20th ANNUAL INJURY REPORT
Season 2011

Assoc Prof John Orchard
Adjunct Associate Professor
University of Sydney

Dr Hugh Seward
Executive Officer
AFL Medical Officers Association

Jessica Orchard
MPH, University of Sydney

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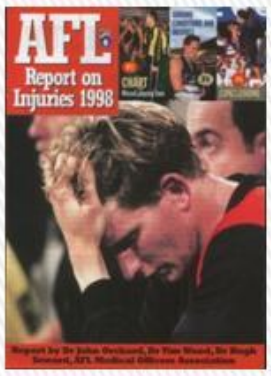

Contents

1 Summary

The 2011 AFL Injury Report is a landmark study, marking 20 years of recording of injury data by the AFL:

- There was 100% participation in the injury survey for all clubs and players, with a public release of the data, the 15th year in a row that both of these have occurred. These outcomes distinguish the AFL Injury Survey as Australia's leading study of its kind and arguably the leader in professional sport around the world. Of the world's major professional sporting competitions, only the NFL has been keeping data for longer than 20 years but it does not make a public release of all data.

- There was a similar overall injury incidence and prevalence in season 2011 compared with season 2010, although the make-up of the injury profile was quite different between the two years. Overall incidence decreased and there were statistically significant falls in the 2011 incidence (compared to the previous 5 seasons) of hamstring muscle strains and all lower limb muscle strains, but there were rises in incidence of concussion and PCL injuries. The increase in prevalence can be largely attributed to higher than usual rates of knee ACL injuries and fractures, which are accompanied by long periods of absence per injury.

- The number one injury in the game in terms of injury numbers and missed games remains the hamstring strain. However missed games through hamstring injuries in 2011 were the lowest for a decade. Both the total incidence (new and recurrent injuries combined) and recurrence rates of hamstring injuries in 2011 were the lowest rates exhibited for the 20 year survey period. The other major soft tissue injury category, groin strains, were also reduced in season 2011 and at a historically low level.

- After one season of the new substitute rule (changing the bench from 4 interchange players to 3 interchange plus 1 substitute), it is too early to be certain about the extent to which this change has contributed to the statistically significant drop in hamstring strains and other lower limb muscle strains in 2011, however the evidence suggests there is some association. The 2011 GPS report showed that average player speed and time spent at the highest speeds both decreased in 2011 for the first time in several years, which was pleasing in the context of reducing the risk of injury. Ongoing assessment of injury rates in 2012 will allow for further analysis to be performed.

- The most severe of the common injuries is still the knee anterior cruciate ligament (ACL) tear, with higher rates in season 2011 compared with recent seasons.

- Shoulder injuries increased further in 2011, following a long-term upward trend. However, there has been a parallel long-term upward trend in numbers of tackles per team per game and the increased incidence of shoulder injury correlates very highly with number of tackles.

- At the start of the season the AFL Medical Officers Association introduced revised Concussion Management guidelines that strengthened a more conservative clinical approach and this was supported by the AFL. Rates of concussion (according to the injury survey definition) have increased in season 2011, albeit with numbers of players missing games still low compared to most other injury categories. While there has been an increase in incidence of concussion in 2011, longer term trends are relatively constant, and it is likely this also represents a change of culture amongst AFL teams. There has been a global shift in many sports to a more conservative approach to concussion management, which may have led to a more cautious decision about return to play the week after injury.

- The recurrence rates for all injuries in 2011 have dropped to the lowest level recorded over the 20 year period, at 9% and into single figures (as a percentage) for the first time. The recurrence rates for many of the major categories, such as hamstring strains, were also down.

- For the first time since the second centre circle rule was introduced for centre bounces in season 2005, there were 4 centre bounce PCL injuries in 2011, after being only 4 in total for the period 2005-10. These lower rates since 2005 have demonstrated the success of the rule. Given the spike in 2011, further monitoring will be undertaken to make sure rates of PCL do not re-increase over the next few years.

2 Introduction

The Australian Football League (AFL) has commissioned an annual injury surveillance report every year since 1992[1-7], so that 2011 marks the 20th AFL Injury Report. The first ever scientific publication on injuries in Australian football was made by Hawthorn's Sandy Ferguson in 1965[8]. The first competition-wide injury survey was conducted by Hugh Seward in the VFL for 3 years during the 1980s[9]. The Australian Sports Commission funded a survey of elite AFL, rugby league and rugby union injuries in 1992[6 7]. The AFL made the decision to continue funding annual surveillance in 1993 and has done so ever since.

Injury surveillance is now recognised as an important obligation of professional sporting bodies [2 10-13], with various levels of success reported[4]. On a national and International level the AFL injury survey model is highly acclaimed, particularly for the annual public release and consistent methodology[14].

The 5th annual AFL injury report was publicly released in 1996[15], believed to be the first occasion worldwide that a professional sport openly tabled its injury data. The National Football League (NFL) in the USA has conducted an injury surveillance system since the 1980s but does not publicly release its data on annual basis (although multiple studies arising have been published in the scientific literature[16-21]). Other bodies known to conduct regular injury surveillance (with various degrees of disclosure) include Cricket Australia[22 23], the National Rugby League (NRL)[24], the National Collegiate Athletic Association (NCAA)[25-27], Union of European Football Associations (UEFA) [10 28 29] and the Rugby Football Union (RFU)[30 31].

The AFL has shown a long-term investment in high quality and consistent injury surveillance along with other advanced research. The AFL has also demonstrated willingness to consider and implement rule changes to improve player safety, where necessary. A documented successful example of this was the centre circle rule change, which has decreased the incidence of ruck-related posterior cruciate ligament (PCL) injuries[3].

The injury survey has also been pivotal in guiding the AFL Research Board to commission and fund projects that further investigate injuries that are common, severe or increasing in incidence. As the AFL was also the first professional sporting body in Australia to implement a funded research board, it has distinguished itself as the most progressive professional sport in this country with respect to injury research, currently devoting approximately $400,000 per annum towards injury research.

It is an ongoing aim of the AFL and the AFL Medical Officers Association (AFLMOA) to remain the 'gold' standard of injury surveillance in Australia and to at least match the best other surveillance systems worldwide.

3 Methods

The methods of the injury survey are now well established and have been previously described in detail [2 32], although minor changes to injury category codes are made on an annual basis. All teams now keep electronic records of injuries. For season 2011, 10 out of 17 teams used the Athletic Logic electronic record system. Other clubs used various other methods and forwarded on their data in alternate formats to the injury survey coordinator.

The standard AFL player contract now includes consent for players' injury records to be passed from team medical staff to the researchers for the purposes of standard injury surveillance. For additional studies (e.g. case follow ups of certain injuries) which would require identification of players to obtain extra information, further consent from each player involved would be required.

