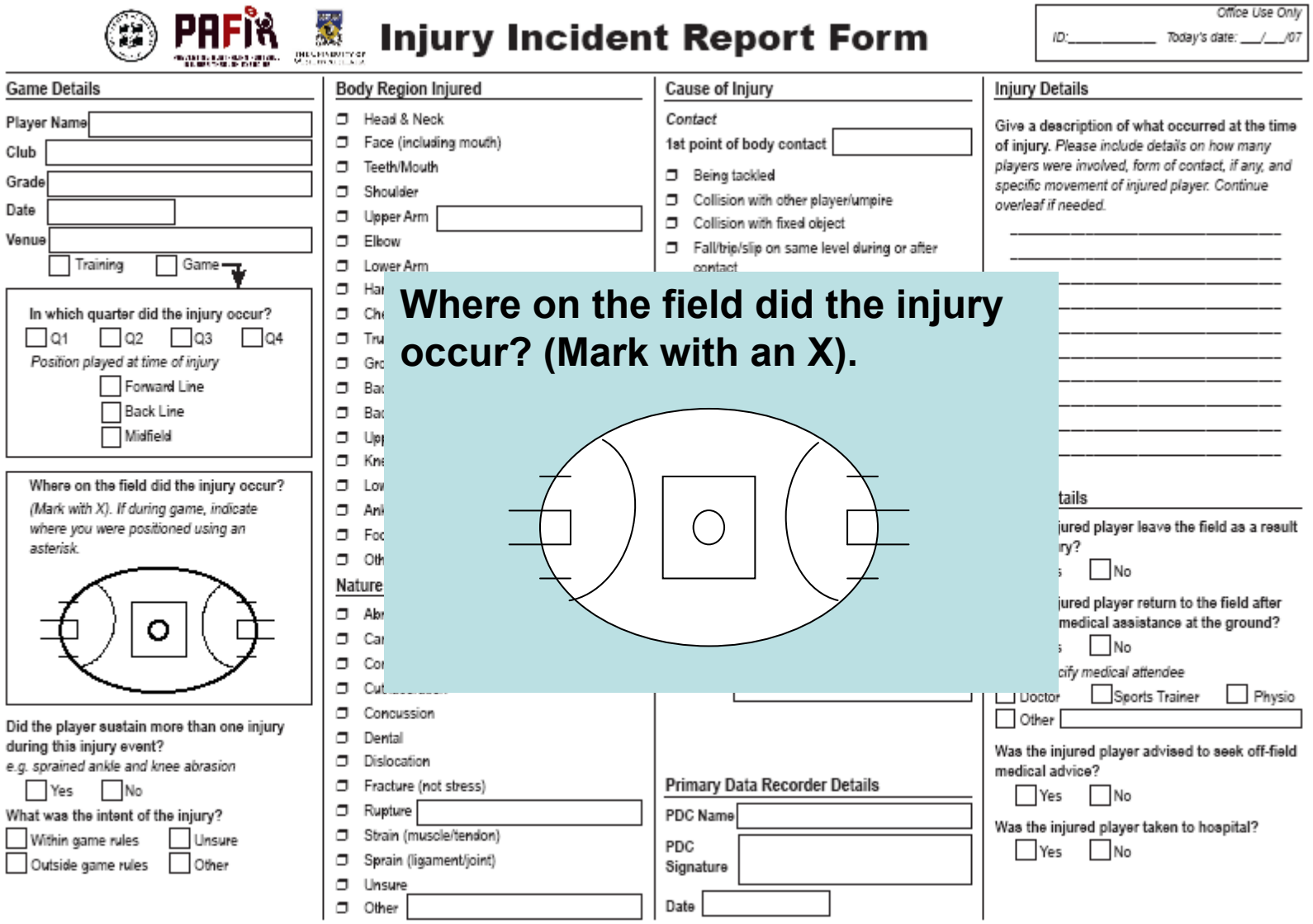
Did the injured player return to the field after receiving medical assistance at the ground?
☐ Yes ☐ No

