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RUGBY HEADGEAR STUDY

Final Report

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EXECUTIVE SUMMARY

The effectiveness of headgear in reducing injury in rugby union football was studied during 2002 and 2003 in Sydney, Australia, using a randomised controlled trial study design. The study was funded by the International Rugby Board. There were three arms in the study: controls, IRB approved headgear and modified headgear. Eighty teams participated in the study in each year in the following age groups: under 13s, under 15s, school opens (under 18) and colts (under 21). The modified headgear was manufactured from thicker and denser polyethylene foam in comparison to the standard headgear. Laboratory testing had shown that the modified headgear performed better than IRB headgear on impact energy attenuation tests.

Player participation, headgear use and injury were recorded at each game during the study. The total number of player game participations with specific game time information and complete information on headgear use in each year was 30,316 and 31,899. Players who reported an injury and either received attention or left the field were recorded as being injured (game injury). Injuries resulting in a player missing a game were also recorded. Concussion was assessed and where possible symptoms were recorded.

Teams were randomised into each arm of the study. According to the randomisation, players in each team in the headgear arms, and those added to the team during the season, were provided with either the standard or modified honeycomb headgear. Players in the control arm were not provided with headgear. While the aims of the study were explained to the players and they were encouraged to wear the headgear allocated to them, players ultimately decided to wear the headgear as they saw fit. Thus, although 36% of the player-game exposures were for players randomised to the modified headgear arm of the study, only 11% of the total game exposures were for players observed by the primary data recorders wearing the modified headgear. In contrast, 29% of player-game exposures were in the IRB approved (standard) headgear arm, and in 46% of exposures IRB approved headgear was observed to be worn.

The rate of all game injuries was 64 per 1,000 player game hours, and the rate of injuries resulting in a missed game was 21 per 1,000 player game hours. The body region with the highest proportion of game injury was the shoulder (13%), followed by the head (13%), face (12%), knee (10%) and ankle (9%). As a proportion of all game injuries, concussion was 11% and neck injury 5%.

There were no statistically significant differences in rates of head injury or concussion, either for game injuries or missed game injuries, between players wearing no headgear, IRB standard headgear and the modified headgear. This was the case with analyses based on randomisation (intention to treat) and observed use of headgear. A non-significant lower rate of concussion and head injury resulting in a missed game was found for those players observed wearing the modified headgear. The incidence rate ratio for modified headgear wearers was 0.43 compared to no headgear, and approximately 0.4 compared to IRB wearers. The analyses also suggested that the risk of head injury, head injury resulting in missed games and concussion was highest for players measured wearing IRB headgear, after taking into account age group. As stated, these were only trends, and were not statistically significant.

Players who wore the IRB or modified headgear had significantly greater rates of neck injury, and non significant higher rates of neck injury resulting in a missed game. While the injury rates were low for both match and missed game injuries, neck injury in rugby can be catastrophic. Two possible explanations for this observation are: players executed unsafe contact skills in the belief that headgear would protect them; and, the rates of neck injury are confounded by player position and headgear wearing patterns. The latter could not be adequately examined statistically due to the low rates of neck injury. This is an area that requires further examination.

Headgear use on its own was not correlated with an increased overall injury rate. However, a multivariate analysis of rates of all injuries by observed headgear use and adjusted for age group/level of play, indicated a significant increase in the injury rate for wearers of standard IRB headgear ($p < 0.05$). The incidence rate ratio was 1.16 compared to the reference of no headgear worn, ie. a 16% increase. Players in colts or in the back five had the highest injury risks in general. Players in the under 13s had the lowest injury rates, either game or missed game injury ($p < 0.01$). With regards to missed game injuries, inside backs had a significantly higher rate of injury than other player positions ($p < 0.05$).

Fourteen hundred and fourteen players (1414) participated in the pre-season surveys and 576 in the end of season surveys in 2002 and 2003. There was a high reported use of mouthguards (90%) in the sample surveyed. Sixty percent of players reported that they had worn headgear for the majority of the previous season. Thus, there was a high pre-existing headgear wearing rate in the sample studied. The reported use of headgear in the previous season was similar to the measured pattern of headgear use, as 57% of player game exposures occurred with players wearing headgear.

Players perceived headgear as providing protection against injury. Players reported that the main reasons for wearing headgear were that they felt safer and they did not want to be injured. Sixty percent (60%) of players believed that headgear could always or often prevent injury and 80% of players felt always or often safer wearing headgear. Interestingly, 66% of headgear wearing players believed that they could always or often play more confidently and tackle harder (55%). Cost and appearance were the two most important reasons that informed selection of headgear. Players chose not to wear headgear because they found it hot or uncomfortable, but indicated that they might commence wearing headgear if they became injured or they received medical advice.

The concern that the players might modify their on field behaviour because they perceive that headgear provides a protective benefit emerges from the survey results. The review of the game video did not appear to provide any evidence that this actually occurred, as players wearing headgear appeared to be no more likely to exhibit grossly poor skills or take risks than those not wearing headgear. The association between neck injury and headgear use might reflect more subtle changes in player skills. This issue can be addressed by providing appropriate information to players and coaches regarding the performance of padded headgear and ensuring that players understand the limits to the performance of headgear.

In summary, the study found that headgear did not reduce the risk of head injury, including concussion. While headgear use was not associated with an overall higher rate of injury, it was associated with significantly greater neck injury rates. Further research is required to understand this phenomenon, as well as to study methods to reduce tackle related injury.

FOREWORD AND ACKNOWLEDGEMENTS

While preparing a report on a major research project there is an opportunity to reflect briefly on the project's history and the people who have made it a success. In 1995, at the time I was wondering how effective padded headgear was in preventing injury, it is now clear that my co-investigators were asking the same questions. From an Australian perspective we were all stimulated by the National Health and Research Council's report on head injury in football, and frustrated by that organisation's failure to support research to address issues raised in its report. Through mutual friends, colleagues and 'hard yakka', the investigators became acquainted and completed a number of projects, either independently or in small research team combinations. The Australian Rugby Union (ARU), the NSW Sporting Injuries Committee, the Victorian Health Promotion Foundation and the Eastern Football League all provided financial and/or administrative support for these earlier Australian based projects. Mr. John Searl of the ARU provided generous encouragement and support for the initial rugby projects. Mr. John Anderson from the NSW Sporting Injuries Committee also deserves special acknowledgement for his encouragement and support.

At the commencement of this study, the ARU assisted greatly in obtaining the support of the large number of clubs and schools required to make the project successful. Mr. John O'Neill, Mr. John Searl and Mr. Geoff Shaw provided much appreciated assistance. We greatly appreciate the support that all the participating schools, clubs, players and coaches provided for the study. Without their support the study would not have been possible, and in return we hope that the results of the study will lead to improvements in injury prevention strategies in rugby union. A list of participating clubs and schools, and personnel is provided later in the report.

At UNSW, Associate Professor Chris Winder, the then head of the School of Safety Science, provided essential support and encouragement. Similar support was received from Research Office staff and Professor Mark Wainwright, now Vice Chancellor. Ms. Maria Romiti, Mr. Cameron French, Ms. Dara Twomey, Rachel Ward and Mr. Trevor Savage have provided valuable and consistent research assistant support to the project. It is also very satisfying to observe and support their development as people and scientists.

Undertaking any research is a hard slog. In addition, this project involved evening and weekend work during the football season. Our families and colleagues have all supported this project. We gratefully acknowledge their support. I wish especially to thank my wife, Gregoria, and my family.

I believe that the study described in this report sets a very high standard in terms of research design and quality in sports safety research. The study has exceeded the original objectives and I hope that the study will assist rugby union address the management of injury risks in general, not limited to head injury and padded headgear. Finally, I wish to express the researchers' thanks for the financial support provided by the International Rugby Board through its Medical Advisory Board.

Dr. Andrew McIntosh May, 2005.

Table of Contents

Table of Tables

Table of Figures

CHAPTER 1

BACKGROUND AND LITERATURE REVIEW

1.1 Background

The use of padded headgear has been proposed as a method to reduce head injuries in rugby union football. According to the International Rugby Board's (IRB) Law 4M - 98g (1), headgear is worn to "reduce the severity and frequency of injuries from impacts with other players or the playing surface". Wilson (2) observed that the "primary reasons for wearing protective headgear are to prevent lacerations to the scalp and to minimise the risk of concussion".

For current forms of padded headgear to demonstrate a role in preventing injury or reducing injury severity, headgear should function to reduce some or all of the common forms of head injury in rugby, namely lacerations, contusions and concussion. From a biomechanical perspective padded headgear can achieve this through the attenuation of impact energy and thereby the reduction of head impact forces to levels that can be tolerated without injury.

Laboratory research to date on the style of padded headgear permitted under Law 4 has shown that the impact energy attenuation performance is unlikely to reduce the risk of concussion (3-5). This is due both to the Law 4 restrictions placed on the thickness and density of foam incorporated into padded headgear and the padded headgear performance standard test method. These factors have resulted in the production of headgear with low impact energy attenuation properties in comparison to other forms of sporting headgear. Therefore, current models of headgear exhibit little capacity to reduce the forces applied to the head during an impact. However, there has been no major well designed study of the on-field performance of padded headgear in rugby.

Head injury and head protection are important issues that concern rugby organisations, players, parents of junior players and national health bodies (6-14). As the majority of players appear to wear headgear in the belief that it will prevent injury, it is important to assess the effectiveness of headgear so players know what they can expect to gain by wearing it. In addition, there have been concerns raised that players wearing padded clothing or protective equipment may either play more recklessly or not execute rugby contact skills well, based on their perception that they are well protected (14).

This report describes a two year randomised controlled trial (RCT) of padded headgear in rugby union football. The study was funded in 2002 by the International Rugby Board following an application to the IRB from the investigators and a peer-review selection process managed by the IRB. The report is presented in six main sections: a literature review; description of the project methods; results of the randomised controlled trial; results of player surveys; results of analysis of game video; and a synthesis and discussion.

1.2 Literature Review

The research group at UNSW prepared a literature review on injury risks in rugby union football in 1998 which has been added to each year. The review was adapted for a report to the International Rugby Board (IRB), authored by Dr. Best and Dr. McIntosh, adapted for a report for the Victorian Smartplay Program in 2002 (15) and, most recently, revised for a report to the Australian Rugby Union and NSW Sporting Injuries Committee in 2004. A copy of the latter report was forwarded to the IRB in early 2004. This review has been revised and tailored for this report.

1.2.1 Definitions: What is an injury?

Reports of rugby and sports injury data have been published increasingly since the late 1970's. Significant variations exist with study designs, the definition of 'an injury' and the assessment of injury severity.

Definitions commonly used for a rugby 'injury' are described in table 1.1. The definition of 'injury' has substantial influence on the calculation of rates of injury. For example, if all game injuries are recorded, the number of 'injured' players will be greater than if injury is only recorded when a player misses training or game play due to the effects of the injury.

In addition to variations in the definition of injury, differences exist in study designs, cohort size and data presentation. Many rugby studies have used questionnaire formats, both prospective and retrospective. Others have presented data from prospective longitudinal studies, injuries that have occurred in a tournament or injury presentations to a medical facility. Similarly, cohort numbers and injury incidence have varied. These are summarised table 1.2. It is often difficult to compare directly reported rates of injury as the injury definition and/or sampling methods differ. It can be seen in table 1.2 that the overall rate of injury in rugby varies between 7 and 120 injuries per 1,000 player hours, i.e. 1,000 hours of athletic exposure. Even accounting for differences in age and level of competition, the difference in injury rates would not be expected to be so great if a standard injury definition had been used.

Author	Injury definition	Grading of severity
Seward et al (13)	Missed game or training or required specific medical treatment	None
Davidson (16)	Sought medical attention at venue or missed school, practice or a game	“Severe” or “minor” on clinical grounds
Gerrard et al (17)	Missed training; missed game	None
Hughes et al (18)	Unable to play or train or required ‘special medical treatment’	Minor ≤1 week Intermediate 1-3 weeks Serious > 3 weeks
Garraway et al (19)	Left the field or training and unable to continue	Transient < 7 days Mild <28days Moderate 29-84 days Severe >84 days
Bird et al (20)	Inability to train or play	Abbreviated Injury Scale
Jakoet et al (21)	Reported to match doctor	None
Targett (22)	Missed 2 training sessions, missed a game or required special medical treatment	Minor < 1 week Moderate 1-3 weeks Severe > 3 weeks
Carson et al (23)	Missed training or playing for > 24 hours or required medical care	Minor <1 week Moderate 1-3 weeks Major >3 weeks
Bathgate et al (24)	Left the field or missed subsequent game	Mild ≤ 1 week Moderate 2-3 weeks Severe >3 weeks
Rotem et al (25)	Sought medical attention at venue	None
Jones et al (26)	Injury treated at Hospital	None
Durie & Munroe (27)	Left the field or complained of discomfort at the end of a match	Minor < 1 week, Moderate 1-3 weeks Severe > 3 weeks
Best et al (28)	Left the field or missed subsequent game	Mild ≤ 1 week Moderate 2-3 weeks Severe >3 weeks

Table 1.1: Injury Definitions and Grading of Severity in Rugby Football

Author	Cohort Size	Injury no.	Injuries/ hours played
Seward et al (13)	27 Teams	243	53/1,000
Davidson (16)	Not given	1444 (116 severe)	18/1,000 (1.4/1,000 severe)
Hughes et al (18)	8 teams	122	48.8/1,000
Garraway et al (19)	1169	512	13.95 /1,000
Bird et al (20)	356	671	82/1,000 male 46/1,000 female
Jakoet et al (21)	416	70	30-43/1,000
Targett (22)	25	51	120/1,000
Carson et al (23)	40	35	7/1,000
Bathgate et al (24)	82	143	69/1,000
Rotem et al (25)	Not Given	2320	18.8/1,000
Durie & Munroe (27)	442	189	27.5/1,000

Table 1.2: Overall Injury Rates in Rugby Football

1.2.2 Review of Injury Data for Specific Groups

Demographic variations exist within available rugby injury data. It is helpful to review this as it affects injury patterns.

1.2.2.1 Males

The vast majority of rugby injury research has studied men's rugby (table 1.3). A number of trends were found:

- Injury rates were lower in recreational players
- Positional differences in injury rates existed, with back row forwards experiencing the highest rate of injury
- There was a high rate of injury recurrence or a previously injured player sustaining a second injury.

Author	Player or Team no.	Injury no.	injuries/1,000 hours played
Seward et al (13)	27 teams	243	53
Hughes et al (18)	8 teams	122	49
Garraway et al (19)	1169	512	14
Bird et al (20)	356	671	82
Jakoet et al (21)	416	70	30-43
Targett (22)	25	51	120
Bathgate et al (24)	82	143	69

Table 1.3: Injury Rates in Male Rugby Players

1.2.2.2 Schoolboy

There is a long history of rugby injury data collection on schoolboys. Davidson (16) collected data over an 18 year period (1969-1986) as the School Medical Officer controlling a casualty station for all Saturday Interschool rugby matches. During this period, 1,444 schoolboys attended the casualty station, with 116 suffering injuries considered to be “severe”. The results are presented in table 1.4. The injury rate was 17.7 per 1,000 hours of match exposure for all injuries, and 1.4 for severe injuries. Sparks (29 & 30) analysed data for an even longer period (1950-1979) at the Rugby School, and observed an injury rate of 19.8 injuries per 1,000 hours of match exposure, where an injury resulted in a missed game. This rate was similar to Durie and Munroe's (27) rate of 19.8 for "minor" injuries. However, other authors observed much lower rates of injuries resulting in loss of playing or training time. For example, Roux et al (31) observed a rate of 7 injuries per 1,000 hours, and Durie and Munroe's (27) rate of 6.5 for "moderate" injuries, i.e. those resulting in being unable to play for 1 to 3 weeks. No catastrophic head injuries were observed in the extended studies of Davidson (16) and Sparks (29,30)

Age (years)	Player hours	No. of injuries	Injury rate per 1,000 player hours
13 and under	8750	119	13.6
14 and 15	7675	141	18.4
16 and over	6410	164	25.6

Table 1.4: Injury rate by age-group, 1982-1986 (Schoolboys)

Davidson (16) noted that:

- Schoolboy injury rates were lower than senior rugby. This concurs with more recent studies (19, 20).
- The injury rate increased with age
- The injury rates increased with increasing grade with a rate of 9.5/1,000 hours for the E to H grades up to 24.4/1,000 hours for A and B grades.

Garraway et al (19) surveyed 204 under 16 schoolboy rugby players and observed an injury incidence rate of 3.4/1,000 player hours.

1.2.2.3 Senior Recreational

There is a wide variation in reported injury rates for senior recreational players; 8.7 to 109 injuries per 1,000 hours played. However, Seward et al (13) and Hughes et al (18) reported similar findings (48.8 and 53 / 1,000 player hours respectively). Table 1.5 summarises data for senior recreational players.

Author	Player no.	Injury no.	Injuries/ hours played	Injuries/player games
Seward et al (13)	6 teams	243	53/1,000	Not reported
Hughes et al (18)	8 teams	122	48.8/1,000	1/16.7 player games
Garraway et al (19)	965	488	8.7-18.4 /1,000	1/1.8

Table 1.5: Injury Rates in Senior Male Recreational Rugby

1.2.2.4 Positional Differences

Injury patterns have been correlated with player position. The results are presented in table 1.6. Overall, forwards were injured more frequently than backs. When the figure is corrected for multiple player positions, the trend is unchanged, apart from the schoolboy and female groups. In senior male rugby there is an overwhelming predominance of injuries to second row and back row forwards.