3.1 Injury Definition

From 1997 onwards, the definition of an injury has been an "injury or medical condition which causes a player to miss a match". This definition and methodology has been chosen to promote consistency across all AFL clubs and from season to season[14]. Player movement monitoring essentially requires that all clubs define the status of each player each round to be either: (1) playing AFL football (2) playing football at a lower level (3) not playing football due to injury or (4) not playing football for another reason. The details for injuries which result in a status of being unable to participate in a match due to injury are then passed on to the injury surveillance coordinator at the end of the season for recording and analysis. These details include diagnosis, which is subsequently coded [33-35] and onset of injury. The injury survey coordinator can cross-check the data provided by each club after the conclusion of the season with the player movement monitoring done in 'real time' during the season, in order to maximise compliance with the injury survey definition. Individual player injury details are not revealed in any report of the injury survey. Player movement monitoring has allowed the injury survey to achieve '100% compliance' for all instances of missed player games in the home and away season since 1997 [2 14]. In 2001 this was extended to include rookie listed players and finals matches. Although this definition attracts some criticism as not surveying the entire spectrum of injuries (e.g. excluding valid injuries which do not cause a player to miss a match[36]), its enormous strength is that a consistent comparison can be made. For a longitudinal study such as the current analysis, if a broader definition was used there may be a concern about changing thresholds for reporting an injury by team medical staff over time [14]. The definition of a condition "causing a player to miss a match" includes illnesses and injuries caused outside football, although these injuries are considered in separate categories when grouped by diagnosis. An injury recurrence is a condition to the

same body part on the same side which causes a later bout of missed matches in the season after return to play.

3.2 Injury Categories

Injury categories are amended slightly on an annual basis depending on which specific diagnoses (using OSICS codes version 9 [34 35]) are included within each category. Where changes have been made they have been made retrospectively for all previous survey years. Therefore, some of the category data presented in this report for previous years varies slightly from what is apparently the same data that has been published before in the previous reports.

3.3 Injury Rates

The major measurement of the number of injuries occurring is seasonal injury incidence measured in a unit of new injuries per club per season (where a club is defined as 40 players and a season is defined as 22 rounds). Since the average club now has approximately 47 players on the list and plays for slightly over 22 rounds (including finals), the exact number of injuries occurring per club is slightly greater than the figures tabulated. For example, a hamstring injury incidence of 6 new injuries per club per season (for 40 players playing 22 weeks) would be equivalent to 7 new injuries per club per season (for 46 players over 23 weeks). The modification is required so that the year-to-year figures are comparable, because average list size changes from year-to-year.

The major measurement of the amount of playing time missed through injury is injury prevalence measured in a unit of missed games per club per season, or alternatively percentage of players unavailable through injury.

The recurrence rate is the number of recurrent injuries expressed as a percentage of the number of new injuries. A recurrent injury is an injury in the same injury category occurring on the same side of the body in a player during the same season. Therefore, by this definition, an injury of one type that recurred the following season was defined as a new injury in that next season.

Comparisons of 2011 incidences were made with the previous five year period (2006-10) to test for significant increases in injury incidence at the $P<0.05$ level.

3.4 Injury Rates for Seasons prior to 1997

As this report is the 20th anniversary, historical data from the early years of the survey is republished. All data from 1992-1996 has been screened to only include injuries which caused a player to miss a match, to maintain consistency with the current definition. Because player movement monitoring was not used efficiently prior to 1997, some injury category tables in section 4.4 of this report may slightly under-report injury rates in those early years.

4 Results

Key indicators for the past 20 years are shown in Table 1. The injury incidence (number of new injuries per club per season) for 2011 was 38.4, a slight reduction from 2010. Injury prevalence was 157.0 missed games per season and continued the upward trend seen since 2003. The rate of recurrent injuries (3.4 per team per season or 9%) was reduced in 2011 and in fact was the lowest reported in the 20 years of the survey.

Table 1 – Key indicators for all injuries over the past two decades

All injuries	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Incidence (new injuries per club per season)	34.4	34.1	34.8	35.3	34.0	34.6	36.9	37.8	38.7	**38.4**	36.0
Incidence (recurrent)	4.4	4.6	3.7	4.8	4.1	5.6	5.4	3.6	4.7	**3.4**	4.4
Incidence (total)	38.7	38.7	38.5	40.1	38.2	40.3	42.3	41.4	43.3	**41.9**	40.4
Prevalence (missed games per club per season)	134.7	118.7	131.0	129.2	138.3	146.7	147.1	151.2	153.8	**157.0**	140.8
Average injury severity (number of missed games)	3.9	3.5	3.8	3.7	4.1	4.2	4.0	4.0	4.0	**4.1**	3.9
Recurrence rate	13%	14%	11%	14%	12%	16%	15%	10%	12%	**9%**	12%

All injuries	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Average
Incidence (new injuries per club per season)	35.4	30.3	33.7	38.2	38.9	40.1	40.3	36.9	37.4	35.8	36.8
Incidence (recurrent)	8.8	7.3	6.0	6.2	4.9	8.0	7.6	5.2	5.9	5.5	6.5
Incidence (total)	44.2	37.6	39.7	44.4	43.8	48.1	47.9	42.1	43.3	41.3	43.3
Prevalence (missed games per club per season)	145.9	122.5	116.3	133.1	140.0	151.2	141.9	135.9	131.8	136.4	135.5
Unaccounted missed games per club per season	9.9	12.6	7.8	4.4	2.7	N/A	N/A	N/A	N/A	N/A	N/A
Average injury severity	4.1	4.0	3.5	3.5	3.6	3.8	3.5	3.7	3.5	3.8	3.7
Recurrence rate	25%	24%	18%	16%	13%	20%	19%	14%	16%	15%	18%

4.1 Injury Incidence

Table 2 (on the following page) details the incidence (new injuries only) of all defined categories. The major categories are illustrated in Figure 1 below.

The highlights for 2011 in terms of new injury incidence were:

- Substantially reduced hamstring injury incidence in 2011 compared to both 2010 and historical levels. Reductions for hamstring injury incidence and lower limb muscle strain combined injury incidence (hamstring, quadriceps, groin and calf strains) were statistically significant (P<0.05).
- Concussion, knee posterior cruciate ligament (PCL), Achilles tendinopathy and 'other' leg/foot/ankle injuries all increased in 2011 compared to 2010 (P<0.05).