If Yes, specify medical attendee
☐ 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

Site on Field Specified



PAFIA

Injury Incident Report Form

Office Use Only
ID:_____ Today's date: ___/___/07

Game Details

Player Name
Club
Grade
Date
Venue
☐ Training ☐ Game

In which quarter did the injury occur?
☐ Q1 ☐ Q2 ☐ Q3 ☐ Q4

Position played at time of injury
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Where on the field did the injury occur?
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☐ Yes ☐ No

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☐ Outside game rules ☐ Other

Body Region Injured

- ❒ Head & Neck
- ❒ Face (including mouth)
- ❒ Teeth/Mouth
- ❒ Shoulder
- ❒ Upper Arm
- ❒ Elbow
- ❒ Lower Arm

Nature

- ❒ Concussion
- ❒ Dental
- ❒ Dislocation
- ❒ Fracture (not stress)
- ❒ Rupture
- ❒ Strain (muscle/tendon)
- ❒ Sprain (ligament/joint)
- ❒ Unsure
- ❒ Other

Cause of Injury

Contact
1st point of body contact

- ❒ Being tackled
- ❒ Collision with other player/umpire
- ❒ Collision with fixed object
- ❒ Fall/trip/slip on same level during or after contact

Primary Data Recorder Details

PDC Name
PDC Signature
Date

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.*

Where on the field did the injury occur? (Mark with an X).

tails

jured player leave the field as a result ry?
☐ No

jured player return to the field after medical assistance at the ground?
☐ No

cify medical attendee
☐ 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

Hardness Measures

Penetrometer

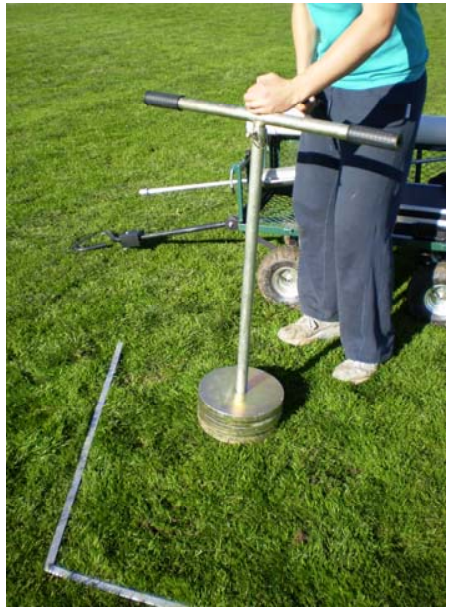
- 9 kg weight
- dropped from 0.5 m pushing the conical shaped head into the surface of the ground
- the depth of penetration was measured in centimetres after each drop and
- three consecutive penetrometer drops

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

Traction Measure

Rotational Traction
Studded Boot



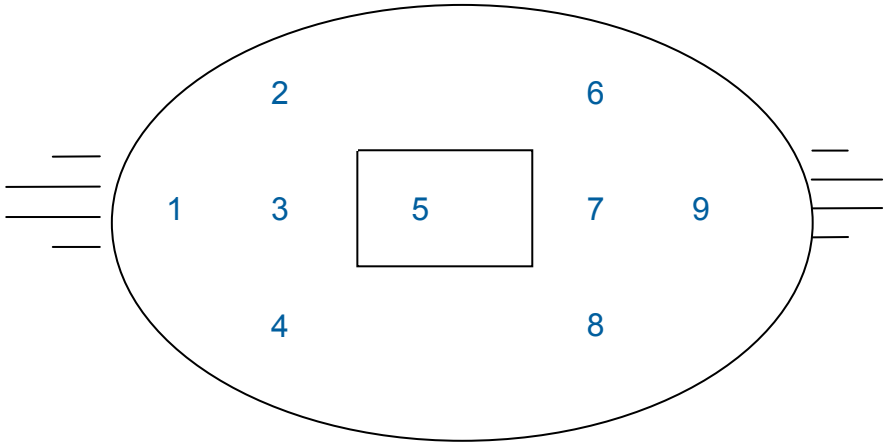
- 40 kg circular weight at the end of a steel pole
- six 16mm football studs arranged in a circular pattern on the base.
- the device was lifted vertically and dropped from 150 mm onto the turf
- a torque wrench inserted into the handle at 90 degrees was used to record the amount of torque (in Newton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