Author	Props	Hooker	Locks	Back row	Halves	Centres	Wings	Full back
Seward et al (13)	9	7	6	1	3&8	2	10	4
Davidson (16)	8	2	7	4	3	5	6	1
Hughes et al (18)	7	6	5	1	4	2	8	3
Bird et al (20)	5	4	1	6	2	3	8	7
Jakoet et al (21)	5	3	3	1	2	4	4	5
Targett (22)	6	5	3	1	7	4	8	2
Bathgate et al (24)	5	2	1	4	7	2	8	6
Durie & Munroe (27)	4	8	5	1	3	2	6	7

Table 1.6: Ranking of Total Injuries per Position

1.2.3 Review of Injury Severity and Sites

1.2.3.1 Injury Severity

A review of the recent literature confirms that most rugby injuries are classified as mild/minor, moderate or severe. Mild/minor injuries account for over half of all injuries reported (table 1.7). The majority of studies have used similar classifications of injury severity, defining the return to play time for mild, moderate and severe injuries as less than one week, between one and three weeks, and more than three weeks respectively. There are some differences in the definition of injury severity between studies and a comparison of injury severity/grading definitions has been included in table 1.1.

Author	Mild/ minor	Moderate/ intermediate	Severe/ major
Davidson (16)	Not reported		0.1/100p-games 14/1,0000 p-hrs
Hughes et al (18)	58.7%	28.6%	12.8%
Garraway et al (19)	38% (+ 22% transient)	16%	16%
Bird et al (20)	76.7%	22.8%	0.5%
Jakoet et al (21)	Not reported		40%
Targett (22)	69.3%	12.8%	17.9%
Carson et al (23)	42.8%	20%	37.2%
Bathgate et al (24)	64%	14%	22%
Durie & Munroe (27)	74%	22%	4%
Average	63.5%	19.5%	17%

Table 1.7 : Grading of Injury Severity. Each injury grade is expressed as a percent of all injuries in the cohort.

1.2.3.2 Injured Body Region

Excluding schoolboy rugby, the lower limb is the most injured site in rugby football. The findings in schoolboy and women's rugby show a higher incidence of injuries to the head and face, including concussion. These are summarised in table 1.8.

1.2.3.2.1 The Head and Face

Most studies report that injuries to the head and face account for between 14 and 26.5% of all injuries in rugby football. Of injuries to the head and face 60-80% are lacerations to the face or scalp. 12-22% of tackle injuries affect the head or face. The proportion of concussion as a total of all injuries has been reported to be between 5 and 15%. Davidson (16) and Sparks (29) did not report any catastrophic head injuries in their landmark studies in schoolboy rugby.

Author	Head & face	Upper limb	Lower limb	Trunk	Concussion (as % total injuries)	Recurrences
Seward et al (13)	25.4	20.3	34.3	NA	5.3	20 – 52
Davidson (16)	NA	27.5	26.2	NA	14.9	NA
Gerrard (17)	14	18	40	15	5	42
Hughes et al (18)	17.3	17.3	48.1	19.2	3.6	15
Garraway et al (19)	16.5	20.9	40	14	4.9	NA
Bird et al (20)	18	24	42.5	14.3	4.5	NA
Jakoet et al (21)	23	29	42	3	3	NA
Targett (22)	26.5	20.4	40.8	10	10	4
Carson et al (23)	14.0	22.9	45.7	17.0	11.4	NA
Bathgate et al (24)	28.7	15.4	51.7	4.2	4.9	NA
Durie & Munroe (27)	9.6	27.4	45.2	10.4	2.2	NA
Marshall et al (32)	25.7	22.4	40	11.8	4.5	NA
Average	21%	22%	41%	12%	7%	

Table 1.8: Injury Sites (% Total injuries).
Where possible concussion has been separated from the head and face category.

1.2.3.2.2 The Upper Limbs

The majority of studies report a range of 18 – 29 % of injuries occurring to the upper limb. Interestingly, the highest rate occurred at the most elite level, to international rugby players at the 1995 Rugby World Cup (21). There is little specific information on the mixture of upper limb injuries. Generally the vast majority of injuries are contusions, strains or sprains. Bird et al (20) reported the shoulder was the location of 10% of total injuries, with 14% of tackle injuries affecting the shoulder.

Hughes et al (18) reported a high recurrence rate of shoulder injuries. They suggested that the recurrence was due to under treated glenohumeral joint (GHJ) instability and rotator cuff tendinopathies. Seward et al (13) found a 3.3% rate of acromio-clavicular joint (ACJ) sprains and 13.2% rate of GHJ dislocation. A study of 105 first class British rugby players revealed that 45% of players gave a history of some form of shoulder joint injury, with the most common mechanism being a fall onto the tip of the shoulder (57%). Average time out of the sport was 4 weeks, with only one player requiring surgery (33).

1.2.3.2.3 The Lower Limbs

In senior rugby, lower limb injuries comprise 34-48% of all injuries. The majority of these injuries involve the knee or ankle. Seward et al (13) reported comparable rates of knee medial ligament strains and ankle lateral ligament strains in rugby union to be similar to rugby league and Australian Football cohorts, whereas thigh haematomas were significantly less common. Anterior Cruciate Ligament (ACL) injuries have been reported at 17% in men, twice the rate of a similar rugby league cohort (3). Wiley (34) observed that of elite rugby players in the 1999 Rugby World Cup one in 12.5 athletes (8%) had suffered an ACL injury during their careers. Twenty athletes in fact competed with ACL deficient knees.

1.2.3.2.4 The Spine

Even though the overall rate of spinal cord injury (SCI) in rugby is low, there is a distinct SCI risk in rugby unlike many other organised sports (35 to 44). This injury is associated primarily with the tackle and scrum (35 to 44). In a recent review of SCI in Australia between 1986 and 1996 (35), only six of the 31 SCI cases occurred in schoolboy rugby, with an annual incidence for schoolboys of 1.7 compared to 4.8 per million adult players for this period. The rate of SCI was 10 to 12 fold greater with adult players than schoolboys (38), an observation supported by Armour et al (43). However, reliable exposure data were not available. Injury rates were greater for forwards than backs and occurred in the tackle and scrum.

In the USA during the period 1970-1996, 36 of the 62 cervical spine injuries in rugby occurred in the scrum, including 14 junior players (36, 37). Considering the whole population there was a significantly higher risk of SCI on scrum engagement compared with scrum collapse. Scrum-related SCI affected the front row with the hooker, one out of 15 players, suffering 30% of SCI (40). Noakes et al (42) reported that there had been a 46% reduction in the number of SCIs in schoolboys during the period 1990-1997 in comparison to the period 1963 to 1989. The authors postulated that this reduction was due to fewer injuries from high tackles, i.e. above the shoulders, rather than effects of the modified scrum laws that commenced in 1990 to prevent scrum engagement related SCI.

1.2.4 Injuries and Phases of Play

The association between injury and phase of play has been observed by a number of researchers. These data are summarised in table 1.9. Tackling accounts for most injuries in rugby. This is a consistent finding in the literature which reports tackling to be the cause of 33-56 % of all injuries (18,19,39,45,46,47,48,49). Wilson et al (45) studied 188 tackle injury events finding the most injured sites being the head/neck/face (22%) and the knee (17%). The ball carrier and tackler were equally injured. Although they comprise 23-29% of total injuries there is no detailed research on injuries related to the ruck and maul. Injuries from the scrum comprise 1-8% of total injuries.

Author	Tackle	Ruck/ Maul	Scrum	Lineout	Running	Foul Play	Game/ Practice
Hughes et al (18)	50.4	22.6	5.3	1.5	NA	NA	1/742hr
Garraway et al (19)	49	17	8	12	14	NA	NA
Bird et al (20)	40	29	7	NA	9	13	8 / 3
Jakoet et al (21)	56	23	1	0	11	9	NA
Bathgate et al (24)	58	15	2	0	20	4	NA
Durie & Munroe (27)	40.5	31.5	13.7	8.3	6	NA	7 / 3

Table 1.9: Injuries according to phase of play (% total injuries)

1.3 Head Injury in Rugby

Head injuries in rugby include superficial head injury, lacerations, abrasions and contusions, and concussion. As described in this chapter, the proportion of head injury has been reported to be between 14 and 26% of all injuries, with concussion accounting for 5 to 15% of all rugby injuries. Therefore, the prevention of head injury is an important area of injury research and risk management.

The risk of catastrophic head injury is very low. Personal communication with the Insitute of Forensic Medicine in Sydney indicates that there have been no deaths in youth rugby in Sydney due to head injury in the period available on their electronic database, ie. since 1994. Unfortunately, hospital admission databases in New South Wales have not yet yielded reliable information on admissions due to head injury in rugby, as the football codes are not separated in the data coding system. Therefore, cases from rugby union, league, Australian football and soccer are mixed together.

1.4 Padded Headgear

The following is a brief summary of the research and opinion regarding padded headgear and helmets at the commencement of the study.

- Well designed headgear has the potential to reduce the risk of contusions, lacerations and concussion.
- The available biomechanical and descriptive data showed that head impacts resulting in concussion were likely to occur in the temporoparietal region, due to the style of rugby and the sensitivity of the head to impacts at this site.
- Biomechanical studies of concussion in senior football showed that the impacts resulting in concussion had on average an impact energy in the range 50-60 J. These impacts were more severe impacts than those reflected in the IRB's test method for padded headgear.
- Laboratory and field studies showed that headgear designed to the IRB's requirements is unlikely to reduce the risk of concussion.
- There was no evidence that shows that headgear is hazardous to other players.
- The test method described in Law 4 for headgear placed restrictions on foam thickness and density that limited the ability of manufacturers to produce headgear that exhibited good impact energy attenuation properties.
- Tests on foams suitable for the production of headgear showed that increasing the thickness to between 12 and 15 mm, and increasing the density to 65 kg/m^3 improved greatly the impact energy attenuation performance.
- The IRB test method for padded headgear was contrary to other international standards for impact energy attenuation in which the pass/fail criterion of force or acceleration was a value which could not be exceeded. In Law 4M, the test method stated that acceleration should be between 200 and 550 g. In contrast international helmet standards set a pass/fail criterion of a maximum value, eg. 250 to 300 g., that could not be exceeded. It is also important to note that these standards had, and still have, tests of much higher energy compared to law 4M.

1.5 Project Aims

The study measured the effectiveness of headgear in the prevention of head injuries in football players. The main aims of the study were to:

1) Examine methods for reducing the incidence of concussion;
2) Monitor the occurrence of head and neck injuries in school age and club level football;
3) Study the biomechanics of head and neck injury in rugby related to player technique, phases of play, and headgear;
4) Assess the effectiveness of headgear in the prevention of head and neck injuries;
5) Examine changes in player attitudes and behaviours towards protective headgear during the 2002 and 2003 seasons;
6) Examine the effects of protective headgear on the behaviour of players, eg. reckless play;
7) Improve the design and safety performance of headgear, based upon the RCT outcomes, within the constraints of the game of rugby; and,
8) Provide an evidence-base for the promotion of protective equipment use amongst football players.

This report addresses the effectiveness of headgear in reducing head injury and concussion, players' attitudes and behaviours with regards to headgear, general injury trends in the cohort studied, and identify injury risk factors.

CHAPTER 2

METHODS

2.1 Study Design

The incidence of head and neck injuries and the protective function of headgear were assessed in school and colts club rugby union football using a three-arm randomised controlled trial (RCT) design. The primary focus was the effectiveness of headgear on head injury. The study arms were:

a. Control – player's usual practice
b. Headgear – standard IRB approved model
c. Headgear – modified model

Sampling units were teams of rugby players. For ease of data collection and in anticipation that players would migrate between A and B grades, or 1st to 4th grades, the teams in an age group were randomised together at each school or club. Randomisation did not occur for each individual player.

Players in groups B and C were provided with headgear. In the control group due to ethical considerations players were free to wear headgear or not, as was their usual practice. Even though each team was provided with headgear, as per the randomisation, players could choose to wear the headgear or not. Due to ethical reasons teams were provided with encouragement, but no incentives to wear headgear. Therefore, some players in the modified headgear arm continued to wear no headgear, and those in the control group might have worn standard headgear. Headgear wearing was monitored at each game in all arms of the study.

The study period was the 2002 and 2003 rugby seasons in Sydney, Australia.

2.2 Ethics

Approval for this study was granted by the Committee on Experimental Procedures Involving Human Subjects at UNSW in 1999 (Project Title: A study of head protection in sports related head injury, CEPIHS No. 99085). The approval letter is attached in appendix A.

2.3 Sample

The sample comprised teams from under 13, 15, 18 (school open) and 21 (colts) participating in competitive rugby in the Sydney Metropolitan Area. Prior to the commencement of the study an invitation letter was sent jointly by the Australian Rugby Union and UNSW to schools and clubs. The letter was followed up by phone calls and meetings with school or club representatives. Once agreement was reached on each club or schools level of involvement, individual teams were contacted through their coaches. Teams were not provided with any incentives to participate and recruitment occurred prior

to randomisation of teams into each study arm. A list of all the Schools and clubs is provided in appendix B.

2.4 Headgear

As a substantial quantity of headgear was required for the study, negotiations with headgear manufacturers commenced in September 2001. A decision was made to engage Body Armour, a New Zealand based company and manufacturer of Canterbury branded headgear, to supply the IRB approved and modified headgear models (figure 2.1). The Honeycomb model was chosen as changes to the foam dimensions could be most easily incorporated, without changing fit and comfort, and without requiring major retooling. Headgear design modifications were based on foam testing undertaken in 2001. The modified headgear was formed using 16 mm thick 60 kg/m^3 polyethylene (PE) foam compared to the standard model of 10 mm thick 45 kg/m^3 foam. Laboratory testing of the modified headgear demonstrated that it offered superior impact energy attenuation performance compared to the standard model, however, the performance did not necessarily extend to providing sufficient protection against the concussive impacts that the authors had observed in previous research (4) in first grade and elite rugby union, rugby league and Australian football.

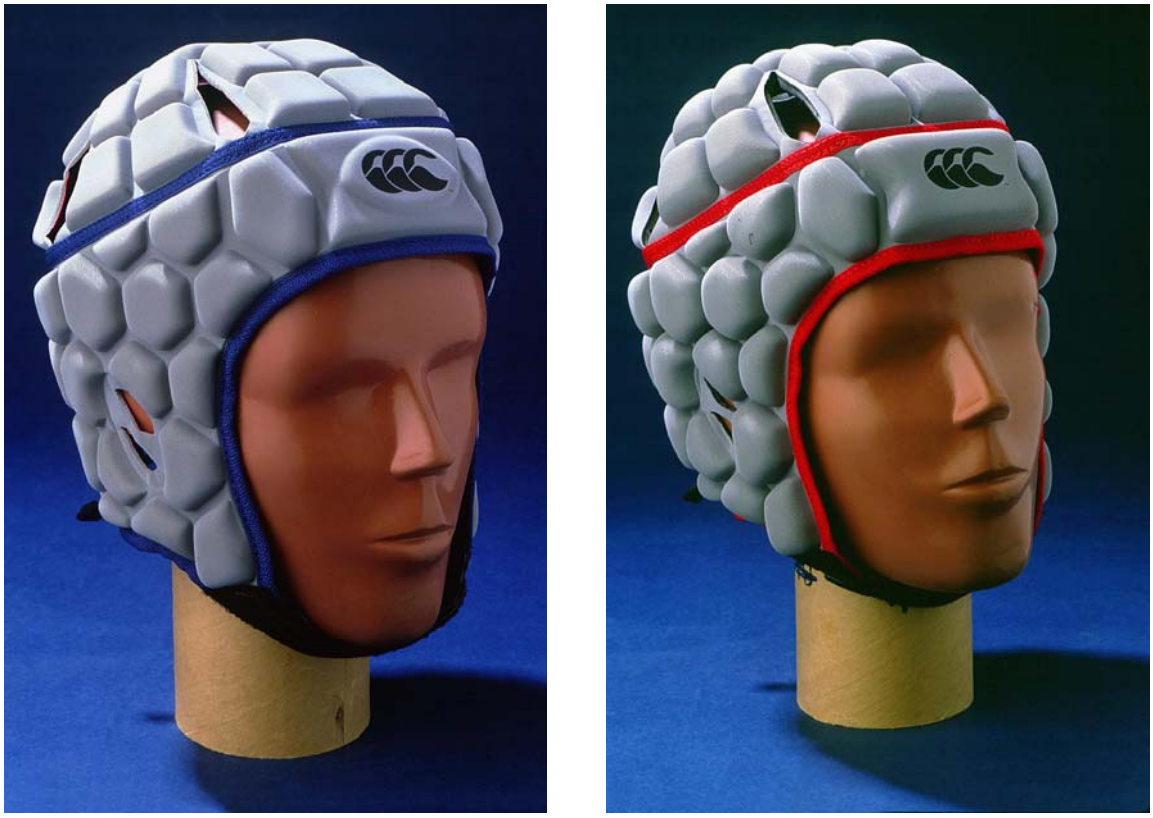


Figure 2.1: Honeycomb headgear standard (left) and modified (right)

		Maximum headform acceleration (g)		
		McIntosh & McCrory (3)	Canterbury brand Honeycomb Headgear by Body Armour	
Impact location	Drop Height (m)	Average of rugby union models	Standard (10mm thick)	Modified (16mm thick)
Lateral	0.3	336	276 (399)	69 (91)
	0.4	449	494 ----	110 (165)
	0.5	----	----	387 (520)
	0.6	----	----	516 (623)
Centre Front	0.3	----	689 (714)	123 (191)
	0.4	----	----	273 (436)

Table 2.1 Headgear laboratory test results from (50). Note: ---- denotes no data reported as tests ceased due to large headform accelerations.

The results presented in table 2.1 show that the average of the headform acceleration maxima for the modified Honeycomb headgear as a percent of the standard headgear was 23% and 33% for the lateral impacts 0.3 and 0.4 m drop heights, respectively, and 27% for the centre front 0.3 m drop tests. A t-test demonstrated significant differences at $p=0.005$ between the standard and modified Honeycomb headgear. There was a gradual decrease in impact energy attenuation with repeat impacts to the same site. Centre front impacts resulted in higher headform accelerations than lateral impacts. Centre front impacts were ceased at 0.4 metres due to the large headform accelerations. The results showed that by increasing the thickness and density of the foam incorporated into the headgear, significant improvements in the headgear performance were achieved. However, the headgear did not provide protection for the more severe head impact that the authors considered might occur during senior rugby.