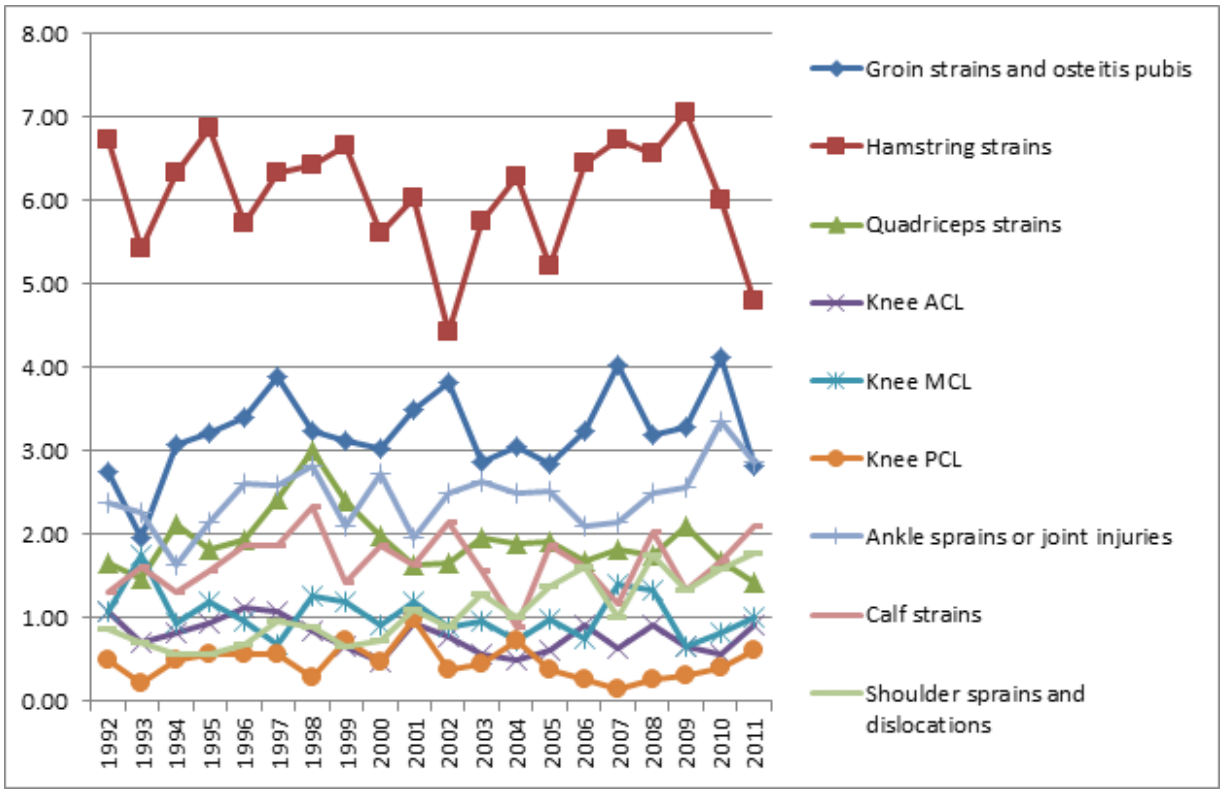

Figure 1 – Injury incidence for major categories over 20 years

Table 2 – Injury Incidence (new injuries per club per season)

Body area	Injury type	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	10yrA
Head/ neck	Concussion	0.7	0.3	0.3	0.7	0.3	0.3	0.4	0.5	0.5	**1.1 ***	0.5
	Facial fractures	0.4	0.6	0.8	0.6	0.3	0.4	0.2	0.5	0.5	**0.5**	0.5
	Neck sprains	0.0	0.0	0.1	0.2	0.3	0.1	0.2	0.1	0.1	**0.1**	0.1
	Other head/neck injuries	0.2	0.3	0.2	0.1	0.2	0.2	0.1	0.1	0.2	**0.2**	0.2
Shoulder/ arm/ elbow	Shoulder sprains and dislocations	0.9	1.3	1.0	1.4	1.6	1.0	1.8	1.3	1.6	**1.8**	1.4
	A/C joint injuries	1.1	0.3	1.1	0.8	1.2	0.8	0.7	0.5	0.8	**0.7**	0.8
	Fractured clavicles	0.3	0.2	0.6	0.3	0.3	0.3	0.1	0.2	0.2	**0.1**	0.3
	Elbow sprains or joint injuries	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.2	0.2	**0.3**	0.1
	Other shoulder/ arm/elbow injuries	0.8	0.5	0.4	0.6	0.3	0.2	0.3	0.1	0.3	**0.4**	0.4
Forearm/ wrist/ hand	Forearm/wrist/hand fractures	1.1	0.8	1.1	1.3	1.1	0.9	1.2	1.1	1.2	**1.6**	1.1
	Other hand/wrist/ forearm injuries	0.4	0.7	0.4	0.3	0.3	0.6	0.4	0.4	0.3	**0.4**	0.4
Trunk/ back	Rib and chest wall injuries	0.9	0.8	0.7	0.4	1.0	0.4	0.7	0.3	0.6	**0.4**	0.6
	Lumbar and thoracic spine injuries	0.9	0.8	1.6	2.1	1.5	1.3	1.5	1.4	1.7	**1.3**	1.4
	Other buttock/back/ trunk injuries	0.4	0.5	0.6	0.4	0.6	0.5	0.7	0.5	0.4	**0.6**	0.5
Hip/ groin/ thigh	Groin strains/osteitis pubis	3.8	2.9	3.1	2.9	3.3	4.0	3.2	3.3	4.1	**2.8**	3.3
	Hamstring strains	4.4	5.7	6.3	5.2	6.4	6.7	6.6	7.1	6.0	**4.8 #**	5.9
	Quadriceps strains	1.7	2.0	1.9	1.9	1.7	1.8	1.8	2.1	1.7	**1.4**	1.8
	Thigh and hip haematomas	1.0	0.3	1.1	1.0	1.1	0.6	0.5	1.0	1.1	**0.5**	0.8
	Other hip/groin/thigh injuries, including hip joint	0.3	0.4	0.3	0.2	0.3	0.8	0.8	1.0	0.7	**1.1**	0.6
Knee	Knee ACL	0.8	0.6	0.5	0.6	0.9	0.6	0.9	0.7	0.6	**0.9**	0.7
	Knee MCL	0.9	1.0	0.7	1.0	0.8	1.4	1.3	0.7	0.8	**1.0**	1.0
	Knee PCL	0.4	0.5	0.7	0.4	0.3	0.2	0.3	0.3	0.4	**0.6 ***	0.4
	Knee cartilage	1.3	1.7	1.2	1.3	1.0	1.2	1.6	2.0	1.7	**1.5**	1.4
	Patella injuries	0.4	0.1	0.1	0.3	0.3	0.3	0.2	0.2	0.5	**0.4**	0.3
	Knee tendon injuries	0.8	0.7	0.4	0.7	0.4	0.3	0.3	0.5	0.4	**0.6**	0.5
	Other knee injuries	0.5	0.7	0.7	0.9	0.2	0.8	1.0	1.0	0.4	**0.8**	0.7
Shin/ ankle/ foot	Ankle joint sprains, including syndesmosis sprains	2.5	2.6	2.5	2.5	2.1	2.2	2.5	2.6	3.4	**2.9**	2.6
	Calf strains	2.2	1.6	0.9	1.9	1.6	1.2	2.0	1.3	1.7	**2.1**	1.6
	Achilles tendon injuries	0.4	0.4	0.2	0.3	0.3	0.4	0.6	0.6	0.4	**0.9 ***	0.5
	Leg and foot fractures	0.8	0.5	0.5	0.4	0.7	0.5	0.5	1.0	0.9	**0.7**	0.7
	Leg and foot stress fractures	0.7	0.9	0.9	0.9	1.1	1.1	0.9	0.9	1.2	**1.3**	1.0
	Other leg/foot/ankle injuries	0.8	1.5	1.7	1.3	1.5	1.3	1.1	1.5	1.7	**2.5 ***	1.5
Medical	Medical illnesses	2.3	2.4	2.0	2.2	0.7	1.9	2.1	2.9	2.1	**1.9**	2.0
Non-football injuries		0.3	0.4	0.1	0.1	0.2	0.2	0.3	0.2	0.5	**0.1**	0.2
NEW INJURIES / CLUB / SEASON		**34.4**	**34.1**	**34.8**	**35.3**	**34.0**	**34.6**	**36.9**	**37.8**	**38.7**	**38.4**	**35.9**

*** 2011 Incidence significantly higher than the seasons 2006-2010 inclusive**

2011 Incidence significantly lower than the seasons 2006-2010 inclusive

4.2 Injury Recurrence

Table 3 shows the rate of recurrence of some of the common injury types which are prone to high recurrence rate. Season 2011 demonstrated the lowest recurrence rates seen in the 20 years of the survey, both for injuries overall and many of the major categories, including hamstring strains.