Grading	Unacceptably Low	Low/Normal	Preferred Range	Normal/High	Unacceptably High
Clegg hammer	<30g	31 – 69g	70 – 89g	90 – 119g	≥120
Studded boot apparatus	<20Nm	21 – 39Nm	40 – 54Nm	55 – 74Nm	≥75Nm
Grading	**Soft/Heavy**	**Slow**	**Good/Firm**	**Fast/Hard**	
Penetrometer	≥ 10.5cm	7.3 – 10.4cm	5.7 – 7.2cm	≤5.6cm	

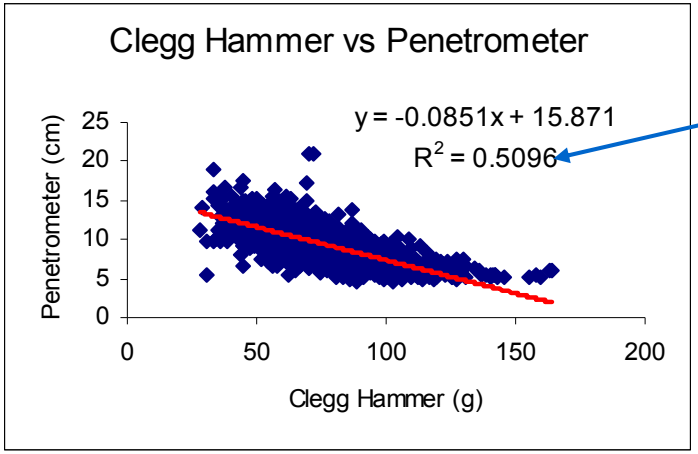
(Chivers & Aldous, 2004; Otago et al.,2007)

Measures & Injuries

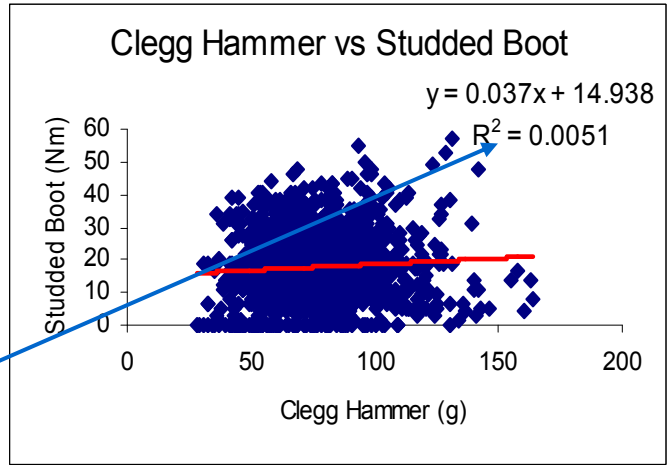
	Overall	Injury Sites
Clegg hammer	28 – 164 g	55 – 134 g
Penetrometer	3.2 – 21.1 cm	5.5 – 13.8 cm
Studded boot	1.36 – 56.94 Nm	6.5 – 49.7 Nm