2.5 Participation and Injury Data Collection

Player game participation, headgear use and all injuries were recorded using standard methods by Primary Data Recorders (PDR). The PDRs were recruited from clubs, the University of Sydney and UNSW. Most recorders were enrolled in undergraduate sport and exercise science, physiotherapy or medical programs. Training sessions were held each year at which the majority of recorders attended. Ad hoc training was given to those who could not attend the formal sessions. Recorders were paid per game recorded and provided with a travel allowance.

Injuries to all body regions were recorded, with the possibility of providing detailed information on head injuries. The forms were designed to be completed without graduate level medical or allied health knowledge or diagnostic skills. Where possible specific diagnoses were recorded as per the Australian Sports Injury Data Dictionary.

Concussion was defined using the inclusive definition agreed to at the First International Conference on Concussion in Sport in Vienna 2001 (51). The following is an extract from the summary statement:

*"**Concussion** is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathological, and biomechanical injury constructs that may be used in defining the nature of a concussive head injury include:*

1. ***Concussion** may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an "impulsive" force transmitted to the head.*
2. ***Concussion** typically results in the rapid onset of short lived impairment of neurological function that resolves spontaneously.*
3. ***Concussion** may result in neuropathological changes but the acute clinical symptoms largely reflect a functional disturbance rather than structural injury.*
4. ***Concussion** results in a graded set of clinical syndromes that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course.*
5. ***Concussion** is typically associated with grossly normal structural neuroimaging studies."*

The following set of signs and symptoms were extracted from the Vienna statement and identified as being typical of concussion (table 2.2). The italicised signs and symptoms indicate those specifically recorded in the rugby headgear study. Concussion typically involved a direct head impact (observed or reported by the player), combined with observation of one or more of the following signs and symptoms.

(a) Cognitive features	(b) Typical symptoms	(c) Physical signs
Unaware of period, opposition, score of game	*Headache*	*Loss of consciousness/impaired conscious state*
Confusion	*Dizziness*	Poor coordination or balance
Amnesia	*Nausea*	*Concussive convulsion/impact seizure*
Loss of consciousness	Unsteadiness/loss of balance	Gait unsteadiness/loss of balance
Unaware of time, date, place	Feeling "dinged" or stunned or "dazed"	Slow to answer questions or follow directions
	"Having my bell rung"	Easily distracted, poor concentration
	Seeing stars or flashing lights	Displaying unusual or inappropriate emotions, such as laughing or crying
	Ringing in the ears	*Nausea/vomiting*
	Double vision	Vacant stare/glassy eyed
		Slurred speech
		Personality changes
		Inappropriate playing behavior—for example, running in the wrong direction
		Appreciably decreased playing ability

Table 2.2: Symptoms and features of concussion

Each week the game schedule for the team cohort was assembled and recorders were allocated to each team. This was a very laborious task, as game time and location were often not finalised until the Friday before the Saturday game. Most recorders stayed with the same teams throughout the study. The recorders attended each game and, with the assistance of team staff, recorded the names of participants, headgear use and injury data, as well as training attendance. The recording forms are attached in appendix C. The recording of compliance data, ie. actual wearing of a specific type of headgear by a player in a game, was completed at all games in the study, including control teams.

Data were recorded during the 2003 season in an Access database and in 2002 in Excel. Reviews of player participation were executed to identify missing players. When players missed games, the coaching or team medical staff were approached to obtain a reason for the player's absence. In those cases where the player was absent due to injury, more accurate medical data pertinent to the injury were obtained from treating medical staff whenever possible. Otherwise, the reasons for absence were recorded, eg. sick, on holidays, or relegated to lower grade.

2.6 Attitude Surveys

Questionnaire surveys were conducted on a sub-set of the participating teams. The surveys are provided in appendix D. Basic demographic data, rugby playing experience, injury experiences, protective/padded clothing use, and attitudes were collected. The surveys were based on previous work of the investigators in rugby (14) and other sports, including Australian football and squash.

Two pairs of research assistants visited teams pre-season, and in the case of colts teams, early season, to conduct surveys of attitudes and to measure height and mass.

In the second year of the project the attitude survey was altered slightly. The modified questionnaire minimised the time required to complete the form and eliminated questions that were considered to be extraneous.

Surveys were repeated at the end of each season. An insert to the standard questionnaire pertaining to the modified headgear was included for those who had worn it during the season. Unfortunately, it was not possible to sample as many players at the end of the season as pre-season. Further, it was not possible to match well the players surveyed pre- and end of season.

2.7 Video Analysis

About 50 games per season were videotaped with the aim to record an equal number of games per study arm and age group. Each video was initially reviewed to assess injury events. After some preliminary analyses, a database was prepared to standardise the event analyses. All injury events were reviewed and, in a second review, a count of all phases of play in each game was made, in addition to a revision of the injury events and near misses. An injury event was defined as an event resulting in an injury as recorded in the injury database. Near misses were defined as events that appeared to have the potential to result in injury. Video of all injury events were copied onto a PC, and examples of good technique and poor technique were also recorded. The counting of phases of play was undertaken primarily to assess whether or not the rate of injuries in tackles was related to the tackle, the larger proportion of tackles in a game compare to set plays, for example, or both. Consideration was given to player behaviour and the role of headgear in reckless play or poor technique.

2.8 Data Analysis and Statistical Methods

All data were entered into a Microsoft Access database. At the end of each season, the data were reviewed and cleaned. For example, multiple entries might have been made for one player under slightly differently spelt surnames. The data were de-identified and exported to Excel to be sent to Dr. Rory Wolfe at Monash University. Dr. Wolfe is a consultant biostatistician and had worked closely with Professor Finch. Dr. Wolfe undertook all statistical analyses under advice from the investigators. The data were then returned to UNSW. Statistical analyses were performed using the STATA software package. Incidence Rate Ratios (IRR) were analysed using Poisson regression with robust standard errors calculated to allow for randomisation by team

Injury rates were calculated as number of injuries divided by time exposed during games. These rates were expressed as number of injuries per 1,000 person-hours of playing time. To compare injury rates between randomization groups, i.e. intention to treat analysis, rate ratios were obtained from Poisson regression models that had number of injuries as the outcome variable and exposure time as a log-offset term and group membership as a covariate in the linear predictor part of the model. Mulitvariate analyses employed the same method but with additional covariates, i.e. the potential confounders, being entered into the linear predictor. These Poisson regression models were fitted to a data set of individual units of exposure, i.e. each game for each player, which allowed the incorporation of time-varying risk factors, e.g. climate conditions, into the analysis. Standard errors were calculated using the information sandwich formula to account for clustering of players in the teams or squads that were used as the units of randomisation to study arm.

All analyses were undertaken using Stata software (52) and the term statistically significant was used to describe a comparison that has an associated p-value < 0.05.

Pre and end of season data for 2002 and 2003 were treated separately and also combined. Where possible, comparison of an individual's experience throughout a season were assessed using each player's unique code. However, there was a discrepancy between those players that completed the pre-season and end of season surveys.

The video analysis data were collated into an Access database. Descriptive analyses were performed at UNSW.

2.9 Project Management

The project was directed by Dr. Andrew McIntosh and run from the School of Safety Science, UNSW. Regular research team meetings were held at UNSW with UNSW staff. Project activity sheets were developed to manage research staff operations and to provide goals and milestones. Communication was maintained with the investigators: Dr. Paul McCrory, Professor Caroline Finch, Dr. John Best and Associate Professor David Chalmers. Meetings with all investigators, except Associate Professor Chalmers, were held in Sydney and Melbourne during 2002 and 2003. Associate Professor Chalmers lives in New Zealand and was unfortunately not able to visit Sydney during 2002, but discussions were held in 2003 in person.

Ms. Maria Romiti and Mr. Cameron French were full time research assistants on the project. Mr. Trevor Savage commenced as a PDR in 2002 and has since taken on a valued role in assisting with data collection, analysis and in the preparation of reports. They were supported by casual staff, including the PDRs. In particular, Ms. Dara Twomey and Mr. Alex Nicholson, both UNSW students, provided very good casual support over the 2 years of the study. Ms. Rachel Ward developed the database for the study.

CHAPTER 3

RESULTS - INJURY, PARTICIPATION AND HEADGEAR EFFECTS

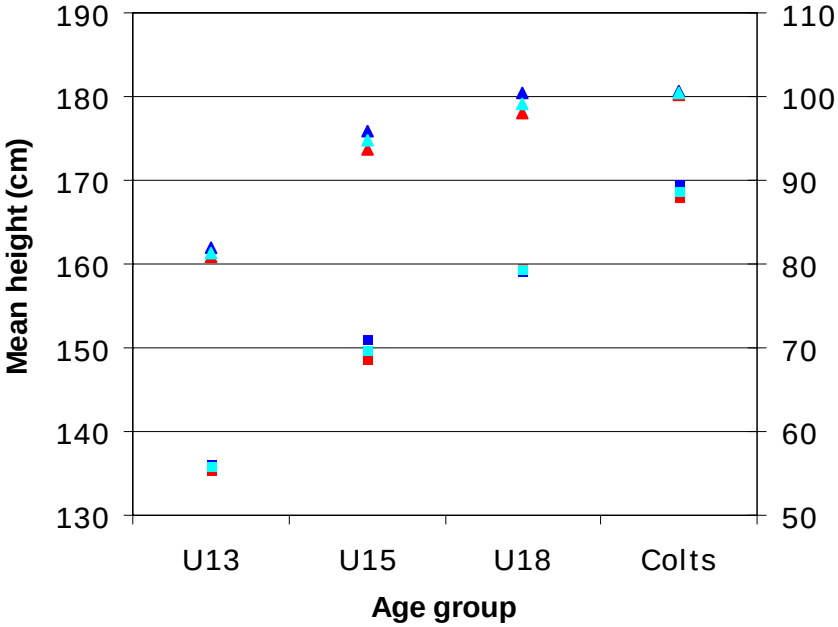
3.1 The Cohort

Participants were recruited in 2002 and 2003 according to the protocol described in chapter 2. Eighty teams participated in each year of the study. There were 1976 and 1955 players that participated in at least one game during the study period, for 2002 and 2003 respectively. Table 3.1 provides anthropometric data derived from the pre-season surveys in 2002 and 2003 combined. Descriptive statistics for height, weight and age for 2002, 2003 and both years combined are presented in figure 3.1. It can be seen that the sample, in terms of player anthropometry was fairly similar in each year of the study, even though the sample was in general different each year.

Age Group		Height (cm)	Weight (kg)	Age (yrs)
U13's	n	299	273	230
	Max	188.0	83.0	NA
	Min	123.0	33.0	NA
	mean	161.4	55.8	13.0
	SD	8.3	11.4	0.3
U15's	n	315	289	280
	Max	195.0	103.0	NA
	Min	155.0	45.0	NA
	mean	174.8	69.9	15.0
	SD	6.9	10.9	0.4
U18's	n	344	344	257
	Max	197.0	124.0	NA
	Min	160.0	53.0	NA
	mean	179.2	79.3	17.4
	SD	6.9	11.8	0.3
Colts	n	451	453	420
	Max	204.0	180.0	NA
	Min	160.0	60.0	NA
	mean	180.5	88.8	19.1
	SD	7.2	15.4	0.9

Table 3.1: Distribution of age, body mass and heights by age group for 2002 and 2003 combined.

Age distributions were as expected as the team cohort classifications were aged based. Mean height increased from 161 cm for U13 to 179 cm for U18 and remained similar at 180 cm for colts (figure 3.1). Mean body mass increased between each age group by about 10 kg., from 56 kg. for U13s to 89 kg. for colts. Amongst these age groups were some very large players, with a 15 year old being measured at 103 kg and one 180 kg player in the colts.



3.2 Participation and Exposure

Tables 3.2 and 3.3 present a detailed description of the number of game participations for each team during 2002 and 2003, respectively. The team ID code indicates whether the team was U13, U15, U18 or U21 through the last two digits. The group columns indicate the study arm to which the team was randomised, not the actual headgear wearing rates. In a few teams the 1st and 2nd 15s combined, and 3rds and below combined were randomised separately.

The average number of games per team per year was twelve, however this varied depending on age group and success in the competition. The number of person games recorded was 15,378 for 2002 and 20,430 for 2003. The recorded game participation per person ranged from 1 game to a median of 9 games for 389 participants, and up to 25 games for 59 participants. The total number of player game participations with complete compliance information was 30,316 and 31,899 with specific game time information. In this study *compliance* refers to headgear use measured by PDRs on individual players at each game. For example, in some case headgear use was not recorded and in other cases the exact game time for a player's participation was not recorded.

	Study Arm		
Team ID	**Control**	**Modified**	**IRB**
BAR13	0	242	0
BAR15	325	0	0
BAR18	365	0	0
CRA13	0	0	289
CRA15	0	331	0
CRA18	413	0	0
EAS21	0	0	1306
GOR21	581	0	0
GRA13	332	0	0
GRA15	0	0	378
GRA18	0	393	0
HUR13	67	0	0
HUR15	89	0	0
HUR18	96	0	0
KNO13	333	0	0
KNO15	369	0	0
OAK18	0	0	792
PAR21	0	1288	0
RIV13	0	378	0
RIV15	0	342	0
RIV18	166	402	0
SBH18	68	0	0
SCO13	0	0	330
SCO15	356	0	0
SCO18	0	420	0
SHO15	0	0	330
SJC13	322	0	0
SJC15	0	0	317
SJC18	164	0	390
SOU21	1073	0	0
WAV13	0	347	0
WAV15	0	280	0
WAV18	130	318	0
WES21	0	1256	0
Sub-Total	5249	5997	4132
Total = 15378			

Table 3.2: Total number of recorded participations in rugby games for season 2002 by randomisation group

Team ID	Control	Modified	IRB
BAR13	0	333	0
BAR15	0	370	0
BAR18	319	0	350
CRA13	0	378	0
CRA15	0	0	300
CRA18	641	0	0
EAS21	0	1606	0
ESU21	0	0	1618
GOR21	738	0	0
GRA13	391	0	0
GRA15	0	296	0
GRA18	0	390	0
KNO13	330	0	0
KNO15	0	0	357
PAR21	0	525	0
RAN21	1656	0	0
RIV13	0	0	343
RIV15	0	376	0
RIV18	640	0	0
SBH13	0	361	0
SBH15	290	0	0
SBH18	0	279	0
SCO13	0	0	399
SCO18	0	630	0
SHO15	0	0	414
SJC13	361	0	0
SJC15	328	0	0
SJC18	353	0	354
SOU21	0	1572	0
WAV13	0	0	384
WAV15	369	0	0
WAV18	433	0	433
WES21	0	0	1513
Sub-Total	6849	7116	6465
Total = 20430			

Table 3.3: Total number of recorded participations in rugby games for season 2003 by randomisation group.

Table 3.4 presents the breakdown of player-game exposures. It compares the study arm to which teams were randomised with the actual compliance (measured headgear wearing patterns) for that arm. For example, the table shows that while 36% of the player-game exposures were for players randomised to the modified headgear arm of the study, only 11% of the total game exposures were for players observed wearing the modified headgear. In contrast, 29% of player-game exposures were in the IRB approved headgear arm, and in 46% of exposures IRB headgear was observed to be worn. The data confirm that players were free to wear headgear as they decided after they had been allocated to a study arm and provided with headgear. The observed IRB headgear included the honeycomb headgear allocated to the players, and all other headgear worn. A check of the headgear typically worn by players revealed that it was IRB approved, and the honeycomb model was popular in the study cohort. The reasons for the low wearing of the modified headgear are reported in the next chapter, but players provided informal feedback that the headgear was too stiff and therefore uncomfortable. Players were encouraged to wash the headgear and wear it at training to improve comfort. Some players in the control and IRB groups wore the modified headgear. Some players participated in both 2002 and 2003, but in different study arms. The PDRs were told that headgear was often recycled in a family or between friends. A few players in the Sydney grade competition were also observed to wear the modified headgear in 2003.

Study Arm	**Headgear Wearing Behaviours**			**Totals (%)**
	IRB	**Modified**	**None**	
Control	5191	110	5072	10373
	50.0%	1.1%	48.9%	(34%)
Modified	3684	2803	4538	11025
	33.4%	25.4%	41.2%	(36%)
IRB	4986	355	3577	8918
	55.9%	4.0%	40.1%	(29%)
Totals	13861 (45.7%)	3268 (10.8%)	13187 (43.5%)	30316 (100%)

Table 3.4: Profile of player-game exposures by headgear worn (compliance) and study arm allocation. 2002 and 2003 data have been combined.

Player Position	Freq.	Percent
Front Row	6922	19.3
Back Five	12078	33.7
Halves	4705	13.1
Inside Backs	4936	13.8
Outside Backs	7025	19.6
Not Recorded	142	0.4
Total	35808	100.00

Table 3.5: Profile of player-game exposures by player position (2002 and 2003 data combined).

In table 3.5 player game exposures are presented divided into player position categories. The relative frequencies reflect closely the number of players in a team in each of these categories: front row = 3 players (20% of team), back five = 5 players (33% of team), halves = 2 players (13% of team), inside backs = 2 players, and, outside backs = 3 players. Therefore, the study cohort was well balanced regarding player position and exposure.

Table 3.6 provides a breakdown of player-game exposures according to age group and team grade (1st 15 or A grade team to 4th 15 or D grade team). There was a bias toward the U21 age group, as these players often played at least twice the number of games per season as the school age players. This occurred because the original allocation of teams made to each study arm was based on the aim of obtaining an equal division of players, not game exposures. The majority of teams were in the first or second grade team for that age group.

Grade	Colts (U21)	Opens (U18)	U15	U13	Total
First grade	3902	2636	3202	2988	12728 (36%)
Second grade	4028	2494	3015	2887	12424 (35%)
Third grade	3417	2064	0	45	5526 (15%)
4th/5th grade	3385	1745	0	0	5130 (14%)
Total	14732 (41%)	8939 (25%)	6217 (17%)	5920 (17%)	35808

Table 3.6: Profile of player-game exposures by age group and grade (2002 and 2003 data combined). Note – only 79 5th grade exposures, all from school open level.