Most contact-mechanism injuries, such as fractures, concussions and 'cork' injuries have a low recurrence rate. The rate of injury recurrence has been showing a fairly steady decline over the last 20 years, with all of the common muscle strains showing a steady decline in recurrence rate[37]. There has been a general trend for team medical staff to be more conservative with injury management, delaying return to play which may have contributed to fewer recurrences.

Table- 3 – Recurrence rates (recurrent injuries as a percentage of new injuries)

Recurrence rates	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	10yrA
Hamstring strains	30%	27%	22%	26%	16%	22%	27%	18%	14%	**12%**	21%
Groin strains and osteitis pubis	23%	20%	24%	23%	28%	39%	23%	19%	20%	**15%**	24%
Ankle sprains or joint injuries	16%	6%	11%	15%	10%	20%	9%	10%	5%	**13%**	11%
Quadriceps strains	17%	9%	6%	20%	19%	18%	15%	15%	18%	**7%**	14%
Calf strains	13%	14%	6%	12%	7%	9%	5%	0%	12%	**5%**	8%
All injuries	13%	14%	11%	14%	12%	16%	15%	10%	12%	**9%**	12%

Recurrence rates	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	10yrA
Hamstring strains	45%	40%	31%	29%	25%	38%	36%	31%	37%	25%	33%
Groin strains and osteitis pubis	29%	43%	33%	27%	22%	36%	31%	6%	16%	20%	26%
Ankle sprains or joint injuries	9%	28%	4%	9%	11%	20%	21%	9%	11%	17%	14%
Quadriceps strains	35%	19%	15%	21%	26%	35%	20%	20%	18%	10%	22%
Calf strains	28%	26%	0%	16%	15%	15%	15%	17%	32%	17%	18%
All injuries	25%	24%	18%	16%	13%	20%	19%	14%	16%	15%	18%

4.3 Weekly player status and injury prevalence

Table 4 details player status on a weekly basis over the past ten seasons. The 'average' status of a club list of 47 players in any given week for 2011 was: 35 players playing football per week, 22 in the AFL; 8 missing through injury; and 4 missing through other reasons (such as suspension, being used as a travelling emergency, team bye in a lower grade, etc).

Table 4 – Average weekly player status by season

All injuries	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Playing AFL	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	**22.0**
Playing lower grade football	12.1	12.0	11.9	12.2	11.8	11.9	11.7	12.8	12.8	**12.5**
TOTAL playing	34.1	34.0	33.9	34.2	33.8	33.9	33.7	34.8	34.8	**34.5**
Not playing because of injury	6.6	5.7	6.4	6.4	7.0	7.4	7.4	7.9	8.1	**8.4**
Not playing for other reasons	2.3	2.5	2.5	2.8	3.1	2.9	3.4	3.5	3.5	**4.0**
TOTAL not playing	8.9	8.2	8.9	9.1	10.1	10.4	10.8	11.4	11.6	**12.4**
Players in injury survey (per club)	43.0	42.2	42.8	43.3	43.9	44.2	44.6	46.1	46.4	**46.9**
Injury prevalence (%)	15.3%	13.5%	14.9%	14.7%	15.9%	16.8%	16.7%	17.2%	17.5%	**17.8%**

Table 5 (on the following page) details the amount of missed playing time attributed to each injury category. The injury prevalence categories tend to mirror the injury incidence results, with similar categories in Table 5 showing increases and decreases to those in Table 2. Soft tissue injury prevalence was reduced in 2011, but many of the contact injury categories were slightly increased in prevalence. Hamstring strain injury prevalence was the lowest figure recorded for 10 years, along with groin injury prevalence. Foot and leg stress fracture prevalence was increased in season 2011.

Table 5 – Injury Prevalence (missed games per club per season)

Body area	Injury type	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	10yrA
Head/ neck	Concussion	2.0	0.6	0.3	0.9	0.3	0.3	0.5	0.7	0.8	**2.2**	0.9
	Facial fractures	1.4	1.0	2.2	1.4	0.8	0.7	0.5	1.1	1.4	**1.6**	1.2
	Neck sprains	0.0	0.0	0.6	0.3	0.3	1.1	1.1	0.1	0.1	**1.5**	0.5
	Other head/neck injuries	0.2	0.7	0.2	0.2	1.1	1.6	0.1	0.3	1.3	**0.2**	0.6
Shoulder/ arm/ elbow	Shoulder sprains and dislocations	5.9	5.7	5.9	7.7	10.8	6.4	10.2	7.7	10.9	**12.1**	8.3
	A/C joint injuries	2.4	0.7	2.5	1.9	2.7	1.4	1.5	1.2	1.5	**2.3**	1.8
	Fractured clavicles	2.0	1.0	3.5	1.3	1.7	1.8	1.1	0.6	0.7	**0.6**	1.4
	Elbow sprains or joint injuries	0.3	0.4	0.7	0.4	0.7	0.8	0.5	1.5	0.2	**1.3**	0.7
	Other shoulder/ arm/elbow injuries	3.4	1.6	1.6	2.4	1.7	0.7	0.7	1.0	0.3	**1.3**	1.5
Forearm/ wrist/ hand	Forearm/wrist/hand fractures	3.1	2.5	3.9	3.8	4.3	2.3	3.2	4.8	3.4	**5.4**	3.7
	Other hand/wrist/ forearm injuries	2.2	2.9	1.2	1.2	0.5	3.1	1.4	0.8	1.1	**1.8**	1.6
Trunk/ back	Rib and chest wall injuries	1.5	1.7	1.3	0.6	2.2	1.9	1.3	0.6	1.3	**0.7**	1.3
	Lumbar and thoracic spine injuries	5.8	2.1	5.4	6.4	5.4	2.8	5.0	4.6	6.9	**5.9**	5.0
	Other buttock/back/ trunk injuries	1.6	1.6	2.3	0.7	1.3	1.7	1.3	1.2	1.0	**1.7**	1.4
Hip/ groin/ thigh	Groin strains/osteitis pubis	15.7	13.7	13.3	11.2	14.0	17.5	12.4	11.7	15.3	**7.9**	13.3
	Hamstring strains	15.6	18.6	21.6	18.6	21.8	24.3	25.8	21.8	20.6	**16.5**	20.5
	Quadriceps strains	4.3	6.0	4.2	6.4	5.5	5.6	6.5	8.4	6.3	**5.7**	5.9
	Thigh and hip haematomas	1.9	0.5	1.7	1.6	1.4	1.0	0.6	1.2	1.9	**0.7**	1.2
	Other hip/groin/thigh injuries, including hip joint	1.2	1.5	2.6	1.0	2.3	4.5	3.4	6.9	4.7	**5.9**	3.4
Knee	Knee ACL	15.3	10.8	10.1	9.3	14.1	15.1	15.3	11.1	7.8	**13.4**	12.2
	Knee MCL	2.8	2.9	2.9	3.0	1.7	4.7	4.0	2.3	2.5	**3.2**	3.0
	Knee PCL	2.3	2.0	6.5	2.7	1.8	1.6	2.2	1.2	3.2	**4.8**	2.8
	Knee cartilage	6.0	7.0	6.1	7.8	5.7	9.1	8.5	10.7	13.0	**7.6**	8.2
	Patella injuries	2.5	0.6	0.1	0.8	1.2	2.7	1.0	1.8	2.4	**1.7**	1.5
	Knee tendon injuries	3.7	2.9	0.9	2.6	1.8	0.7	1.1	0.8	0.8	**2.3**	1.7
	Other knee injuries	1.0	2.4	1.3	3.8	0.2	2.6	2.7	2.6	0.9	**2.3**	2.0
Shin/ ankle/ foot	Ankle joint sprains, including syndesmosis sprains	5.9	5.3	6.4	9.2	8.1	7.1	7.0	8.9	9.2	**8.7**	7.6
	Calf strains	4.4	3.8	1.7	4.5	3.4	3.1	4.4	3.0	3.7	**5.5**	3.8
	Achilles tendon injuries	0.9	1.5	0.8	1.9	2.1	2.2	4.1	2.2	3.4	**4.0**	2.3
	Leg and foot fractures	7.9	2.9	3.7	2.7	5.7	2.7	3.2	7.5	7.6	**4.6**	4.9
	Leg and foot stress fractures	3.9	5.3	6.3	5.1	8.2	6.8	7.3	11.0	8.5	**10.2**	7.3
	Other leg/foot/ankle injuries	2.3	3.7	4.3	4.2	4.1	4.2	4.6	6.8	5.7	**9.3**	4.9
Medical	Medical illnesses	2.9	3.8	4.2	3.6	0.7	3.1	3.5	3.7	3.2	**3.2**	3.2
Non-football injuries		2.4	1.0	0.4	0.1	0.5	1.4	1.1	1.3	2.4	**0.5**	1.1
MISSED GAMES / CLUB / SEASON		134.7	118.7	131.0	129.2	138.3	146.7	147.1	151.2	153.8	**157.0**	140.8