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

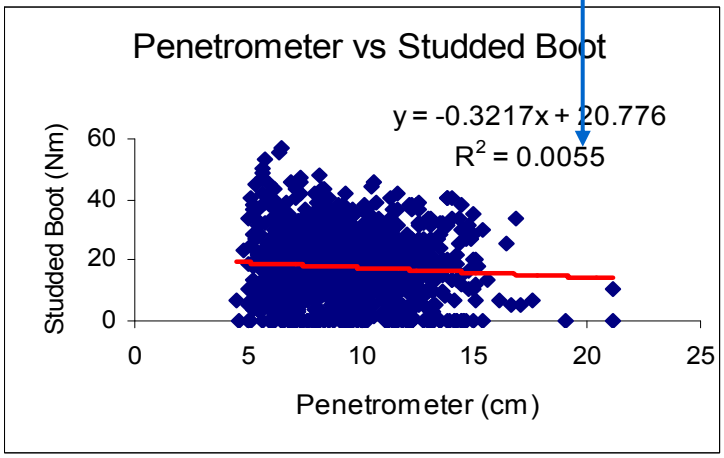
Relationships Between Properties



Moderate Relationship



Poor Relationship



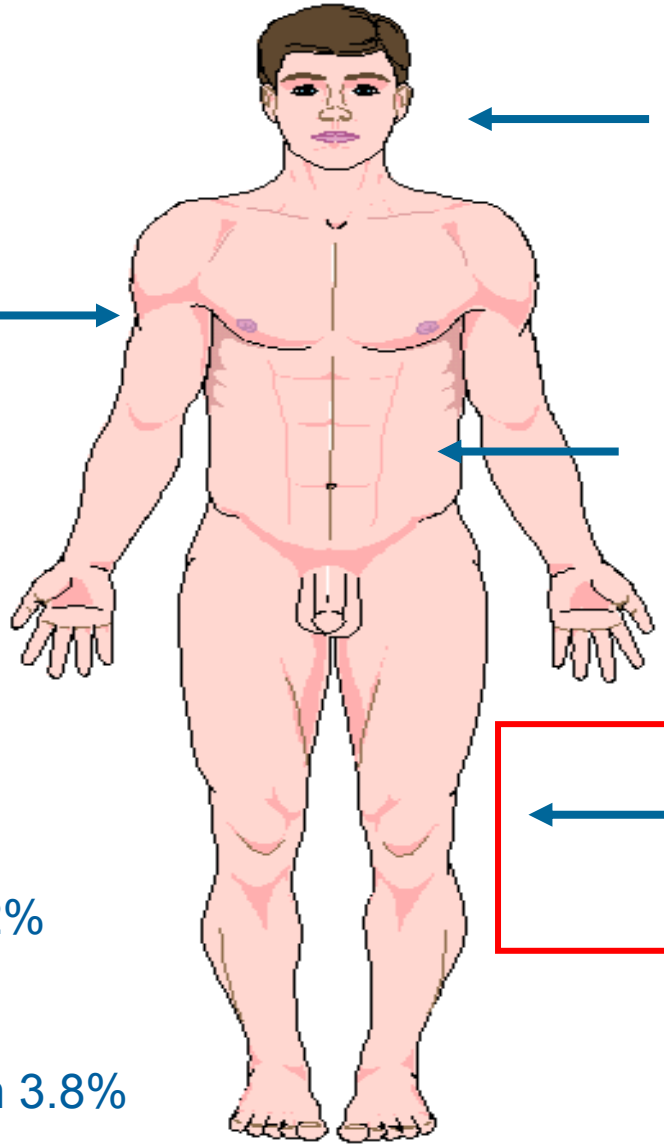
Injuries per Category

(number with % in brackets)

Grading	Unacceptably Low	Low/Normal	Preferred Range	Normal/High	Unacceptably High
Clegg hammer (g) (n=130)	0(0)	50(38.5)	40(30.8)	36(27.7)	4(3.1)
Studded boot (Nm) (n=105)	53(50.5)	51(48.6)	1(1.0)	0(0)	0(0)
Grading	**Soft/Heavy**	**Slow**	**Good/Firm**	**Fast/Hard**	
Penetrometer (cm) (n=124)	44(35.5)	60(48.4)	19(15.3)	1(0.8)	