3.3 Injury Patterns and Rates

In section 3.3 the basic descriptive statistical results, including injury patterns and rates, are presented. Statistical analyses of factors contributing to injury rates are presented later in the report.

3.3.1 Injury Patterns for all Participants Combined

There was a total of 1,841 injuries experienced by 1,159 players recorded in the study. This included injuries that were reported at the game and those leading to missed games. Six hundred and four injuries resulting in a player missing at least one game the following weekend were experienced by 585 players. Therefore, about one third of game injuries resulted in a player missing at least one game of rugby.

Tables 3.7 to 3.9 present the injury profiles for body region, nature and injury event for the total study, without division by age or headgear use. The head, face, shoulder, knee and ankle were the regions most often injured. Twenty-five percent of all injuries were to the head and face. Thirty-seven percent of injuries were sprains or strains, 13% superficial, 11% concussion and 4% fractures. Body contact was involved in the majority of injuries with the tackle contributing to 43% of all injuries. Therefore, the overall injury patterns were similar to those reported in the studies reviewed in chapter 1.

Injury Region	Frequency	Percent
Shoulder	242	13.2
Head	234	12.7
Face	223	12.1
Knee	178	9.7
Ankle	166	9.0
Thigh	137	7.4
Neck	96	5.2
Hand/fingers	85	4.6
Thorax	83	4.5
Lower leg	62	3.4
Lower back	43	2.3
Wrist	27	1.5
Pelvis	23	1.3
Elbow	23	1.3
Upper arm	16	0.9
Forearm	17	0.9
Foot/toes	17	0.9
Hip	13	0.7
Abdomen	11	0.6
Not specified	145	7.9
Total	1841	100.0

Table 3.7: Region of injury (2002 and 2003 data combined). The table includes injuries recorded at the game and those resulting in missed games.

Nature of Injury	Frequency	Percent
Sprain/strain	683	37.1
Superficial	240	13.0
Intracranial (concussion)	199	10.8
Blood Nose	104	5.7
Open wound	105	5.7
Muscle/tendon	88	4.8
Fracture	72	3.9
Symptoms	41	2.2
Dislocation	39	2.1
Solarplexus contusion	20	1.1
Eye	14	0.8
Overuse injury	14	0.8
Undiagnosed rib trauma	12	0.7
Nerve injury	7	0.4
Dental	1	0.1
Respiratory dysfunction	2	0.1
Other/unspecified	200	10.9
Total	1841	100.0

Table 3.8: Nature of injury (2002 and 2003 data combined). The table includes injuries recorded at the game and those resulting in missed games.

Seventy-five percent (75%) of participants concussed during a game left the field of play and did not return to play that game. The remaining 25% of concussed players received on-field attention and completed the game. No concussed player lost consciousness for longer than 5 minutes and only 20% of players lost consciousness. Almost 50% of concussed players suffered from headaches or dizziness and 22% had limited post traumatic amnesia. Six percent of the concussion cases were sent to hospital from the game.

Injury Event	Frequency	Percent
Being tackled	453	24.5
Tackling another player	352	19.0
Struck by another (attacking situation)	134	7.2
Struck by another (defensive situation)	89	4.8
Collision with other player/referee	80	4.3
Scrum collapse or scrum contact	56	3.0
Overuse	55	3.0
Overexertion (eg. Muscle tear)	49	2.6
Fall/stumble on same level	40	2.2
Rucking	40	2.2
Twisting to pass or accelerate	33	1.8
Slip/trip	17	0.9
Landing from jump	14	0.8
Collision with fixed object (goal post)	9	0.5
Temperature related (eg. Heat stress)	7	0.4
Struck by ball	5	0.3
Jumping in line out	6	0.3
Clothing or equipment	1	0.1
Other/unknown	401	21.8
Total	1841	100.00

Table 3.9: Injury event (2002 and 2003 data combined). The table includes injuries recorded at the game and those resulting in missed games.

Injury rates expressed as the number of injury occurrences per player-game exposure hours were derived. This is equivalent to the term athletic exposure that is used in some sports injury epidemiological studies. Table 3.10 presents these rates for all injuries, ie. irrespective of body region or severity. The table includes injuries that were attended to during a game and those resulting in a missed game. The data show that the overall injury rate was 63.7 injuries per 1,000 hours of player-game exposure. Overall injury rates were fairly similar when the rates based on actual headgear wearing patterns were compared (compliance data). In this case, the number of games in which no headgear, modified headgear, or IRB headgear was worn were summed to derive the denominator, and the number of injuries for these groups became the numerator in the calculation of injury rates. The total number of injuries included was 1839, as two injuries were not associated with game time data. The injury rates are also presented in figure 3.2. The overall injury rate is also comparable to other studies reported in chapter 1 that used a similar definition of injury.

	No. inj	Game time (x 1,000hr)	Rate	95% CI (1,000hr)
Overall	1839	28.86	63.7	60.9 to 66.7
Randomised group (n=31899 observations in analysis)				
Control	709	10.04	70.6	65.6 to 76.0
Modified	688	10.65	64.6	60.0 to 69.6
IRB	442	8.17	54.1	49.3 to 59.4
Compliance (n=30316 observations in analysis)				
Wore IRB	828	12.38	66.9	62.5 to 71.6
Wore Modified	175	2.89	60.6	52.2 to 70.2
Wore none	799	13.00	61.5	57.4 to 65.9

Table 3.10: Rates of "All injuries" per 1,000 hours of player-game exposure with 95% confidence intervals, CI; Overall, by randomised group, by actual headgear worn (i.e. compliance)

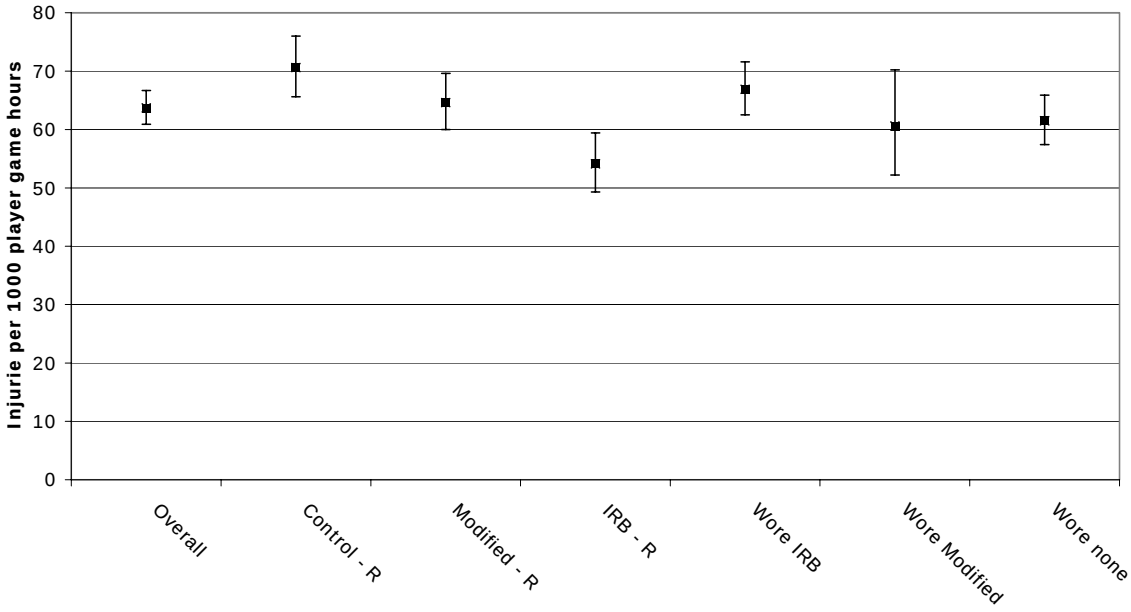


Figure 3.2: Overall injury rates for study arm and compliance. The mean and 95% confidence interval is presented for each group. The suffix –R indicates that the rate is for the study arm to which the player in his team was allocated randomly

The injury rates were calculated according to player position and season (2002 or 2003). These are presented in table 3.11. Statistical analyses of the effect of these factors on injury rates are presented later in the report. The contents of table 3.11 is presented in figure 3.3

	No. inj	**Game time**	**Rate**	**95% CI (1,000hr)**
Player position	(31780 records included in the analysis)			
Front row	342	5.70	60.0	54.0, 66.7
Back five	648	9.50	68.2	63.1, 73.6
Halves	230	3.93	58.5	51.4, 66.6
Inside backs	264	3.99	66.1	58.6, 74.6
Outside backs	342	5.60	61.0	54.9, 67.9
Season	(31899 records included in the analysis)			
2002	810	13.20	61.4	57.3, 65.8
2003	1029	15.67	65.7	61.8, 69.8

Table 3.11: All injuries – Rates per 1,000 hours of player –game exposure.

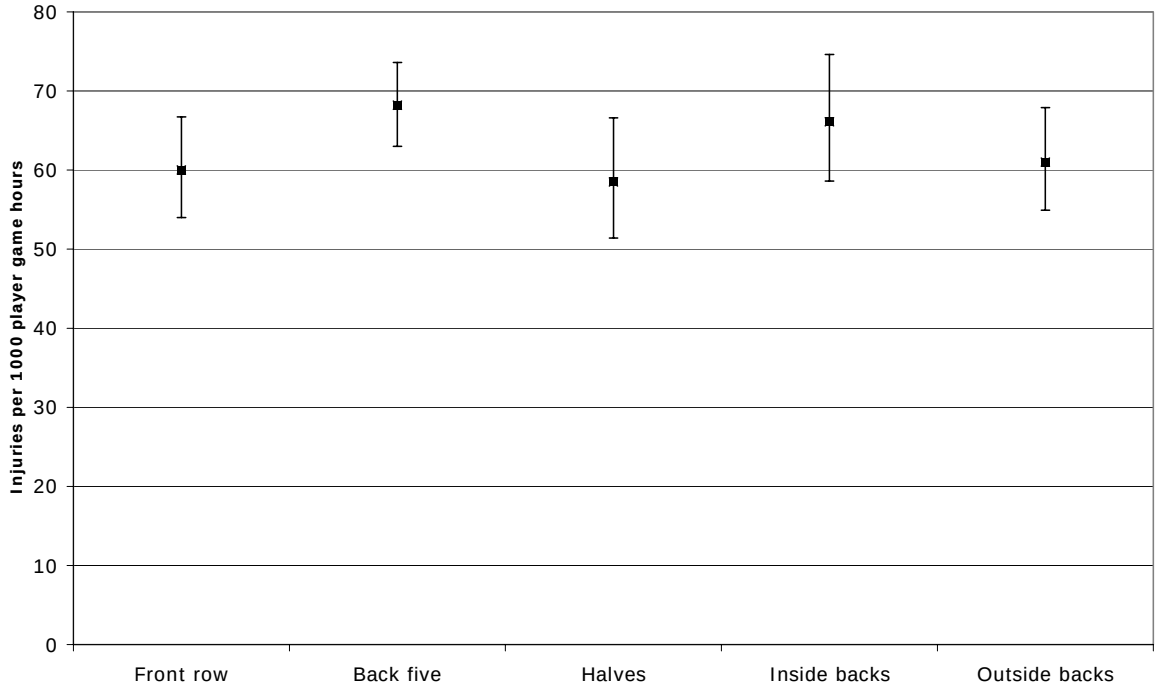


Figure 3.3: Mean injury rates (per 1,000 player game hours) and 95% confidence intervals by player position.

3.3.2 Injury Patterns by Age Group

Injury patterns were analysed according to age group and are presented in tables 3.12 to 3.14. The data are also presented in figures 3.4 and 3.5. The tables present a breakdown of injuries according to body region, nature of injury and injury event.

Body Region		Colts	Opens	U15	U13
Total	n	946	461	250	184
Head	%	11.6	12.8	14.8	15.2
Face	%	11.2	15.0	11.2	10.9
Neck	%	4.9	4.8	5.2	8.1
Sub-total H/F/N	%	27.7	32.6	31.2	34.2
Thorax	%	4.2	5.2	4.4	4.3
Abdomen	%	0.3	1.1	0.8	0.5
Lower Back	%	2.2	1.3	2.8	4.9
Pelvis	%	1.4	0.6	2.0	1.1
Shoulder	%	13.8	13.7	12.8	8.7
Upper Arm	%	0.7	0.6	0.8	2.2
Elbow	%	2.0	0.4	0.8	0.0
Forearm	%	0.6	1.1	2.0	0.5
Wrist	%	2.0	0.9	0.4	1.6
Hand/Fingers	%	5.2	4.3	3.2	4.3
Hip	%	0.9	0.4	0.0	1.1
Thigh	%	8.5	7.4	4.4	6.5
Knee	%	10.5	8.5	8.8	9.8
Lower Leg	%	3.1	4.6	2.4	3.3
Ankle	%	10.0	8.0	8.8	6.5
Foot/Toes	%	0.6	1.1	2.0	0.5
Not Specified	%	6.1	8.2	12.4	9.8

Table 3.12: Region of Injury by age group

Under 13 **Under 15**

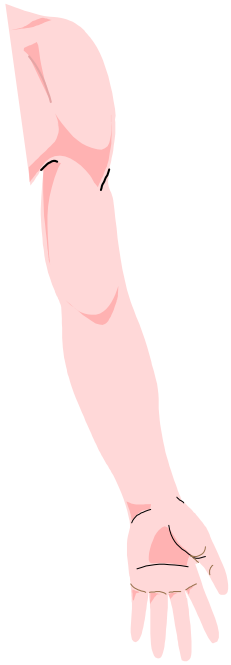


Figure 3.4: Injuries by Region for schoolboy under 13's and 15's
(% all injuries)

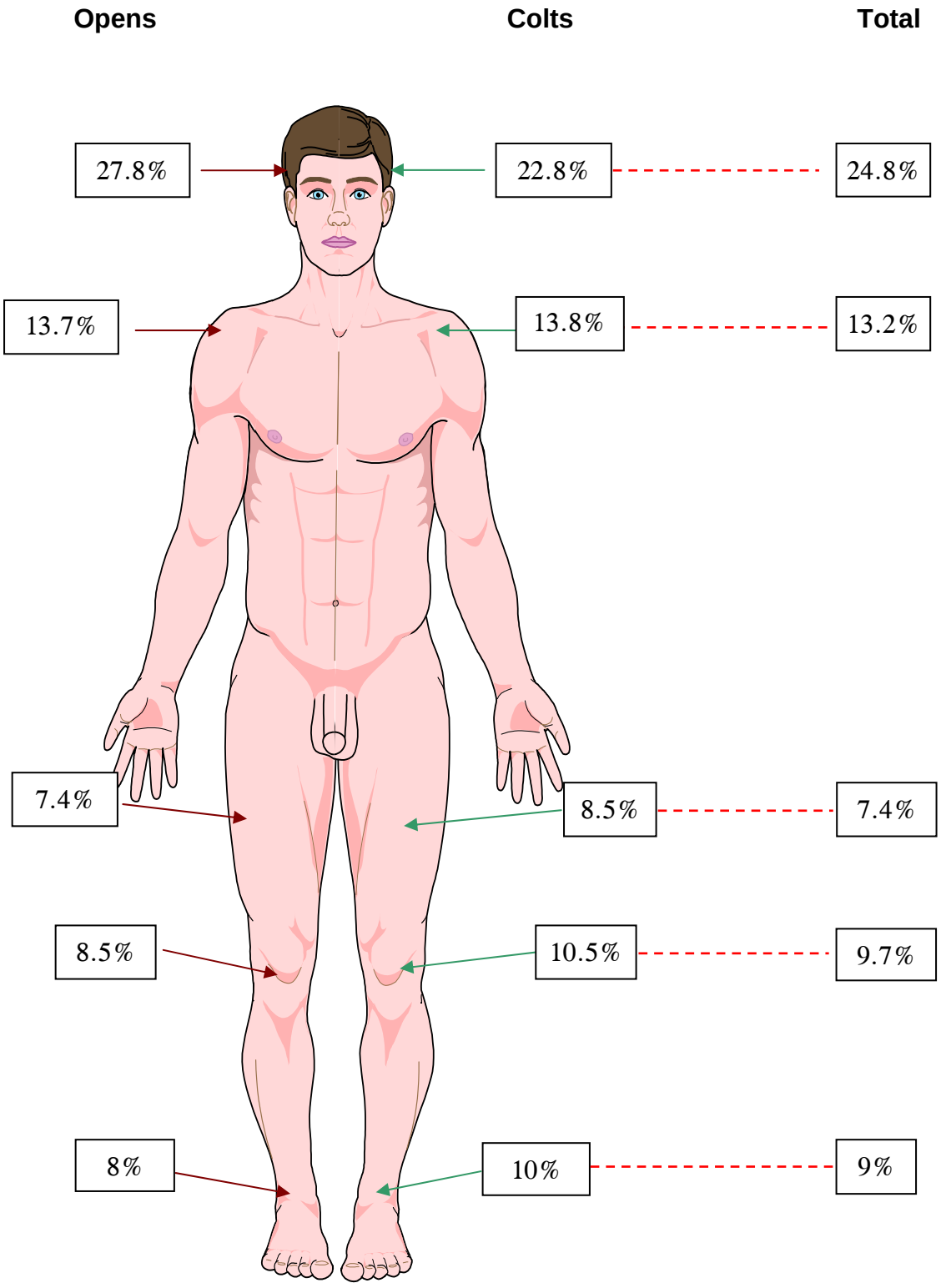


Figure 3.5: Injuries by Region for schoolboy opens and Colts Rugby (% all injuries)

Nature Of Injury		Colts	Opens	U15	U13
Superficial	%	12.8	14.3	9.6	15.8
Open Wound	%	6.5	5.4	4.0	4.3
Fracture	%	2.7	6.9	4.0	2.2
Dislocation	%	1.9	3.0	2.4	0.5
Sprain/Strain	%	42.9	29.9	30.0	34.8
Nerve Injury	%	0.7	0.0	0.0	0.0
Muscle/Tendon	%	5.5	4.1	3.2	4.9
Eye	%	0.6	0.4	0.8	2.2
Intracranial/Concussion	%	9.8	10.8	13.6	12.0
Dental	%	0.0	0.2	0.0	0.0
Symptoms	%	1.9	2.2	3.6	2.2
Overuse Injury	%	0.8	0.9	0.4	0.5
Blood Injury	%	4.5	7.6	7.6	3.8
Undiagnosed Rib Trauma	%	0.6	1.1	0.4	0.0
Solarplexus Contusion	%	0.6	1.1	2.0	2.2
Respiratory Dysfunction	%	0.0	0.2	0.0	0.5
Other/unspecified	%	7.8	11.7	18.4	14.1
Total	n	946	461	250	184

Table 3.13: Nature of Injury by age group

The proportion of concussion cases was greater in the U15s (13.6%) and U13s (12.0%) compared to the opens and colts.