4.4 Analysis and discussion for significant injury categories

(a) Hamstring and lower limb muscle strain injuries

Hamstring injuries are the most common injury in the AFL and are responsible for the highest number of matches missed through injury [2]. They are also common in other sports[38 39]. In sports where positional requirements vary, hamstring strains are far more common in the positions where sprinting is more often required[40].

Hamstring injuries can occur acutely from a high intensity event (as per the 100m sprinter tearing the muscle after 40m of running) and also as a gradual onset 'overuse' injury with specific onset being difficult to isolate. The majority of hamstring injuries in Australian football occur in matches although some occur during training sessions or by other means. Known risk factors include player age, past history of hamstring injury, strength deficits, indigenous race and past history of other injury (including calf, knee, ankle and groin injuries)[41-44].

Previous analysis of hamstring and other muscle strain data shows a high rate of recurrence [37 42 44-49]. The current AFL data shows that management of these injuries has become more conservative over the last 20 years in the AFL, with recurrence tending to decrease but severity (using average missed games per injury as the measure) tending to increase (Table 6). This change in management strategy has possibly been led by research showing that recurrence rates remain high for many weeks after the initial injury[45] and that performance of players is often decreased in the matches soon after return from hamstring strain[49]. Hamstring injuries are known to affect older players and those with a past history of injury more often[37 42 44-49] than other players.

Recent analysis of hamstring injuries over the period 2003-2010 (where interchange rates were increasing substantially) showed that individuals who interchanged often were protected against hamstring injury but this protection was outweighed by the increased risk of injury to their opponents and as such a higher overall risk of injury for that game[50]. The net effect was that hamstring injury rates rose significantly over the period 2003-2010 (Table 6). It is presumed that interchange usage reduces fatigue (which may be protective) but increases the speed of the game (which may add a risk factor). Hamstring injury rates did not fall over the period 2003-2010 despite interchange use rising markedly, suggesting that high interchange rates were not protective for the competition as a whole and may have contributed to the rise in this injury category. This relationship is further pronounced when looking at lower limb muscle strains as a grouped category including groin, calf and quadriceps strains, which previous research had shown to have been increasing at a rate of statistical significance over the period 2003-10, a trend which has not continued in 2011[58].

Table 6 shows that in 2011 there was a major drop in all of hamstring incidence, prevalence and recurrence rates. It is too early to definitively attribute this drop

to the new substitution rule (discussed in section 4.5), but at the very least the substitution rule has certainly not led to an increase in hamstring strains, which some had predicted.

Table 6 – Key indicators for hamstring strains over the past two decades

Hamstring injuries	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	10yrA
Incidence	4.4	5.7	6.3	5.2	6.4	6.7	6.6	7.1	6.0	**4.8**	5.9
Prevalence	15.6	18.6	21.6	18.6	21.8	24.3	25.8	21.8	20.6	**16.5**	20.5
Severity	3.5	3.2	3.4	3.6	3.4	3.6	3.9	3.1	3.4	**3.5**	3.5
Recurrence rate (%)	30%	27%	22%	26%	16%	22%	27%	18%	14%	**12%**	21%

Hamstring injuries	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	10yrA
Incidence	6.7	5.4	6.3	6.9	5.7	6.3	6.4	6.7	5.6	6.0	6.2
Prevalence	21.2	19.0	16.9	20.0	17.1	20.0	21.0	22.3	22.4	21.3	20.1
Severity	3.2	3.5	2.7	2.9	3.0	3.2	3.3	3.3	4.0	3.5	3.2
Recurrence rate (%)	45%	40%	31%	29%	25%	38%	36%	31%	37%	25%	33%

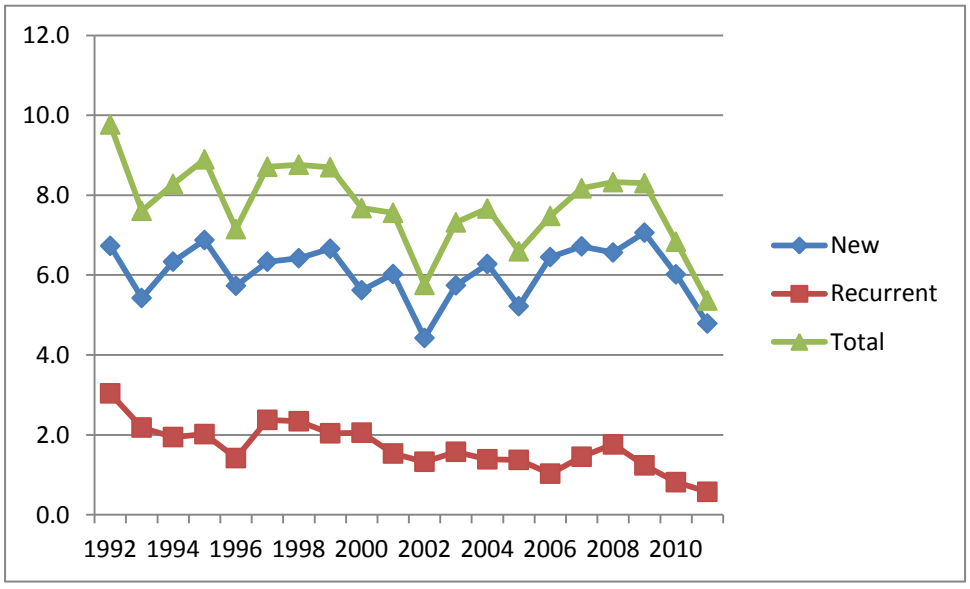

Figure 2 – Hamstring injury incidence (new recurrent and total injuries) over 20 years

Figure 2 show the combined incidence of new, recurrent and total hamstring injuries over the 20 year period of the injury survey. Whilst all three dropped in 2011, the trend over the 20 years is for new injuries to have stayed relatively constant, whilst recurrent injuries and total injuries have dropped.