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

Injuries



Head /neck/face

15.4%

Upper limbs

10.8%

Torso/back

9.2%

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

Lower limbs

64.6%

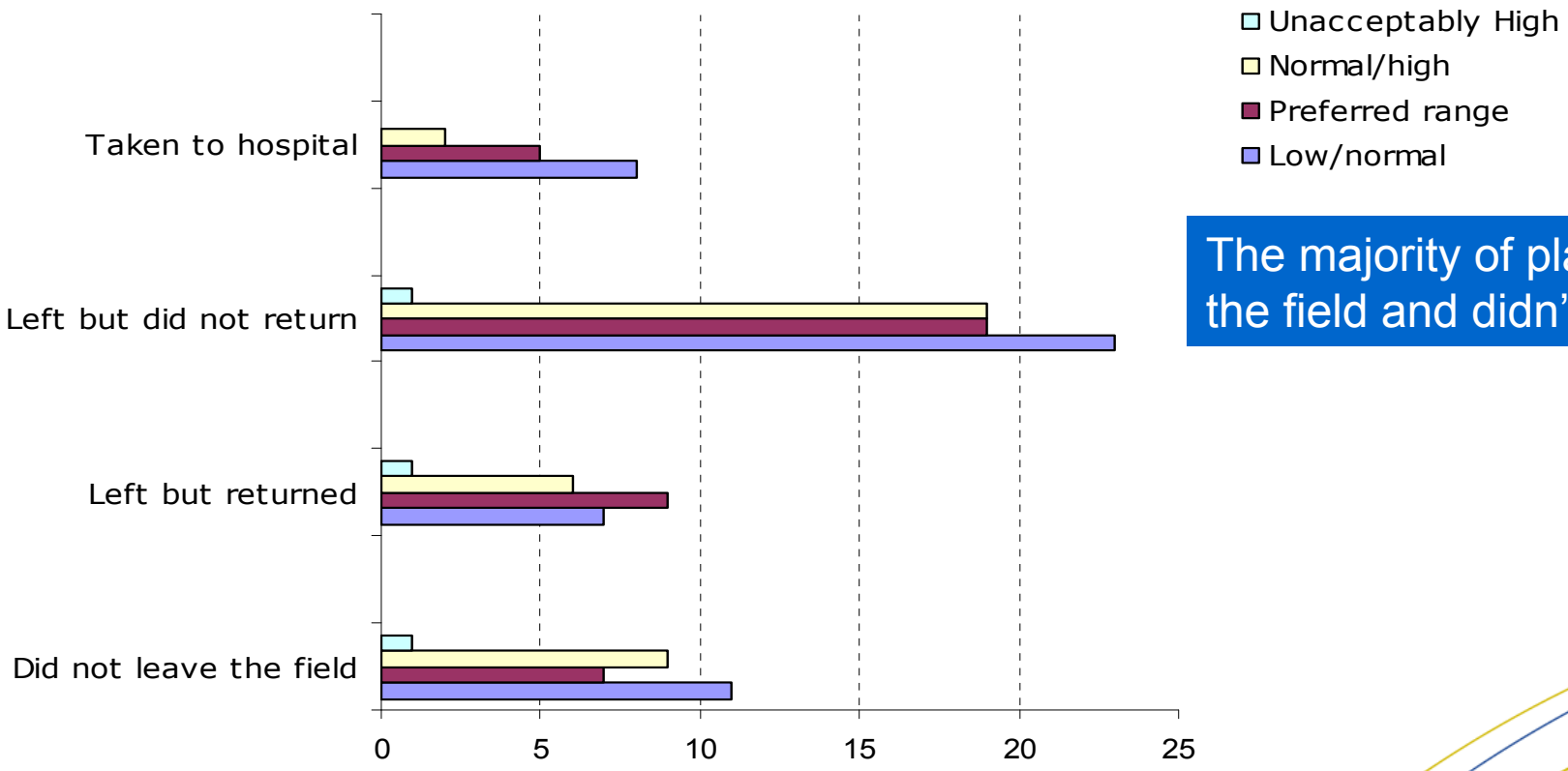
Cause of Injury

- 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

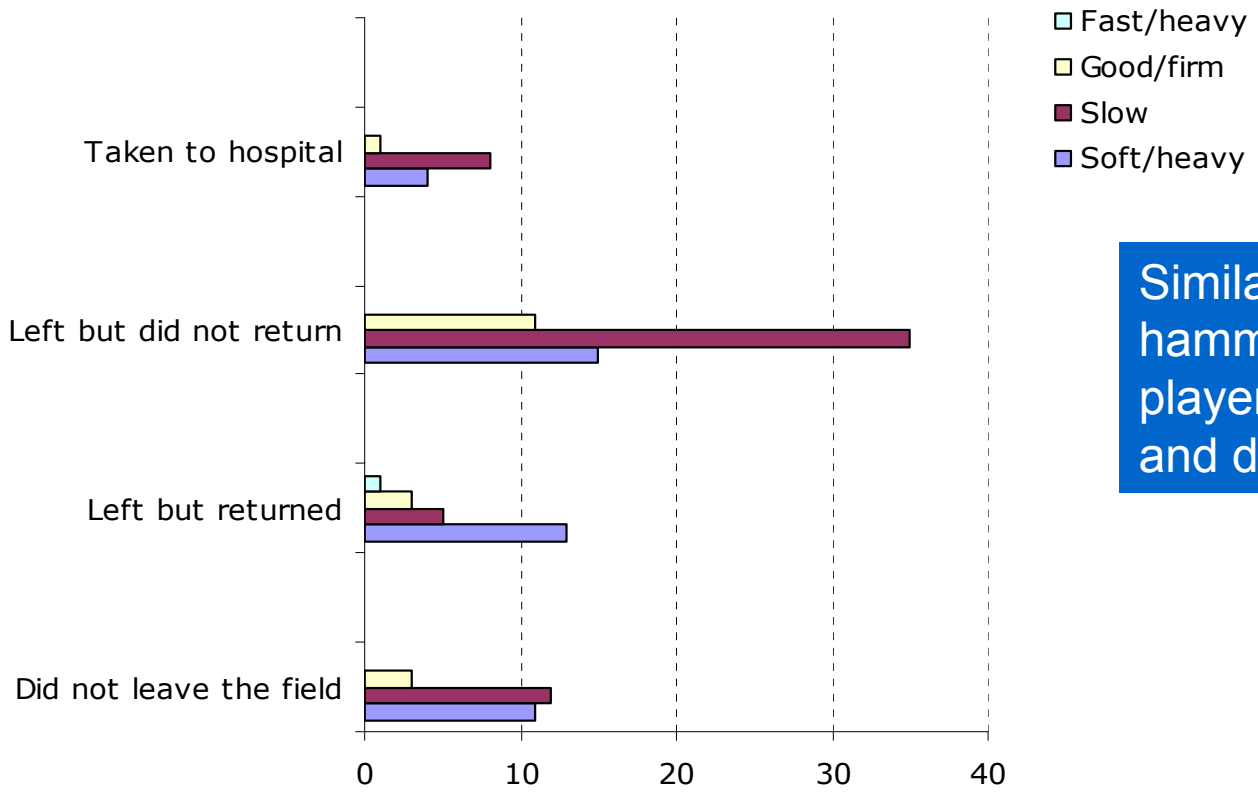
Injury Severity - Clegg hammer