It can be seen in table 3.14 that contact situations, especially the tackle, accounted for the majority of injuries. Due to the nature of the game and general difficulty in identifying the injury event, the event could not be identified in about 30% of injuries.

Injury Event		Colts	Opens	U15	U13
Tackling Another	%	18.8	16.9	21.6	22.8
Being Tackled	%	27.4	23.0	22.0	17.9
Struck By Another (Attack)	%	7.6	7.4	6.4	6.5
Struck By Another (Defence)	%	4.9	5.4	3.6	4.9
Scrum Collapse	%	2.6	3.7	2.0	4.9
Struck By Ball	%	0.3	0.2	0.0	0.5
Collision With Other	%	4.0	5.6	4.0	3.3
Collision With Fixed	%	0.4	0.2	0.8	1.1
Fall/Stumble	%	2.6	1.5	2.0	1.6
Jumping In Line Out	%	0.4	0.2	0.4	0.0
Landing From Jump	%	0.9	0.9	0.0	0.5
Slip/Trip	%	0.7	1.3	0.8	1.1
Twisting	%	2.0	1.7	0.4	2.7
Overexertion	%	4.4	1.1	0.8	0.0
Overuse	%	3.6	2.6	2.4	1.6
Temperature Related	%	0.4	0.0	0.4	1.1
Rucking	%	2.6	1.7	1.6	1.6
Clothing or Equipment	%	0.1	0.0	0.0	0.0
Other/Unknown	%	15.9	26.5	30.8	27.7
Total	n	946	461	250	184

Table 3.14: Injury event by age group

Injury rates increased with each age group from U13 to U21. These are presented in table 3.15 and figure 3.6. The injury rate for the colts was greater than the overall rate and almost double that for players in the U13 division. Based on the rate and the confidence intervals, it would appear that the injury rate for the colts is significantly greater than the opens and U15s, and the injury rate for the U13s is significantly lower than the rest (section 3.3.7).

	No. Injuries	Game time (x 1,000)	Rate	95% CI (1,000hr)
Overall	1839	28.86	63.7	60.9 to 66.7
Level	(31899 records included in the analysis)			
Colts	944	12.85	73.4	68.9, 78.3
Opens	461	7.31	63.0	57.5, 69.1
U15	250	4.45	56.2	49.6, 63.6
U13	184	4.25	43.3	37.5, 50.1

Table 3.15: Age group and injury rates for "All injuries" per 1,000 hours of game time with 95% confidence intervals.

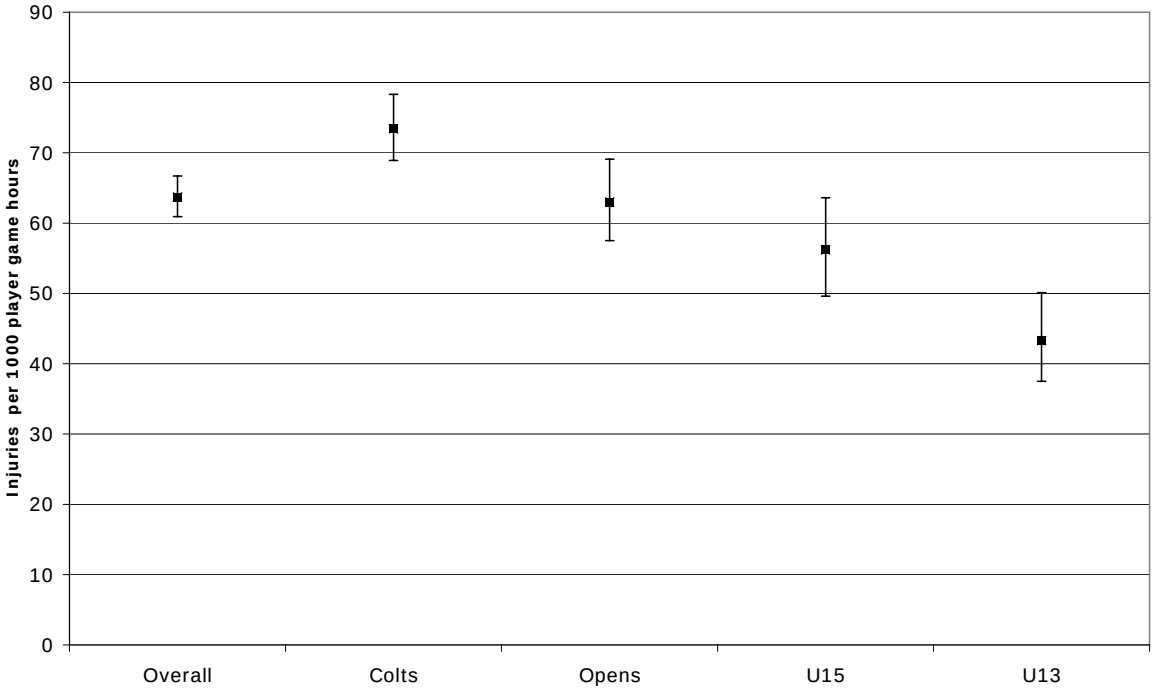


Figure 3.6: Mean injury rate (per 1,000 player game hours) and 95% confidence intervals by age group.

3.3.3 Patterns of Injury Resulting in a Missed Game

Injuries to players that resulted in the player missing a game, normally a period of 7 days after the game in which they were injured, were analysed as a sub-set of all injuries. Therefore, the 604 injuries listed in this section overlap greatly with the total of 1,841 for all injuries presented in the previous section. Reworded, about one third of players who were injured during a game missed at least one game due to the injury. These injuries were considered to reflect injury severity, although it is recognised that many factors influence return to play decisions, not simply injury severity.

The research team attempted to obtain reliable information regarding the nature of these injuries, but focussed on head and neck injuries. Due to players not returning to their original team, lack of accurate injury diagnosis, and difficulty contacting appropriate people to obtain reliable medical records, there is a large proportion of 'not specified/unknown' entries in the missed game injury data. Whereas there were only 8% of all injuries in which the region of injury was unspecified or unknown, this was 18% for missed game injuries. The 18% is unlikely to include head, face or neck injuries as injuries to these body regions were thoroughly followed up. Unfortunately, due to the time involved, this was at the expense of clarifying the details of injuries to other body regions. Table 3.16 presents the region of injury for missed game injuries. This shows that, besides unknown, the shoulder, knee, ankle, head and thigh were the top five regions injured, that resulted in the player missing a game.

Region	Freq.	Percent
Shoulder	120	19.9
Knee	70	11.6
Ankle	54	8.9
Head	49	8.1
Thigh	47	7.8
Hand/fingers	27	4.5
Neck	22	3.6
Thorax	17	2.8
Lower leg	16	2.7
Lower back	14	2.3
Face	12	2.0
Foot/toes	12	2.0
Wrist	11	1.8
Elbow	8	1.3
Pelvis	7	1.2
Forearm	4	0.7
Abdomen	2	0.3
Upper arm	2	0.3
Hip	2	0.3
Not specified	108	17.9
Total	604	100%

Table 3.16: Body region for injuries resulting in a missed game

With regards to the nature of injury, sprains/strains, fractures and concussion were the top three known injury types (table 3.17). Since the exact cause or event that led to an injury was often difficult to define, table 3.18 shows that the injury event was defined for only about two thirds of the cases, with contact phases, eg. tackling, the main cause of injury.

Nature of Injury	Freq.	Percent
Sprain/Strain	257	42.6
Fracture	58	9.6
Intracranial (inc concussion)	47	7.8
Superficial	33	5.5
Dislocation	22	3.6
Muscle/Tendon	17	2.8
Open wound	8	1.3
Overuse injury	6	1.0
Symptoms	3	0.5
Eye	2	0.3
Undiagnosed rib trauma	2	0.3
Solarplexus contusion	1	0.2
Unspecified	148	24.5
Total	604	100%

Table 3.17: Nature of injury for injuries resulting in a missed game

Injury Event	Freq.	Percent
Being tackled	129	21.4
Tackling another player	94	15.6
Struck by another (attacking)	27	4.5
Overexertion	22	3.6
Struck by another (defensive)	19	3.2
Overuse	18	3.0
Collision with other person	16	2.7
Fall/stumble on same level	11	1.8
Rucking	9	1.5
Twisting to pass or accelerate	8	1.3
Scrum collapse or scrum contact	7	1.2
Other (specified)	14	2.2
Other/unknown	230	38.1
Total	604	100%

Table 3.18: Injury event for injuries resulting in a missed game.

Figure 3.7 presents a comparison of all injuries and injuries resulting in a missed game by body region. The shoulder and knee became more prominent as injured body regions in missed game injuries, while the face decreased from 12% to 2% from all injuries to missed game injuries. Normal knee and shoulder function is obviously a pre-requisite for rugby performance, which explains absence due to injuries at these regions.

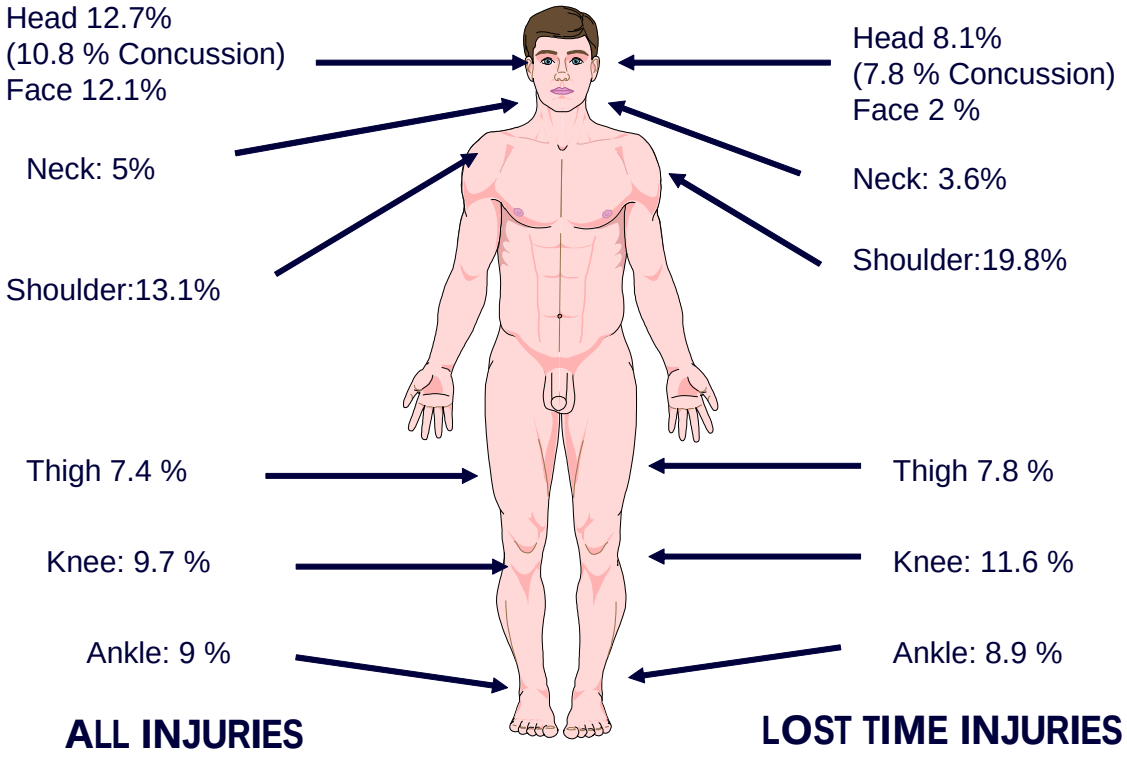


Figure 3.7: Comparison of all injuries and injuries resulting in a missed game by body region.

The pattern of injuries resulting in a missed game were calculated according to age group (table 3.19) and player position (table 3.20). There were minor variations in the regions of injury with shoulder injury increasing as a proportion of injury with age and head injury peaking with the under 15 and school open (under 18) players. Knee injuries were slightly greater with U13s and decreased with increasing age.

Region	Age group			
	Colts %	Opens %	U15 %	U13 %
Shoulder	21.8	19.1	19.2	12.0
Ankle	9.9	9.3	8.1	4.0
Thigh	9.6	6.8	6.1	4.0
Knee	8.6	9.1	10.0	11.6
Head	7.5	9.3	9.1	6.0
Hand/fingers	3.4	5.6	5.1	6.0
Thorax	3.1	2.5	2.0	4.0
Neck	2.7	3.7	5.1	6.0
Lower leg	2.7	3.7	1.0	2.0
Elbow	2.4	0.0	1.0	0.0
Face	2.1	2.5	1.0	2.0
Lower back	2.1	1.9	2.0	6.0
Wrist	2.1	1.9	0.0	4.0
Foot/toes	1.4	1.9	4.0	2.0
Abdomen	0.3	0.6	0.0	0.0
Pelvis	0.3	1.2	2.0	4.0
Upper arm	0.3	0.6	0.0	0.0
Forearm	0.3	1.9	0.0	0.0
Hip	0.3	0.6	0.0	0.0
Not specified	13.3	18.5	25.3	28.0
Total	293	162	99	50

Table 3.19: Region of injury for injuries resulting in missed games by age group.

Region	Player position				
	Front row %	Back five %	Halves %	Inside back %	Outside back %
Shoulder	25.2	19.9	20.3	14.9	19.5
Knee	5.8	11.7	14.5	10.9	15.5
Ankle	10.7	8.3	7.3	9.9	8.1
Head	6.8	7.8	10.1	5	11.4
Thigh	1.9	4.9	7.3	13.9	13
Hand/fingers	6.8	2.9	5.8	6.9	2.4
Neck	7.8	6.8	0	0	0
Thorax	5.8	2.9	1.5	3	0.8
Lower leg	1.9	1.9	2.9	5	2.4
Lower back	2.9	2.9	0	3	1.6
Face	1.9	0.5	1.5	2	4.9
Wrist	1.9	2.9	1.5	1	0.8
Foot/toes	1	2.9	4.4	1	0
Elbow	1	1.5	1.5	1	1.6
Pelvis	0	0.5	0	3	2.4
Forearm	1	1	0	1	0
Abdomen	0	0.5	0	0	0.8
Upper arm	1	0	0	0	0.8
Hip	0	0.5	1.5	0	0
Not specified	16.5	19.9	20.3	18.8	13.8
Total (N)	103	206	69	101	123

Table 3.20: Region of injury for injuries resulting in missed games by player position

The injury rates for all missed game injuries are presented in table 3.21 (rate per 100 player game hours). The overall injury rate for injuries resulting in a missed game was 20.9 per 1,000 player game hours of exposure. This means that a team of 15 players experienced one injury which resulted in a missed game for every three to four games they played, assuming a game was around one hour. The arm to which the player was randomised did not appear to influence the overall rate of injuries resulting in a missed game, however the group wearing the modified headgear had the lowest overall injury rate. Table 3.21 also indicates that age group influenced injury rate. The under 13 year olds having the lowest rate of injury and the colts the greatest rate (figure 3.8).

		No. Injuries	Game time (1,000 hours)	Rate	95% CI
Overall		602	28.86	20.9	19.3 to 22.6
Randomisation group	Control	215	10.04	21.4	18.7 to 24.5
	Modified	233	10.65	21.9	19.2 to 24.9
	IRB	154	8.17	18.8	16.1 to 22.1
Compliance (observed headgear use)	None	272	13.0	20.9	18.6 to 23.6
	Wore Modified	47	2.89	16.3	12.2 to 21.6
	Wore IRB	271	12.38	21.9	19.4 to 24.7
Age group	Colts	291	12.85	22.6	20.2 to 25.4
	Opens	162	7.31	22.2	19 to 25.8
	U15	99	4.45	22.3	18.3 to 27.1
	U13	50	4.25	11.8	08.9 to 15.5

Table 3.21: Age group and injury rates for injuries resulting in a missed game. Rate expressed as per 1,000 player game hours.