(b) Shoulder injuries

Table 7 shows a steady increase in the prevalence and severity of shoulder injuries over the past decade, after the results were fairly stable in the 1990s. There are two major potential drivers of this trend. It is likely that the increased number of tackles per game (Figure 4) during the last decade has contributed to the increased risk of shoulder injury, simply by weight of greater exposure. Both the tackling and tackled player may injure their shoulder, with number of tackles (which have increased over the past decade) indicating increased exposure to shoulder injuries.

Table 7 – Key indicators for shoulder injuries over the past two decades

Shoulder sprains & dislocations	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	10yrA
Incidence	0.9	1.3	1.0	1.4	1.6	1.0	1.8	1.3	1.6	**1.8**	1.4
Prevalence	5.9	5.7	5.9	7.7	10.8	6.4	10.2	7.7	10.9	**12.1**	8.4
Severity	6.7	4.4	5.9	5.6	6.7	6.3	5.8	5.7	6.9	**6.8**	6.1
Recurrence rate	13%	9%	11%	20%	13%	16%	9%	12%	26%	**11%**	14%

Shoulder sprains & dislocations	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	10yrA
Incidence	0.9	0.7	0.6	0.6	0.7	1.0	0.9	0.7	0.7	**1.1**	0.8
Prevalence	5.9	3.9	4.0	2.7	3.0	5.1	5.9	5.6	4.0	**5.4**	4.6
Severity	6.8	5.5	7.1	4.8	4.4	5.3	6.5	8.5	5.6	**4.9**	5.9
Recurrence rate	42%	20%	11%	11%	8%	12%	13%	27%	17%	**10%**	17%

There is also a likely contribution of a greater tendency for teams to end a player's season somewhat earlier with shoulder reconstruction. In the 1990s, the standard management for a shoulder instability episode was to return the player back to competition as soon as possible. If a player had suffered multiple shoulder instability episodes during the season, then once the season had finished a specialist's opinion was sought and the player considered for shoulder reconstruction. The management in recent years had changed. Players are given longer to return (if they do choose to return) and hence the severity is higher but recurrence rate is lower. In particular, surgery is often performed mid-season if the player is young, considered highly likely to suffer from a recurrence, or if the team is unable to make the finals. Figure 3 shows that in the 1990s the number of players missing through shoulder injuries in round 11 (mid-season) compared to the last round of the season was not substantially different. However, in the last ten years, there have been far more players missing in the final round than mid-season. Many of these will have elected to end their season early to undergo shoulder surgery in order to be fully fit for round 1 of the following year.

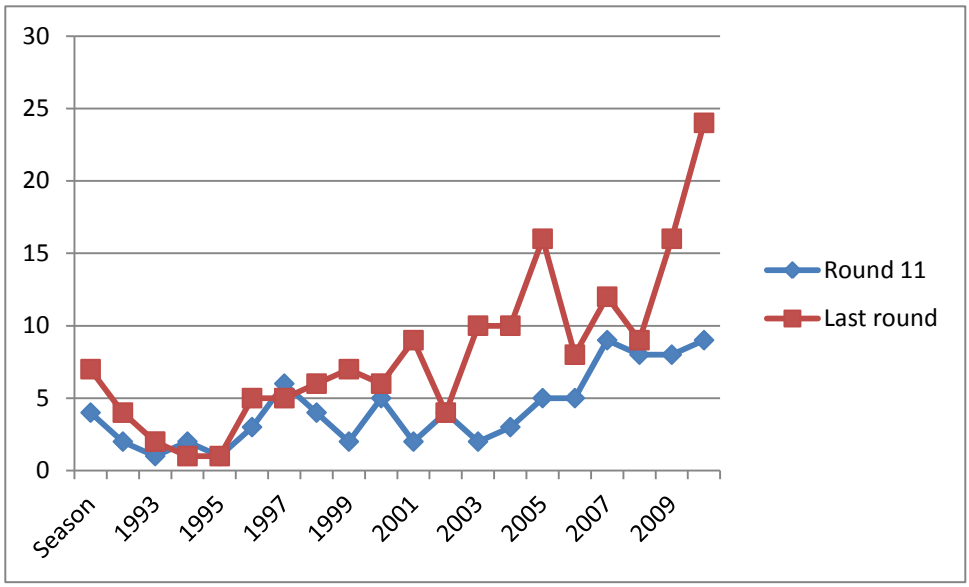

Figure 3 – Listed players missing with shoulder injuries in round 11 compared to the last round of the season over a 20 year period

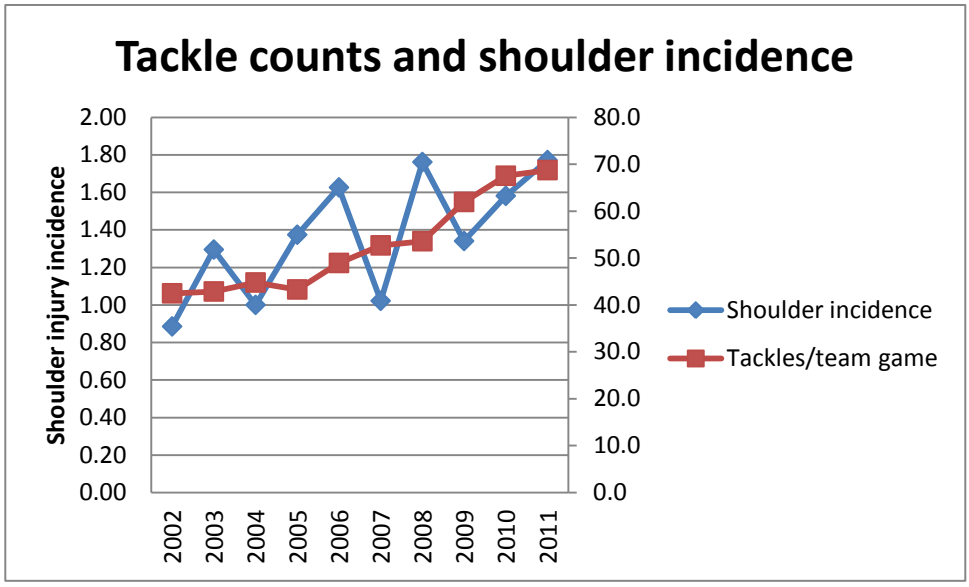

Figure 4 – Correlation between tackles/team game and shoulder injury incidence from 2002-2011 inclusive

(c) Knee PCL injuries

The two major knee ligament injuries are anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) injuries. There have been lower rates of PCL injuries since the introduction of the centre circle rule in season 2005 which has prevented injuries in ruckmen (Table 8) [3]. After 5 centre bounce PCL injuries in 2004, there were only 4 in total for the six seasons from 2005-2010. However, there were 4 centre bounce PCL injuries in total for 2011 which is against the longer term trend. The AFL will evaluate these four injuries to see if there is anything common about each instance, and continue to monitor PCL injury trends over the next few years to determine whether any further action is required.