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

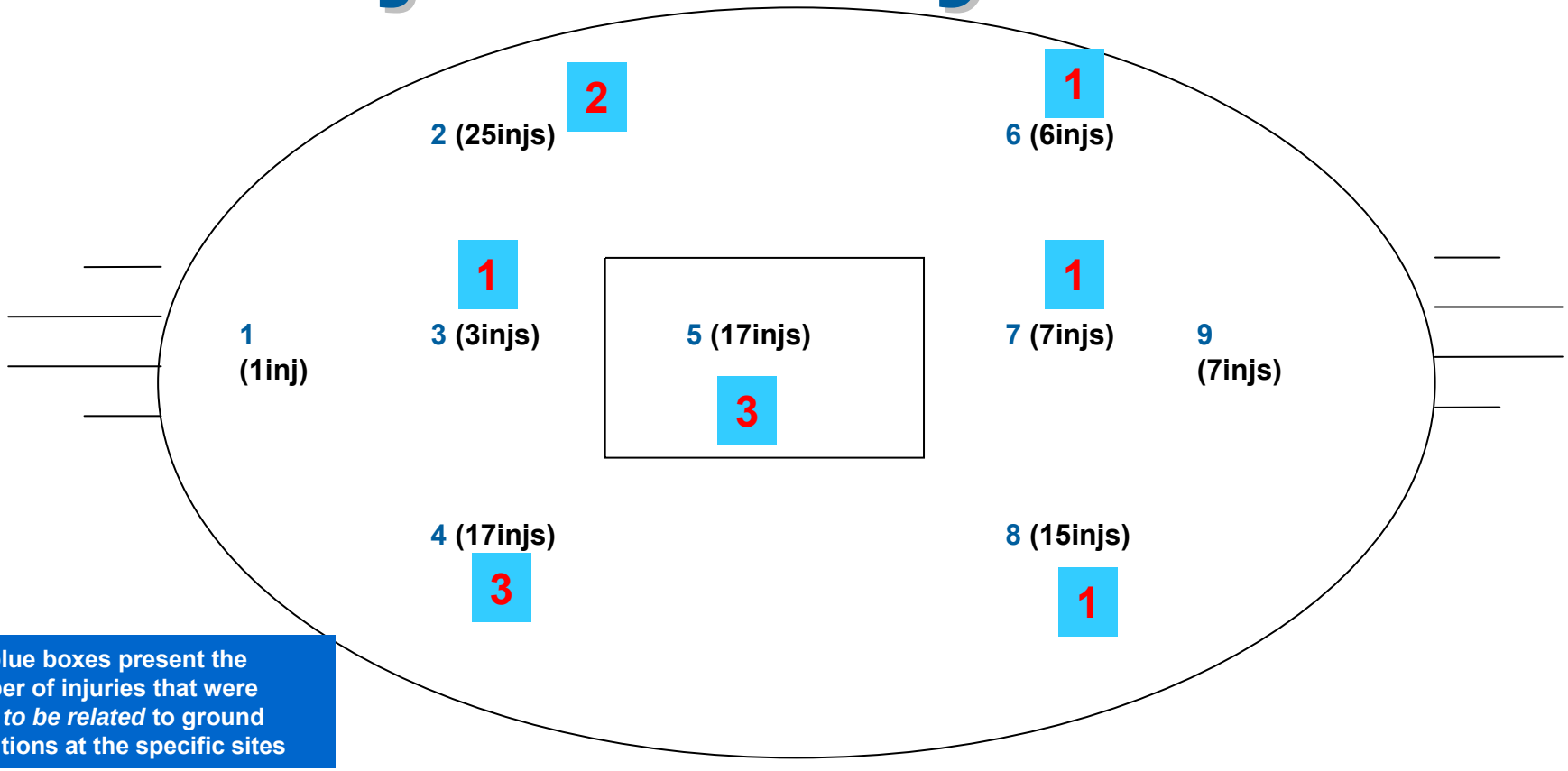
- None of the injuries *likely to be related* to ground conditions were sustained on unacceptably high Clegg hammer readings, or hard/fast penetrometer readings.

- 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



The blue boxes present the number of injuries that were *likely to be related* to ground conditions at the specific sites

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

Predictors of Injury

Factor	Associated	p value
Player position	X	0.56
Body region	√	<0.001
Nature of injury	√	<0.001
Mechanism of injury	√	0.001
Clegg hammer hardness	√	0.002
Penetrometer hardness	X	0.45
Rotational traction	X	0.31

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

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