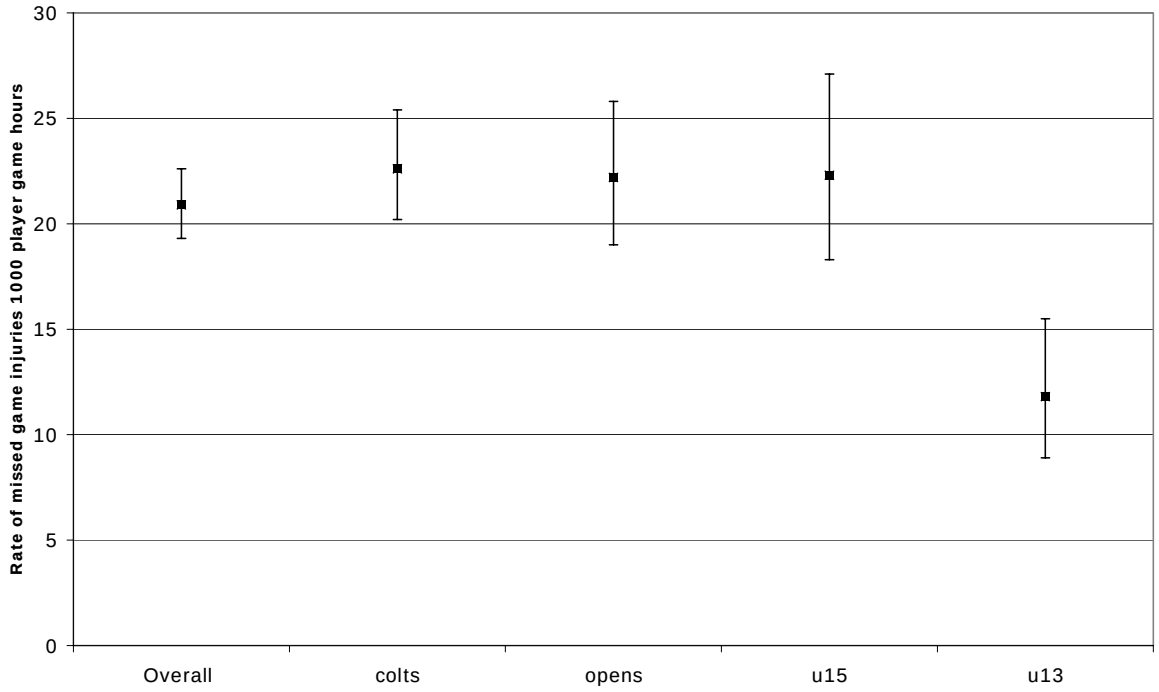


Figure 3.8: Plots of rates of missed game injury by age group – mean and 95% CI. Injury rate denominator is 1,000 player game hours.

3.3.4 Head Injury, Study Arm and Headgear Use

Table 3.22 presents the head injury rates calculated per unit exposure according to both study arm allocation and observed use of headgear (compliance) in a game. In table 3.23 the rates of head injuries resulting in a player missing at least one game (normally 7 days after the injury) are presented according to exposure in a study arm and for observed headgear use. A great deal of effort was exerted to collect accurate data for all head, neck and facial injuries. It is recognised that a player missing a game due to head injury or concussion is only an indirect measure of the severity of the injury. The player's family, coach and medical advice, as well as their knowledge and adherence to the IRB's policy on return to play after concussion, are other factors that could not be controlled or measured in the study.

The overall rate of head injury was 8.1 per 1,000 hours. Based on the study arm only, players allocated to the modified headgear arm had a slightly higher rate of injury than those in the control or IRB headgear arms (figures 3.9, 3.10 and 3.11). However, when the rates were calculated according to observed use of headgear, those players wearing modified headgear had the lowest rate of head injury.

	No. Injuries	Game time (1,000 hrs)	Rate	95% CI
Overall	234	28.86	8.11	7.13 to 9.22
Randomisation Analysis				
Control	82	10.04	8.16	6.57 to 10.14
Modified	96	10.65	9.02	7.38 to 11.01
IRB	56	8.17	6.85	5.27 to 8.91
Compliance Analysis				
Wore IRB	106	12.38	8.56	7.08 to 10.36
Wore Modified	22	2.89	7.61	5.01 to 11.56
Wore none	100	13.00	7.70	6.33 to 9.36

Table 3.22: Rates of head injuries per 1,000 hours of game time; Overall, by randomised group, by actual headgear worn (i.e. compliance)

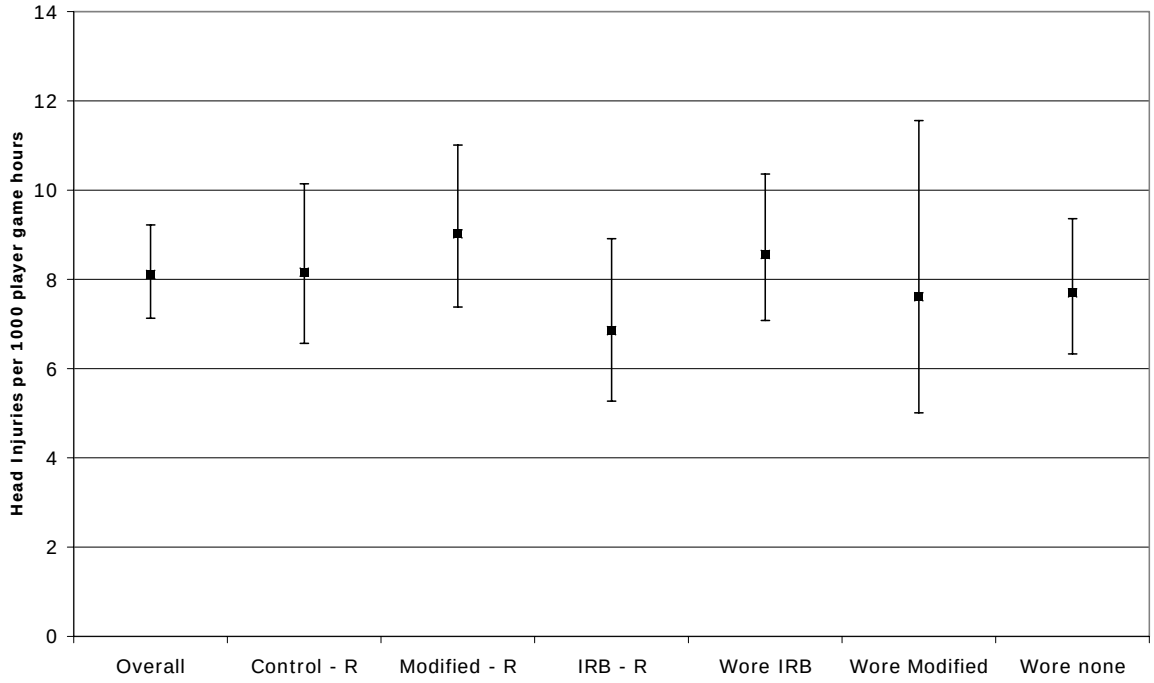


Figure 3.9: Comparison of the rates of all head injuries. The mean and 95% confidence intervals are presented. The rate is per 1,000 player game hours. The suffix - R indicates the arm of the study in which the player was randomised.

The number of players who missed a game due to a head injury in 2002 and 2003 was very low. Only 49 players missed at least one game. The issue of the IRB's safety directive and this observation will be discussed later in the report. Only two players wearing modified headgear missed a game due to a head injury, resulting in the lowest rate, 0.69 per 1,000 hours compared to 1.86 for IRB approved headgear wearers and 1.69 for players wearing no headgear. Confidence intervals for the modified headgear compliance category were wide compared to the other two groups. The descriptive statistics for injury rates for the nature of injury category 'concussion' are presented in table 3.24. The results are comparable with table 3.22 for head injury. The overall rate of concussion was 6.9 per 1,000 hours compared to 8.1 for the body region category 'head'.

	No. Injuries	Game time (1,000 hrs)	Rate	95% CI
Overall	49	28.86	1.70	1.28 to 2.25
	Randomisation Analysis			
Control	19	10.04	1.89	1.21 to 2.97
Modified	15	10.65	1.41	0.85 to 2.34
IRB	15	8.17	1.84	1.11 to 3.05
	Compliance Analysis			
Wore IRB	23	12.38	1.86	1.23 to 2.80
Wore Modified	2	2.89	0.69	0.17 to 2.77
Wore none	22	13.00	1.69	1.11 to 2.57

Table 3.23: Rates of Head injuries causing missing games per 1,000 hours of game time; Overall, by randomised group, by observed headgear worn (i.e. compliance)

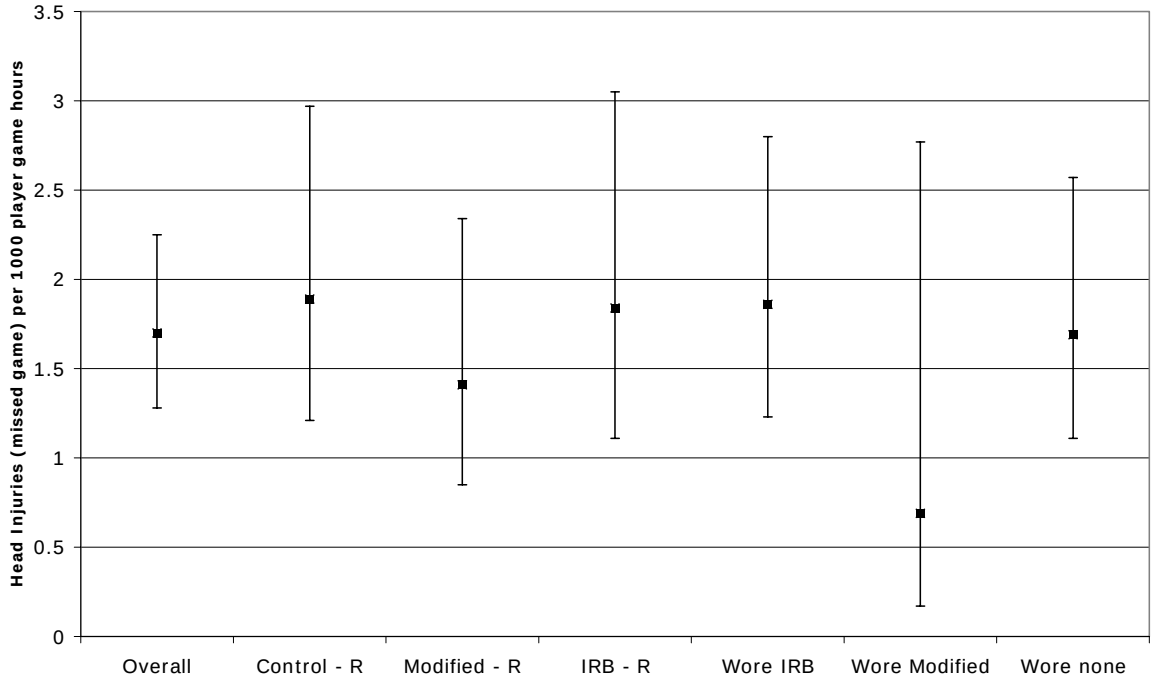


Figure 3.10: Comparison of head injuries resulting in a missed game. The mean and 95% confidence intervals are presented. The rate is per 1,000 player game hours. The suffix - R indicates the arm of the study in which the player was randomised.

	No. Injuries	Game time (1,000 hrs)	Rate	95% CI
Overall	199	28.86	6.89	6.00 to 7.92
	Randomisation Analysis			
Control	67	10.04	6.67	5.25 to 8.47
Modified	80	10.65	7.51	6.04 to 9.35
IRB	52	8.17	6.36	4.85 to 8.35
	Compliance Analysis			
Wore IRB	90	12.38	7.27	5.91 to 8.94
Wore Modified	19	2.89	6.57	4.19 to 10.31
Wore none	85	13.00	6.54	5.29 to 8.09

Table 3.24: Rates of Concussions (intracranial) per 1,000 hours of game time; Overall, by randomised group, by actual headgear worn (i.e. compliance)

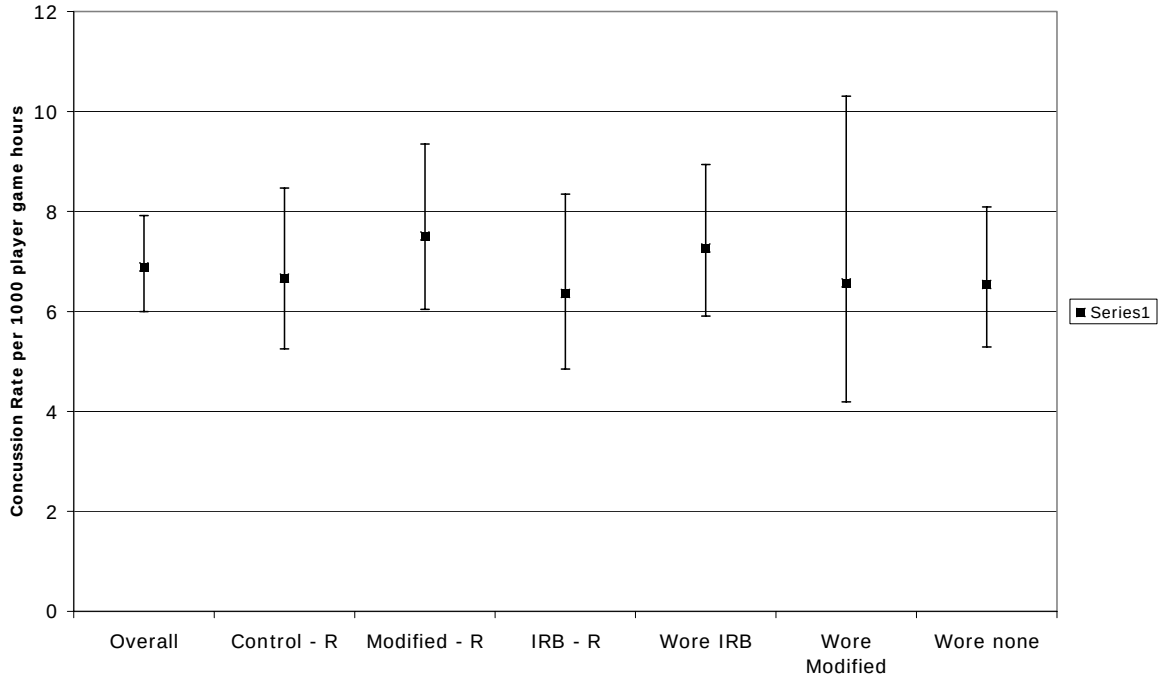


Figure 3.11: Comparison of the rates of all concussions. The mean and 95% confidence intervals are presented. The rate is per 1,000 player game hours. The suffix - R indicates the arm of the study in which the player was randomised.

3.3.5 Injury, Player Position and Grade

In this section injury patterns have been analysed according to player position and grade. Injury patterns for grade and player position are presented in tables 3.25 to 3.30. Injury rates by player grade are presented in table 3.31. The patterns of body region injured and nature of injury were similar across grades, with some small differences, eg. there was a higher proportion of shoulder injuries in the first or A grade players.

Region		1st	2nd	3rd	4th/5th
Shoulder	%	14.8	12.8	11.2	11.1
Head	%	12.9	13.4	8.5	14.8
Face	%	11.4	10.9	14.3	14.8
Knee	%	8.8	9.4	11.2	11.1
Ankle	%	8.7	9.6	10	7.4
Thigh	%	7.9	7.1	7.7	6.6
Thorax	%	5.9	2.7	5	4.5
Neck	%	4.8	6.1	4.6	4.9
Hand/Fingers	%	4	5.8	3.9	4.5
Lower Leg	%	3.4	3	3.1	4.5
Lower Back	%	2.3	2.8	2.3	1.2
Wrist	%	1.8	1.3	1.5	0.8
Pelvis	%	1.2	1	2.7	0.4
Elbow	%	1	1.8	1.2	0.8
Upper Arm	%	0.8	1.3	0	0.8
Forearm	%	0.7	1.7	0.4	0.4
Foot/Toes	%	0.7	1.2	1.2	0.8
Abdomen	%	0.5	0.7	0.4	0.8
Hip	%	0.5	1	0.8	0.4
Not Specified	%	7.9	6.5	10	9.1
Total	n	735	604	259	243

Table 3.25: Region of injury (all injuries) by grade

Nature Of Injury		1st	2nd	3rd	4th/5th
Sprain/Strain	%	38.2	39.4	34.8	30.5
Superficial	%	12.4	11.4	15.4	16.5
Intracranial (Inc. concussion)	%	11.6	10.4	7.7	12.8
Blood Injury	%	5.3	4.6	6.2	8.6
Open Wound	%	4.6	6.5	5.4	7.4
Muscle/Tendon	%	4.6	6	4.3	2.9
Fracture	%	4.2	3.6	5.4	2.1
Dislocation	%	2	2	2.7	2.1
Symptoms	%	1.8	2.5	2.3	2.9
Other (specified)	%	5	3.7	5.4	4.8
Unspecified	%	10.2	9.9	10.4	9.5
Total	n	735	604	259	243

Table 3.26: Nature of injury (all injuries) by grade.

The front row had the highest proportion of shoulder injuries, 18%, and the outside backs had the lowest proportion, 11% (table 3.27). The halves had the highest proportion of head injuries, 19%, followed by the outside backs, 14%. The halves also had the highest proportion of concussion but the lowest proportion of sprains/strains compared to the other player position groupings (table 3.28).

Region		Forwards		Backs		
		Front Row	Back 5	Half	Inside	Outside
Shoulder	%	18.4	12.2	11.7	12.5	10.5
Face	%	11.1	15.1	12.2	8.7	10.2
Head	%	10.5	11.7	19.1	10.9	13.7
Neck	%	8.5	6.3	2.2	3.4	3.5
Ankle	%	7.3	7.9	7.8	12.5	11.1
Thorax	%	6.4	4	3	5.7	3.8
Knee	%	6.1	9.6	11.3	9.1	12.5
Hand/Fingers	%	5.3	3.9	5.7	5.7	3.8
Thigh	%	3.8	6.2	7.4	10.2	11.4
Lower Back	%	3.5	2.3	1.3	3	1.5
Lower Leg	%	2.3	3.9	3.9	3.4	3.2
Elbow	%	2.1	1.1	0.4	1.5	1.2
Upper Arm	%	1.8	0.9	0.4	0	0.9
Foot/Toes	%	1.8	0.9	1.3	0.4	0
Forearm	%	1.2	0.8	0.9	0.8	1.2
Wrist	%	1.2	2.2	0.9	1.1	1.2
Abdomen	%	0.6	0.5	0.4	0	1.5
Pelvis	%	0.3	1.4	0.9	1.9	1.8
Hip	%	0.3	1.4	0.9	0	0.3
Not Specified	%	7.6	7.9	8.3	9.4	7
Total	n	342	648	230	265	343

Table 3.27: Region of Injury (all injuries) by player position.