Figure 5 – Ruckmen are less likely to injure PCL since the 2005 centre circle rule was introduced

Table 8 – Key indicators for PCL injuries over the past two decades

PCL injuries	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	10yrA
PCL incidence	0.4	0.5	0.7	0.4	0.3	0.2	0.3	0.3	0.4	**0.6**	0.4
PCL prevalence	2.3	2.0	6.5	2.7	1.8	1.6	2.2	1.2	3.2	**4.8**	2.8
No of PCL injuries (total)	7	8	13	7	5	3	5	6	8	**13**	7.5
Number of centre bounce PCL injuries	3	2	5	1	0	0	2	1	0	**4**	1.6

PCL injuries	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	10yrA
PCL incidence	0.5	0.2	0.5	0.6	0.6	0.6	0.3	0.7	0.5	1.0	0.6
PCL prevalence	3.5	2.1	3.4	2.0	3.1	1.9	2.2	5.2	2.3	5.9	3.2
No of PCL injuries (total)	7	3	8	9	10	10	5	12	8	18	9.0
Number of centre bounce PCL injuries	0	1	1	2	1	1	2	3	4	4	1.9

(d) Knee ACL injuries

Knee ACL injury incidence has been generally steady over the past few seasons (Table 9) although there was a higher reported incidence and prevalence in 2011. There has been a tendency for increased use of LARS artificial ligament ACL reconstructions over the past 4 seasons in the AFL. 11 LARS reconstructions have been performed on 9 players (from 5 clubs). It is clear that there is a much quicker return to play with the majority of these 11 returning to play in the season of the injury. However, there are concerns about the longevity of these grafts. Of the 11 reconstructions performed, 3 have needed revision. Two players were delisted at the end of the season in which they undertook a LARS reconstruction, so were not followed long-term as part of the injury survey. Of the six surviving LARS grafts, none have been followed for more than 18 months, compared to some players who have survived a decade with a traditional graft. It is worth bearing in mind that approximately 15% of those players with a traditional graft will suffer a re-rupture of their graft whilst on an AFL list. From this cohort of players who have had LARS ACL reconstructions, within a few years the AFL injury survey is likely to be able to define both the benefits (i.e. quicker return to play) and the risks (i.e. possible greater risk of graft re-rupture in the longer term) of LARS reconstructions.

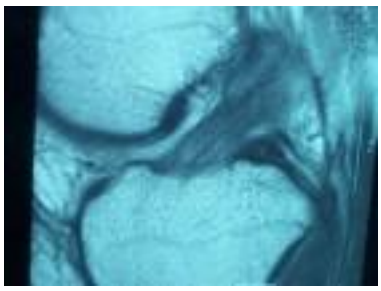

Figure 6 – MRI scan of torn ACL

Recent research of all ACL injuries in Australia has confirmed trends noted in the AFL injury report. At amateur (population) level, Australia has one of the highest rates of ACL reconstruction in the world[51]. In addition, the northern parts of Australia have a higher rate of ACL reconstruction than the southern parts [51]. This suggest that weather/grass conditions are a risk factor for ACL injuries in amateur sports played outdoors on grass of all types, which has been previously demonstrated in the AFL [52].

Table 9 – Key indicators for ACL injuries over the past two decades

ACL injuries	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	10yrA
ACL incidence	0.8	0.6	0.5	0.6	0.9	0.6	0.9	0.7	0.6	**0.9**	0.7
ACL prevalence	15.3	10.8	10.1	9.3	14.1	15.1	15.3	11.1	7.8	**13.4**	12.2
No of ACL reconstructions using autografts	15	11	9	10	19	13	15	13	5	**15**	12.5
Pre-existing ACL injuries/non-AFL injuries	1	0	0	0	1	1	0	0	3	**0**	0.6
No of graft ruptures	4	0	2	1	4	2	4	1	0	**4**	2.2
No of LARS reconstructions	0	0	0	0	0	0	2	0	4	**5**	1.1
Partial injuries	0	0	0	0	0	0	1	1	2	**1**	0.5

ACL injuries	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	10yrA
ACL incidence	1.1	0.7	0.8	0.9	1.1	1.1	0.8	0.7	0.5	0.9	0.9
ACL prevalence	15.1	5.5	10.1	14.3	17.0	17.8	15.8	10.8	4.8	13.6	12.6
No of ACL reconstructions using autografts	16	7	13	15	20	21	15	8	8	17	14.0
Pre-existing ACL injuries/non-AFL injuries	2	0	1	1	3	3	2	2	1	1	1.6
No of graft ruptures	1	0	3	3	5	4	2	0	1	1	2.0
No of LARS reconstructions	0	0	0	0	0	0	0	0	0	0	0.0
Partial injuries	0	4	0	1	1	0	0	3	0	0	0.9

(e) Responsible approach to concussion

The AFL Medical Officers Association introduced revised Concussion Management Guidelines at the beginning of the 2011 Season which led to a more conservative approach to concussion management.

Table 10 shows consistently low incidence and prevalence for concussions which cause a game to be missed (generally one injury or less per club per season). However, there was an apparent rise in both incidence and prevalence in 2011. The rise over the last year in the AFL corresponds with a worldwide trend amongst many sports to recognise the potential long-term effects of concussion[53-55] and a more conservative approach with return-to-play decisions.

The new Concussion Guidelines (in combination with the substitute rule) have led to more conservative concussion management practices, which is a significant factor in the increase, although the sensitivity of this survey cannot attribute the entire increase to this factor. The injury survey is not the best way to assess the full impact of concussion (as it only captures injuries which cause missed playing time), but can be used in conjunction with other specific studies.

Whilst additional research on concussion in the AFL is already underway[56], any change to the definition of concussion for the survey should be avoided so as to not affect the ability to detect long-term trends. There are many occasions and reports from other codes of football where retired players concede that on occasions when they received concussions they did not report the symptoms to team medical staff. AFL players are strongly encouraged by clubs to report all instances of suspected concussion, and research to date has suggested the current AFL practices are consistent with the best available standards[56]. This has been demonstrated by several other sports using the new AFL Concussion Guidelines as a benchmark for adjusting their own approach to concussion management[68].

The AFL remains strongly committed to player welfare and has introduced several law and tribunal changes in recent years to reduce the risk of head and neck injury such as a reduced tolerance of head-high contact, stricter policing of dangerous tackles, and the introduction of rules to penalise a player who makes forceful contact to another player with his head over the ball.

Table 10 – Key indicators for concussion over the past two decades

Concussion	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	10yrA
Incidence	0.7	0.3	0.3	0.7	0.3	0.3	0.4	0.5	0.5	**1.1**	0.5
Prevalence	2.0	0.6	0.3	0.9	0.3	0.3	0.5	0.7	0.8	**2.2**	0.9

Concussion	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	10yrA
Incidence	1.3	0.8	0.8	0.8	0.9	0.6	0.7	0.5	0.6	0.7	0.8
Prevalence	2.0	1.0	0.9	0.8	1.2	0.7	0.7	0.5	0.7	1.3	1.0

(f) Groin injuries

Groin injuries (including osteitis pubis) have been generally one of the three injury categories that cause the most missed playing time in the AFL. As a group, groin injuries represent a number of overlapping diagnoses, including adductor muscle strains, tendinopathy, osteitis pubis and sports hernias. In general these injuries have a high rate of recurrence and a high rate of becoming chronic. Incidence appears to be quite constant from season to season (3-4 new injuries per club per season) but prevalence (missed playing time) and recurrence rates vary from season to season.