		Forwards		Backs		
Nature		**Front Row**	**Back 5**	**Half**	**Inside**	**Outside**
Sprain/Strain	%	38.9	35.5	31.3	43	37.6
Superficial	%	14	14	10.4	10.9	13.1
Intracranial	%	9.1	9.6	15.2	9.8	12.5
Muscle/Tendon	%	5.3	4.6	3.9	4.2	5.8
Blood Nose	%	5.3	7.3	6.5	2.6	4.7
Open Wound	%	4.4	7.3	6.1	5.3	4.4
Fracture	%	3.8	3.7	3.5	4.5	4.4
Symptoms	%	2.3	2	3.5	1.5	2.3
Overuse	%	1.8	0.6	0.4	0.4	0.6
Dislocation	%	1.2	1.5	4.4	1.5	2.9
Other (specified)	%	4.8	3.3	4	4.5	3.9
Unspecified	%	9.4	10.7	10.9	11.7	7.9
Total	n	342	648	230	265	343

Table 3.28: Nature of injury (all injuries) by player position

The injury events by grade and player position are presented in tables 3.29 and 3.30. No specific pattern emerged with regards to event and grade or event and player position. It was unfortunate that it was very difficult to identify accurately each event or phase of play that caused injury. This was due mainly to play being obscured. Even when video analysis was used, it was still difficult to identify always the injury event (see chapter 5).

Injury Event		**1st**	**2nd**	**3rd**	**4th/5th**
Being Tackled	%	25.8	22.8	27	22.6
Tackling Another	%	18.9	20.4	15.8	20.2
Struck By Another (Attack)	%	7.5	6	7.7	9.5
Struck By Another (Defence)	%	4.6	4.5	5.8	5.3
Scrum Collapse	%	3.9	3.1	1.5	1.6
Collision With Other Player	%	3.4	5.3	3.5	5.8
Overuse	%	3.3	2.5	3.5	2.9
Fall/Stumble	%	2.6	1.8	1.9	2.1
Overexertion	%	2.3	3.1	2.7	2.5
Rucking	%	1.9	2	1.9	3.7
Twisting	%	1.1	1.8	1.9	3.7
Other (specified)	%	2.8	3.3	2.4	4.4
Unspecified	%	21.6	23.4	24.3	15.6
Total	n	735	604	259	243

Table 3.29: Injury event by grade

Injury Event		Forwards		Backs		
		Front Row	Back 5	Half	Inside	Outside
Being Tackled	%	20.2	21.3	28.7	29.1	28
Tackling	%	17.8	19.4	20.9	16.6	20.1
Scrum Collapse	%	11.1	2	0.9	1.1	0
Struck (Attack)	%	8.8	6.5	9.6	5.7	7.3
Collision with other person	%	5.6	4.8	5.6	1.9	3.5
Struck (Defence)	%	4.4	5.7	3.9	2.6	6.1
Overuse	%	3.5	4.2	3	1.9	1.2
Fall/Stumble	%	2	1.8	1.3	2.6	3.2
Rucking	%	1.5	4.3	1.7	1.1	0
Other (specified)	%	2.7	7.7	5.6	10.6	11.7
Unspecified	%	22.5	22	18.7	26.8	18.9
Total	n	342	648	230	265	343

Table 3.30: Injury event by player position

The results in table 3.31 indicate that the back five had the highest rate of injury, followed closely by the inside backs, with the halves having the lowest injury rate. There was also a trend for the injury rate to increase slightly in the lower grades.

	No. Injuries	Game time (1,000 hrs)	Rate	95% CI
Grade	**(31899 records included in the analysis)**			
1st	734	11.67	62.9	58.5, 67.6
2nd	603	9.68	62.3	57.5, 67.4
3rd	259	4.04	64.1	56.7, 72.4
4th / 5th	243	3.47	70.0	61.7, 79.4
Player Position	**(31780 records included in the analysis)**			
Front Row	342	5.70	60.0	54.0, 66.7
Back Five	648	9.50	68.2	63.1, 73.6
Halves	230	3.93	58.5	51.4, 66.6
Inside Back	264	3.99	66.1	58.6, 74.6
Outside Back	342	5.60	61.0	54.9, 67.9

Table 3.31: Injury rates (all injuries) by grade and player position. Denominator is 1,000 player game hours.

An analysis of injuries resulting in a missed game revealed small differences between grades (table 3.32). The inside backs had the highest rate of injury resulting in a missed game and the front row the lowest (figure 3.12).

	No. Injuries	Game time (1,000 hrs)	Rate	95% CI
Grade	**(31899 records included in the analysis)**			
1st	257	11.67	22	19.5 to 24.9
2nd	187	9.68	19.3	16.7 to 22.3
3rd	91	4.04	22.5	18.3 to 27.7
4th / 5th	67	3.47	19.3	15.2 to 24.5
Player Position	**(31780 records included in the analysis)**			
Front Row	103	5.7	18.1	14.9 to 21.9
Back Five	206	9.5	21.7	18.9 to 24.8
Halves	69	3.93	17.5	13.9 to 22.2
Inside Back	100	3.99	25	20.6 to 30.5
Outside Back	122	5.6	21.8	18.2 to 26

Table 3.32: Injury rates (missed game injuries) by grade and player position. Denominator is 1,000 player game hours.

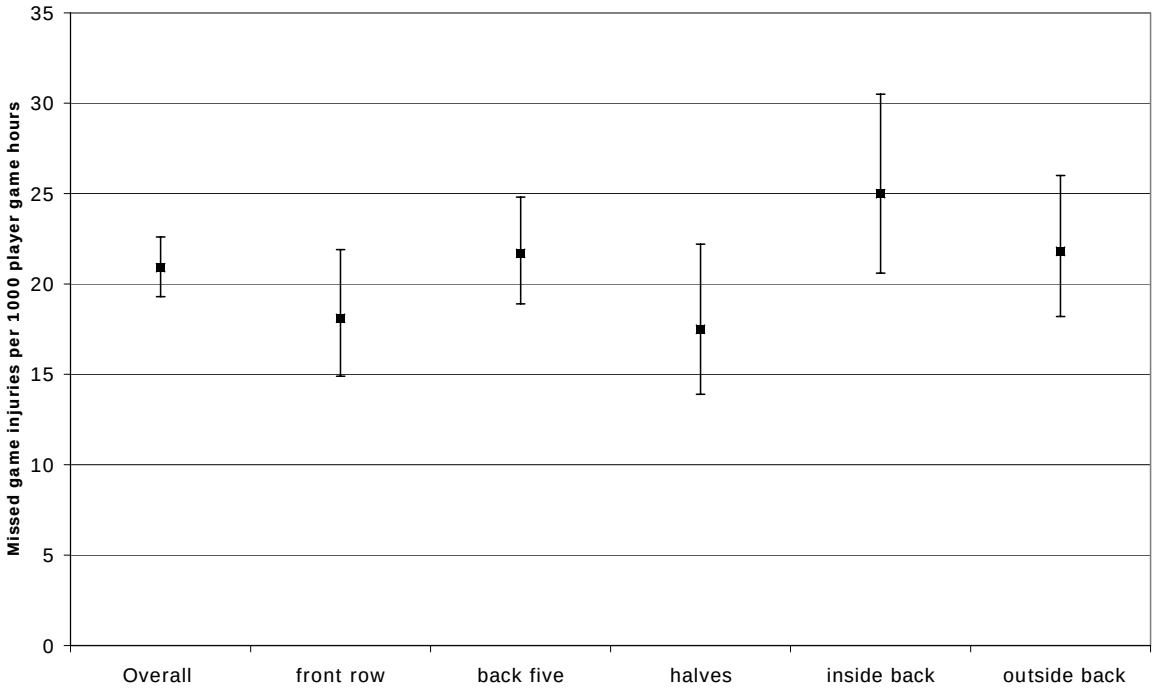


Figure 3.12: Comparison of the rates of missed game injuries by player position. The mean and 95% confidence intervals are presented. The rate is per 1,000 player game hours.

3.3.6 Other Factors and Injury

Other factors including season, ground condition, weather etc at the game were assessed. The factors were assessed subjectively by the recorders. In table 3.33 it can be seen that the overall rates of injury in the two years were fairly similar. The rate increased slightly from 61.4 injuries per 1,000 hours by 7% to 65.7 injuries per 1,000 hours from 2002 to 2003. This implies indirectly that the data recording methods did not change substantially between years.

	No. Injuries	Game time (1,000 hrs)	Rate	95% CI
Season	**(31899 records included in the analysis)**			
2002	810	13.20	61.4	57.3, 65.8
2003	1029	15.67	65.7	61.8, 69.8

Table 3.33: Injury rates for each season.

The game days were characterised as typically still, dry and warm (table 3.34). Even though the rugby season is in winter, Sydney has had low rainfall during the last three years. The grounds were characterised as being dry, even, firm with good grass cover. This reflects the sample, either Sydney private school or Sydney club grounds (table 3.35).

	Variable	Freq	Percent
Wind	Windy	3921	29.7
	Still	9295	70.3
	Total	13216	100.0
Humidity	Humid	808	6.2
	Dry	12250	93.8
	Total	13058	100.0
Temperature	Hot/Warm	8661	61.9
	Warm	1400	10.0
	Cool/Cold	3933	28.1
	Total	13994	100.0
Rain	Drizzle/Heavy Rain	652	4.3
	Overcast	3598	23.9
	Sunny/Clear	10800	71.8
	Total	15050	100.0

Table 3.34: Game - specific variables relating to weather

	Variable	Freq	Percent
Grass cover	Poor	3938	12.0
	Good	28766	88.0
	Total	32704	100.0
Playing surface	Wet	6677	19.4
	Dry	27703	80.6
	Total	34380	100.0
Playing surface hardness	Hard/Firm	20620	59.7
	Soft	13280	38.5
	Muddy	621	1.8
	Total	34521	100.0
Playing surface level	Even/Level	29196	86.2
	Uneven	4678	13.8
	Total	33874	100.0

Table 3.35: Game -specific variables relating to ground condition.

3.3.7 Statistical Analyses of Factors Affecting Injury Rates

The results of statistical analyses for the randomised controlled trial are presented in this section. The analysis was by Poisson regression. Table 3.36 presents the results of the univariate analysis of the rate of all injuries (game and missed game injuries) using the independent variable 'Randomisation' (control, modified headgear and IRB headgear) and 'Compliance' (no headgear, wearing modified headgear and wearing IRB headgear). The incidence rate ratios (IRR) are presented. IRRs are simplistically the ratio of the incidence rate for one variable compare to another, eg. rate of injury for modified headgear wearers over the rate for those not wearing headgear. The analysis of the independent variable 'Randomisation' shows that there was no significant difference in the rate of all injury across the three arms of the study, although the relative rate was lowest for those players randomised into the IRB arm of the study (0.77 relative to the control group). When the data were analysed according to actual headgear wearing patterns 'Compliance', there was also no statistical difference in the rate of all injuries between players based on their headgear wearing patterns. In this case those wearing IRB had the highest rate of injury relative to the two other groups. A similar pattern was observed for missed game injuries (table 3.37). The data show that headgear does not increase the risk of injury overall, either a game injury or an injury resulting in a missed game.

Variable	IRR	P-value	95% CI
Randomisation	**(comparisons among 3 groups, p=0.16)**		
Control	(reference)		
Modified	0.92	0.62	0.64, 1.30
IRB	0.77	0.15	0.54, 1.10
Compliance	**(comparisons among 3 groups, p=0.17)**		
Wore IRB	(reference)		
Wore modified	0.91	0.52	0.67, 1.23
Wore None	0.92	0.06	0.84, 1.00

Table 3.36: Univariate analysis of all injuries – randomisation and compliance groups

Variable	IRR	P-value	95% CI
Randomisation	**(comparisons among 3 groups, p=0.33)**		
Control	(reference)		
Modified	1.02	0.87	0.78, 1.34
IRB	0.88	0.35	0.68, 1.15
Compliance	**(comparisons among 3 groups, p=0.32)**		
Wore None	(reference)		
Wore modified	0.78	0.2	0.53, 1.14
Wore IRB	1.05	0.62	0.87, 1.25

Table 3.37: Univariate analysis of missed game injuries – randomisation and compliance groups

Table 3.38 shows that player position had a marginally significant effect on injury rates ($p=0.08$) with the back five (locks, number 8 and breakaways) exhibiting the greatest rate of injury ($p=0.08$). Their rate, compared to the front row as reference, was 1.14, with the inside backs also having a higher rate of injury than front row, halves and outside backs. Analysis of injury rates with respect to grade (1st/A to 4th/D) did not show a significant difference, although as observed previously there is a trend for the lower grades to have a higher rate of injury. There was a gradual increase in injury rate from U13s to U21s that is statistically significant ($p<0.01$). Players in the U13s had an IRR of 0.59 compared to U21s/Colts, and the rate increased with increasing age. The rate of all injury in 2003 was not significantly different to 2002.

Variable	IRR	P-value	95% CI
Player position	**(comparisons among 5 positions, p=0.08)**		
Front row	(reference)		
Back five	1.14	0.08	0.98, 1.31
Halves	0.97	0.78	0.82, 1.16
Inside back	1.10	0.27	0.93, 1.31
Outside back	1.02	0.82	0.88, 1.18
Grade	**(comparisons among 4 grades, p=0.72)**		
1st grade	(reference)		
2nd grade	0.99	0.85	0.89, 1.10
3rd grade	1.02	0.87	0.81, 1.27
4th/5th	1.11	0.41	0.86, 1.43
Level	**(comparisons among 4 levels, p=0.003)**		
Colts	(reference)		
Opens	0.86	0.32	0.63, 1.16
Under-15	0.77	0.11	0.55, 1.06
Under-13	0.59	<0.01	0.42, 0.82
Season			
2002	(reference)		
2003	1.07	0.44	0.90, 1.27

Table 3.38: Univariate analysis of all injuries – player position, grade and age group.

Table 3.39 shows that player position was significantly associated with the rate of injury resulting in a missed game ($p=0.03$). The inside backs had the highest rate of injury resulting in a missed game. Their injury rate, compared to the front row as reference, was 1.39. Analysis of the relative rates of injury with respect to grade (1st/A to 4th/D) did not show a significant difference. Level of play had a significant effect on the rate of injuries resulting in missed games ($p<0.001$). Players in the U13s had an incidence rate ratio of 0.52 compared to U21s/Colts that was significant ($p<0.001$). There was a significantly higher rate of missed game injury in 2003.

Variable	IRR	P-value	95% CI
Player position	**(comparisons among 5 positions, p=0.03)**		
Front row	(reference)		
Back five	1.20	0.26	0.87, 1.65
Halves	0.97	0.86	0.70, 1.36
Inside back	1.39	0.01	1.10, 1.75
Outside back	1.20	0.24	0.88, 1.65
Grade	**(comparisons among 4 grades, p=0.76)**		
1st grade	(reference)		
2nd grade	0.88	0.31	0.68, 1.13
3rd grade	1.02	0.88	0.77, 1.35
4th/5th	0.87	0.53	0.58, 1.33
Level	**(comparisons among 4 levels, p<0.001)**		
Colts	(reference)		
Opens	0.98	0.89	0.73, 1.31
Under-15	0.98	0.86	0.81, 1.19
Under-13	0.52	<0.001	0.40, 0.67
Season			
2002	(reference)		
2003	1.25	0.01	1.06, 1.47

Table 3.39: Univariate analysis of missed game injuries – player position, grade and age group.

Multivariate analyses using the pairs of independent variables – randomisation and age group, and compliance and age group – were performed. The results are presented in table 3.40. The results show that after controlling for age group there were no significant differences in the analysis of injury rates for randomisation groups. However, after controlling for age in the compliance analysis, those wearing IRB headgear had a significantly higher injury rate (IRR=1.16). Therefore, age group/level of play was a potentially confounding effect.

Variable	IRR	IRR Adjusted	P-value	95% CI
Randomisation	**(*p=0.16 **p=0.10)**			
Control	(reference)			
Modified	0.92	0.88	0.47	0.63, 1.24
IRB	0.77	0.75	0.10	0.54, 1.06
Compliance	**(*p=0.17 **p=0.03)**			
Wore None	(reference)			
Wore modified	0.98	1.05	0.75	0.78, 1.41
Wore IRB	1.09	1.16	0.01	1.04, 1.29

Table 3.40: Multivariate analysis of all injuries adjusting for age group, (Colts/Open/U-15/U-13), randomisation and headgear use
P-values for comparisons among 3 groups in univariate* and multivariate** analyses

3.4 Analysis of Headgear and other Factors Influencing Head Injury

3.4.1 Head Injury and Concussion - Headgear

The effect of headgear on head injury and concussion rates was assessed using univariate and multivariate Poisson regression. For the univariate analyses, the independent variable was either 'randomisation' group or 'compliance' group. As stated earlier, the randomisation group reflects an 'intention to treat' basis for analysis, while the 'compliance' group assesses injury rates based on actual patterns of headgear use. Table 3.41 shows that on an intention to treat basis there was no statistical difference between injury rates for the three arms of the study. Those players allocated to the IRB headgear arm had the lowest relative rate of injury and those allocated to the modified arm had the highest. There was no statistically significant difference in rates of head injury based on actual headgear wearing patterns. The IRR shows that those players wearing no headgear or modified headgear had a lower, but not significant, rate of head injury than players wearing IRB headgear.

Variable	IRR	P-value	95% CI
Randomisation (comparisons among 3 groups, p=0.48)			
Control	(reference)		
Modified	1.10	0.66	0.71, 1.72
IRB	0.84	0.49	0.51, 1.38
Compliance (comparisons among 3 groups, p=0.72)			
Wore IRB	(reference)		
Wore modified	0.89	0.55	0.61, 1.30
Wore None	0.90	0.50	0.66, 1.22

Table 3.41: Univariate analysis of head injuries across study arms (randomisation) and headgear use (compliance)

The analysis presented in table 3.41 was repeated for the outcome variable head injury resulting in a missed game (table 3.42). There were no statistically significant differences in lost time head injury rates for either the randomisation arm or headgear worn (compliance). The results show that the relative rate of experiencing a head injury resulting in lost time while wearing modified headgear was 0.37 compared to wearing IRB headgear, and approximately 0.41 compared to no headgear. These differences were not significant. The size of the confidence limits for the modified headgear group is indicative of the few cases that contributed to this estimate.