Injuries to this region may in fact be increasing slightly more than is appreciated by an analysis of the category of groin injuries. There is an increasing appreciation of the role of hip joint pathology in treating groin pain, as evidenced by the increasing rates of 'other hip and thigh' injuries over the past decade.

Even taking the diagnostic challenges into account, there is no doubt that 2011 was a 'good' year for groin injuries with historically low incidence, prevalence and recurrence rates (Table 11).

Table 11 – Key indicators for groin and hip injuries over the past two decades

Groin injuries	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	10yrA
Incidence	3.8	2.9	3.1	2.9	3.3	4.0	3.2	3.3	4.1	**2.8**	3.3
Prevalence	15.7	13.7	13.3	11.2	14.0	17.5	12.4	11.7	15.3	**7.9**	13.2
Severity	4.1	4.8	4.4	3.9	4.3	4.3	3.9	3.5	3.7	**2.8**	4.0
Recurrence rate	23%	20%	24%	23%	28%	39%	23%	19%	20%	**15%**	24%
Other hip	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	10yrA
Incidence	0.3	0.4	0.3	0.2	0.3	0.8	0.8	1.0	0.7	**1.1**	0.6
Prevalence	1.2	1.5	2.6	1.0	2.3	4.5	3.4	6.9	4.7	**5.9**	3.5

Groin injuries	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	10yrA
Incidence	2.7	2.0	3.1	3.2	3.4	3.9	3.2	3.1	3.0	3.5	3.2
Prevalence	11.5	8.2	10.3	10.1	10.3	16.7	13.6	9.4	7.5	13.6	11.2
Severity	4.2	4.1	3.3	3.1	3.0	4.3	4.2	3.0	2.5	3.9	3.6
Recurrence rate	29%	43%	33%	27%	22%	36%	31%	6%	16%	20%	26%
Other hip	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	10yrA
Incidence	0.1	0.3	0.2	0.1	0.2	0.4	0.2	0.3	0.3	0.3	0.2
Prevalence	0.1	1.3	0.7	0.1	0.7	1.6	0.5	2.3	1.4	1.7	1.1

4.5 Introduction of the Substitute Rule

In 2011, the interchange system was changed from an unlimited bench of four interchange players to three interchange players and one substitute player who can only enter the ground if permanently replaced. The AFL is the first sport which has created a hybrid bench, although team sports in general have a diverse variety of interchange and substitute arrangements[57]. There were multiple rationales for the institution of the substitute rule, including 1) Congestion, 2) Fairness and 3) Injury. AFL overall injury incidence and prevalence had slightly but significantly increased over the decade to 2010, particularly in terms of lower limb muscle strains. Over this same time period interchange use by AFL teams had substantially increased[58]. While there was not a direct linear relationship between interchange use and injury rates, further analysis and research suggested there was some association.

Detailed published analysis of hamstring injuries, the most common injury, has now shown that interchanges are protective for the individual player but increase risk for opposition players[58]. Although these findings do not fully explain the underlying mechanisms, a simple paradigm which is consistent would be that a player who has just come on to the ground having interchanged is temporarily less likely to get injured (because he is rested) but that his direct opponent is temporarily more likely to get injured (as he is a fatigued player competing against, and trying to run with, a rested player). There is no protective net effect for the competition as a whole when interchanges increase.

It is sensible to suggest that the interchange movement itself does not impact on the risk (as it is almost unheard of for a player to strain a hamstring running to leave the field) but that interchange use is a proxy for the real risk factor (i.e. average player running speed). The latest AFL GPS research showed there was a decrease in playing intensity by 3.1% in 2011 for the first time since 2005, along with decreases in average speed and time spent at the highest speeds above 16 and 18 km/hr[64]. As yet it is not possible to know whether the substitute rule has lowered soft tissue injuries due to reduced average player running speed but the data is encouraging. Further analysis is required, including in future seasons, to make firm conclusions about this outcome. The 2011 data confirms the substitute rule has not negatively impacted injuries overall in 2011 (as some predicted it would), and may have arrested a long-term increasing trend in soft tissue injuries by preventing the speed of the game reaching a new level, consistent with the objectives of the rule[69].

To put the workload impact of the rule change in perspective, clubs were still able to maintain the same total number of interchanges in 2011 (average of 118 interchanges in 2011 compared with 117 in 2010), and it equated to just over 1 minute extra time on ground per player per quarter, which was approximately the same increase in time on ground regardless of position played[64].

Furthermore, the impact of the substitute rule needs to be evaluated in the context of the three objectives for which it was introduced and not just the injury component, including fairness where RMIT research has confirmed teams are now less disadvantaged when a team sustains an injury especially early in a match[70].

4.6 Byes and resting players

Byes may have had a minimal impact in lowering injury prevalence in 2011, but by about 0.5% of total missed time only. There were an average of 8.4 players missing per team per week in season 2011, dropping to 7.7 the week after the bye and then 8.1 two weeks after the bye. This means that having two byes (as opposed to the usual one) may have saved about 17 missed player games across to course of the year (about 0.5% of missed player games in total). It is therefore unlikely that the return to one bye per team in 2012 will have any meaningful change on injury rates.

5 Conclusions

Season 2011 revealed a sizeable drop in the major soft tissue injury categories of hamstring strains, groin strains & quadriceps strains. The reduction in incidence for hamstring injuries and total lower limb muscle strains was statistically significant ($P<0.05$ compared to seasons 2006-2010). It is too early to directly attribute these reductions to the substitute rule after one season, but at the very least it has certainly not led to an increase in these injury categories, which some had predicted.

Recurrence rates continue to fall and are now down to under 10%, the lowest rates reported in the 20 years of the AFL Injury Report. Regardless of whether this is due to more conservative practices or better judgment and assessment, this is an exceptional trend and reflects the high standard of medical management provided by AFL Club Medical Staff.

Although absolute numbers remain low, there was a significant rise in the incidence of concussion in 2011. The more conservative management of concussion in 2011 resulting from the introduction of revised AFLMOA Concussion Management guidelines appears to have contributed to this increase, and the further research commissioned by the AFL into the longer term effects of concussion is encouraged. The introduction of the substitute rule has also assisted with Concussion Management, often placing less pressure on Clubs to withdraw a player from the game without affecting a team's level of rotations and subsequent chances of winning.

For the first time since the introduction of the centre-circle rule in 2005, there was a rise in PCL injuries. Further analysis will be undertaken to see whether there is anything common about these incidences, such as ruckmen being exposed to excessively high PCL forces at the centre bounce.

Finally, it is worth reflecting on the achievements of 20 years of AFL injury surveillance:

- The AFL injury survey is the world's longest running publicly-released injury survey in sport;
- The survey has run for 20 seasons, achieving 100% participation and compliance over the last 15 seasons; and
- The survey has led directly and indirectly to dozens of published studies[2 5 32 52 59-63] and interventions which have improved the safety of the AFL competition (e.g. ruck rule changes to decrease PCL injuries).

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