Variable	IRR	P-value	95% CI
Randomisation (comparisons among 3 groups, p=0.81)			
Control	(reference)		
Modified	0.74	0.54	0.29, 1.89
IRB	0.97	0.94	0.42, 2.24
Compliance (comparisons among 3 groups, p=0.41)			
Wore IRB	(reference)		
Wore modified	0.37	0.19	0.09, 1.61
Wore None	0.91	0.72	0.54, 1.53

Table 3.42: Univariate analysis of head injuries causing missed games across study arms (randomisation) and headgear use (compliance)

Tables 3.43 and 3.44 show that on randomisation there was no statistical difference between rates of concussion for the three arms of the study. Those players allocated to the IRB headgear arm had the lowest relative rate of concussion and those allocated to the modified arm had the highest compared to controls. There was no statistically significant difference in rates of concussion based on actual headgear wearing patterns. The incidence rate ratios show that those players wearing modified headgear had a similar rate as those not wearing headgear, and those wearing IRB headgear had a relative rate of 1.11. A non-significant lower rate of concussion resulting in a missed game was observed with the modified headgear wearers. The incidence rate ratio for modified headgear wearers was 0.43 compared to no headgear, and approximately 0.4 compared to IRB wearers.

Variable	IRR	P-value	95% CI
Randomisation (comparisons among 3 groups, p=0.78)			
Control	(reference)		
Modified	1.13	0.65	0.67, 1.90
IRB	0.95	0.87	0.54, 1.69
Compliance (comparisons among 3 groups, p=0.74)			
Wore None	(reference)		
Wore modified	1.01	0.98	0.67, 1.69
Wore IRB	1.11	0.45	0.69, 1.21

Table 3.43: Univariate analysis of concussion across study arms (randomisation) and headgear use (compliance)

Variable	IRR	P-value	95% CI
Randomisation (comparisons among 3 groups, p=0.76)			
Control	(reference)		
Modified	0.73	0.50	0.30, 1.80
IRB	1.02	0.95	0.45, 2.32
Compliance (comparisons among 3 groups, p=0.45)			
Wore None	(reference)		
Wore modified	0.43	0.24	0.10, 1.76
Wore IRB	1.10	0.71	0.66, 1.83

Table 3.44: Univariate analysis of concussion resulting in a missed game across study arms (randomisation) and headgear use (compliance)

The statistical analysis indicates that modified headgear resulted in a non-significant reduction in the rate of head injury and concussion, as indicated by missed games. The incidence rate ratios for concussion for wearers of IRB headgear were greater than non-wearers and modified headgear wearers. For head injury, wearers of the IRB headgear had a slightly lower rate of head injury resulting in missed games compared to non-headgear wearers.

3.4.2 Head Injury and Concussion Rates – Player Position, Grade and Age Group

Rates of head injury and concussion are presented in tables 3.45 to 3.47 for selected variables, eg. player position, grade, level and season. The head injury rate was greatest for the halves, 4th grade/Ds, colts and in 2002, but the differences were not significant.

	Variable	No. Injury	Game time (1,000hr)	Injury Rate	95% CI
Player Position	Front Row	36	5.70	6.32	4.56, 8.75
	Back Five	76	9.50	8.00	6.39, 10.01
	Halves	44	3.93	11.19	8.33, 15.04
	Inside Backs	29	3.99	7.26	5.04, 10.45
	Outside Backs	47	5.60	8.39	6.30, 11.16
Grade	1st	95	11.67	8.14	6.66, 9.96
	2nd	81	9.68	8.36	6.73, 10.40
	3rd	22	4.04	5.44	3.58, 8.27
	4th/5th	36	3.47	10.37	7.48, 14.38
Level	Colts	110	12.85	8.56	7.10, 10.32
	Opens	59	7.31	8.07	6.25, 10.41
	U15	37	4.45	8.32	6.03, 11.48
	U13	28	4.25	6.59	4.55, 9.55
Season	2002	117	13.20	8.87	7.40, 10.63
	2003	117	15.67	7.47	6.23, 8.95

Table 3.45: Head injuries – Rates per 1,000 hours

The head injury rates were calculated by dividing the number of head injuries for the level of each factor, eg. player position, by the denominator of player game exposure time for each factor. For example, there were 36 head injuries to front row players in 5,700 hours of participation.

The head injury patterns are reflected in concussion rates, except that U15s had the highest rate of concussion. This means that the colts had a relatively greater, but not significant, proportion of superficial head injury than the school age players.

	Variable	No Injury	Game time (1,000hr)	Injury Rate	95% CI
Player Position	Front Row	31	5.70	5.44	3.82, 7.73
	Back Five	62	9.50	6.52	5.09, 8.37
	Halves	35	3.93	8.90	6.39, 12.40
	Inside Back	26	3.99	6.51	4.43, 9.56
	Outside Back	43	5.60	7.67	5.69, 10.35
Grade	1st	85	11.67	7.29	5.89, 9.01
	2nd	63	9.68	6.51	5.08, 8.33
	3rd	20	4.04	4.95	3.19, 7.67
	4th/5th	31	3.47	8.93	6.28, 12.70
Level	Colts	93	12.85	7.24	5.90, 8.87
	Opens	50	7.31	6.84	5.18, 9.02
	U15	34	4.45	7.64	5.46, 10.69
	U13	22	4.25	5.18	3.41, 7.87
Season	2002	98	13.20	7.43	6.09, 9.05
	2003	101	15.67	6.45	5.30, 7.83

Table 3.46: Concussions – rates per 1,000 hours

Player Position	No Injury	Game time (1,000hr)	Injury Rate	95% CI
Front Row	7	5.70	1.23	0.59, 2.58
Back Five	16	9.50	1.68	1.03, 2.75
Halves	7	3.93	1.78	0.85, 3.73
Inside Backs	5	3.99	1.25	0.52, 3.01
Outside Backs	14	5.60	2.50	1.48, 4.22
Grade				
1st	19	11.67	1.63	1.04, 2.55
2nd	15	9.68	1.55	0.93, 2.57
3rd	7	4.04	1.73	0.83, 3.63
4th/5th	8	3.47	2.30	1.15, 4.61
Level				
Colts	22	12.85	1.71	1.13, 2.60
Opens	15	7.31	2.05	1.24, 3.40
U15	9	4.45	2.02	1.05, 3.89
U13	3	4.25	0.71	0.23, 2.19

Table 3.47: Head injuries causing missed games by player position, grade and age group– Rates per 1,000 hours

Univariate analyses of the relative rate of head injury, concussion and head injury resulting in missed games were performed for the factors: player position, grade, level and season. The results are presented in tables 3.48 to 3.50. Except for the effect of grade on head injury rate, with 3rd. grade having the lowest incidence rate ratio, no other statistically significant effects were observed. The data reinforce the observation that the risk of injury, including concussion, head injury and head injury resulting in missed games, was lowest for the U13 players, with the rate of concussion the highest for U15 players. Halves and outside backs had the highest incidence rate ratio amongst player positions with respect to concussion. Front row players had the lowest rate of concussion.

Player position (comparisons among 5 positions, p=0.11)			
Front row	(reference)		
Back five	1.27	0.21	0.87, 1.84
Halves	1.77	0.03	1.06, 2.96
Inside back	1.15	0.52	0.75, 1.76
Outside back	1.33	0.11	0.94, 1.87
Grade (comparisons among 4 grades, p=0.03)			
1st	(reference)		
2nd	1.03	0.88	0.73, 1.44
3rd	0.67	0.06	0.44, 1.02
4th/5th	1.27	0.20	0.88, 1.84
Level (comparisons among 4 levels, p=0.63)			
Colts	(reference)		
Opens	0.94	0.80	0.60, 1.48
Under-15	0.97	0.91	0.59, 1.60
Under-13	0.77	0.27	0.48, 1.23
Season			
2002	(reference)		
2003	0.84	0.31	0.60, 1.18

Table 3.48: Univariate analysis of head injuries by player position, grade, age group and season.

Variable	IRR	P-value	95% CI
Player position (comparisons among 5 positions, p=0.17)			
Front row	(reference)		
Back five	1.37	0.52	0.53, 3.58
Halves	1.45	0.46	0.55, 3.85
Inside back	1.02	0.97	0.44, 2.37
Outside back	2.03	0.08	0.92, 4.49
Grade (comparisons among 4 grades, p=0.72)			
1st	(reference)		
2nd	0.95	0.85	0.57, 1.60
3rd	1.06	0.91	0.37, 3.05
4th/5th	1.42	0.37	0.66, 3.03
Level (comparisons among 4 levels, p=0.22)			
Colts	(reference)		
Opens	1.20	0.58	0.64, 2.26
Under-15	1.18	0.63	0.59, 2.35
Under-13	0.41	0.08	0.15, 1.13

Table 3.49: Univariate analysis of head injuries causing missed games by player position, grade and age group.

Variable	IRR	P-value	95% CI
Player position (comparisons among 5 positions, p=0.10)			
Front row	(reference)		
Back five	1.20	0.32	0.84, 1.72
Halves	1.64	0.06	0.98, 2.73
Inside back	1.20	0.40	0.79, 1.82
Outside back	1.41	0.06	0.99, 2.01
Grade (comparisons among 4 grades, p=0.17)			
1st grade	(reference)		
2nd grade	0.89	0.54	0.62, 1.28
3rd grade	0.68	0.12	0.42, 1.11
4th/5th	1.23	0.31	0.83, 1.81
Level (comparisons among 4 levels, p=0.43)			
Colts	(reference)		
Opens	0.95	0.82	0.58, 1.53
Under-15	1.06	0.85	0.61, 1.83
Under-13	0.72	0.23	0.42, 1.23

Table 3.50: Univariate analysis of Concussions by player position, grade and age group.

3.4.3 Multivariate Analysis of Head Injury and Concussion Rate.

Multivariate analyses using Poisson regression of head injury rates, game and missed game rates, using the independent variables randomisation or compliance and adjusted for age group did not reveal any significant relationships. The analysis reinforced that the relative rate of head injury resulting in a missed game was lower for players wearing the modified headgear after taking into account their age group (tables 3.43 & 3.44). The analyses also suggest that the rate of head injury, head injury resulting in missed games and concussion (table 3.45) was highest for players measured wearing IRB headgear, after taking into account age group. As stated, these are only trends, and are not statistically significant.

Variable	IRR	Adjusted IRR	P-value	95% CI
Randomisation (*p=0.48, **p=0.48)				
Control	(reference)			
Modified	1.10	1.09	0.70	0.69, 1.72
IRB	0.84	0.83	0.49	0.49, 1.41
Compliance (*p=0.72, **p=0.66)				
Wore None	(reference)			
Wore modified	0.99	1.03	0.91	0.67, 1.58
Wore IRB	1.11	1.14	0.41	0.84, 1.54

Table 3.51: Multivariate analysis of head injuries adjusting for age group, Colts/Open/U-15/U-13. P-values for comparisons among 3 groups in *univariate and **multivariate analyses

Variable	IRR	Adjusted IRR	P-value	95% CI
Randomisation (*p=0.81, **p=0.81)				
Control	(reference)			
Modified	0.74	0.75	0.55	0.29, 1.92
IRB	0.97	0.98	0.97	0.42, 2.28
Compliance (*p=0.41, **p=0.49)				
Wore None	(reference)			
Wore modified	0.41	0.46	0.27	0.12, 1.83
Wore IRB	1.10	1.14	0.62	0.68, 1.91

Table 3.52: Multivariate analysis of head injuries causing missed games adjusting for age group, Colts/Open/U-15/U-13 P-values for comparisons among 3 groups in *univariate and **multivariate analyses

Variable	IRR	IRR Adjusted	P-value	95% CI
Randomisation (*p=0.78, **p=0.78)				
Control	(reference)			
Modified	1.13	1.12	0.69	0.65, 1.91
IRB	0.95	0.94	0.85	0.52, 1.72
Compliance (*p=0.74, **p=0.67)				
Wore None	(reference)			
Wore modified	1.01	1.06	0.80	0.70, 1.60
Wore IRB	1.11	1.13	0.37	0.86, 1.49

Table 3.53: Multivariate analysis of concussions adjusting for age group, Colts/Open/U-15/U-13. P-values for comparisons among 3 groups in *univariate and **multivariate analyses

3.5 Analysis of the influence of Headgear and other factors on Head, Neck and Facial Injury

Statistical analyses were undertaken to examine relationships between the following variables:

Independent Variables	**Dependent Variables**
Randomisation	Neck injury rate
Compliance (headgear use)	Facial injury rate
Age group / Level of play	Head and neck injury rate
Grade	Head, neck and facial injury rate
Season	
Player position	

There were some significant differences observed between the rate of facial injury when analysed according to the independent variables listed above. There was a significantly increased rate of facial injury for the back five compared to all other player positions and under 13s had a significantly lower rate of facial injury. Headgear did not influence facial injury rates. There were only 12 facial injuries that resulted in a player missing a game (rate = 0.42 per 1,000 player hours). There were no statistically significant factors associated with these injuries (table 3.54).

	IRR	p-value	95% CI	
Player position (comparisons among 5 groups, p=0.001)				
Front row	(reference) Rate = 6.67 per 1,000 hrs			
Back five	1.55	0.004	1.15	2.07
Halves	1.07	0.80	0.64	1.79
Inside back	0.86	0.55	0.53	1.40
Outside back	0.94	0.77	0.60	1.46
Level (comparisons among 4 groups, p=0.06)				
Colts	(reference) Rate = 8.25 per 1,000 hrs			
Opens	1.14	0.61	0.69	1.91
Under-15	0.76	0.37	0.42	1.38
Under-13	0.57	0.07	0.31	1.06

Table 3.54: Analysis of rate of facial injury (all) versus player position and level of play.

There were a number of significant differences observed between the rates of all neck injuries and lost time neck injuries calculated on study arm and headgear wearing patterns (tables 3.55 and 3.56). In all, 96 neck injuries were reported at an overall rate of 3.33 per 1,000 hrs (95% CI = 2.72 to 4.06). There were only 22 neck injuries resulting in a player missing a game, resulting in an overall rate of 0.76 per 1,000 hours. The rates of all and missed time neck injuries for players randomised to the IRB headgear arm of the study were significantly lower than in the two other arms. The rate ratio for the IRB arm of the study demonstrated an 80% reduction compared to the control arm for missed game injuries. However, this difference did not exist when neck injury rates were calculated based on compliance. When neck injury rates were compared based on actual headgear wearing patterns, the modified headgear wearers had the greatest rate of all neck injuries, at 2.59 times non-wearers. This increased rate of all neck injuries was significant ($p=0.003$). For missed game injuries, the IRB and modified headgear wearers had the higher rates of neck injuries than non-wearers, however these were not significant.

The analysis of all neck injuries showed that the front row had the greatest rates of injury and the backs had a significantly lower rate of neck injury. All missed game neck injuries occurred to forwards; due to this and the low absolute number of injuries, a statistical analysis was not possible. It was also not possible to analyse neck injuries related to headgear use after controlling for player position. It is possible that the data were confounded by more forwards wearing headgear. No significant differences were observed based on analyses of grade, level or season.

Variable	IRR	p-value	95% CI	
Randomisation group (comparisons among 3 groups, p=0.01)				
Control	(reference) Rate = 4.08 per 1,000 hrs			
Modified	0.92	0.79	0.50	1.68
IRB	0.45	0.01	0.24	0.85
Compliance (comparisons among 3 groups, p=0.01)				
Control	(reference) Rate = 2.54 per 1,000 hrs			
Modified	2.59	0.003	1.38	4.85
IRB	1.40	0.12	0.92	2.13
Player position (comparisons among 5 groups, p=0.0002)				
Front row	(reference) Rate = 5.09 per 1,000 hrs			
Back five	0.85	0.46	0.55	1.32
Halves	0.25	0.001	0.11	0.55
Inside back	0.44	0.05	0.19	1.02
Outside back	0.42	0.03	0.19	0.94

Table 3.55: All neck injuries univariate analysis (Rate ratios analysed using Poisson regression with robust standard errors calculated to allow for randomization by team)

Variable	IRR	p-value	95% CI	
Randomisation group (comparisons among 3 groups, p=0.06)				
Control	(reference) Rate = 1.19 per 1,000 hrs			
Modified	0.63	0.36	0.23	1.71
IRB	0.20	0.02	0.05	0.79
Compliance (comparisons among 3 groups, p=0.12)				
Control	(reference) Rate = 0.46 per 1,000 hrs			
Modified	3.00	0.05	1.01	8.93
IRB	2.10	0.16	0.74	5.96

Table 3.56: Neck injuries resulting in missed games: Univariate analysis (Rate ratios analysed using Poisson regression with robust standard errors calculated to allow for randomization by team)

When the body regions head and neck were combined, there were few overall significant factors. The associations observed with neck injuries became trends, eg. backs had a lower non-significant relative rate of head and neck injury compared to forwards, and there was a significant difference in rates based on grade of play, however with no specific trend within the four grades.

Significant differences were observed with head and face injury rates for divisions based on player position and level of play, but not for study arm or headgear use (table 3.57). The under 13s had the lowest rate of all head and face injuries compared to the other levels of play. The back five and halves had statistically significantly higher rates of all head and facial injury compared to other player positions. However, the outside backs had the highest rate of head and face injury resulting in a missed game ($p=0.04$), which was roughly double that of other player positions (table 3.58).

	No. Injuries	Game time (1,000hr)	Rate	95% CI
Player position (comparisons among 5 groups, p=0.02)				
Front row	(reference) Rate =12.98			
Back five	1.41	0.004	1.11	1.79
Halves	1.41	0.06	0.98	2.03
Inside back	1.00	0.99	0.72	1.40
Outside back	1.13	0.45	0.82	1.54
Level (comparisons among 4 groups, p=0.04)				
Colts	(reference) Rate = 16.80 per 1,000 hrs			
Opens	1.04	0.84	0.69	1.57
Under-15	0.87	0.55	0.55	1.37
Under-13	0.67	0.08	0.43	1.04

Table 3.57: Analysis of all head and face injuries.

Variable	IRR	p-value	95% CI	
Player position (comparisons among 5 groups, p=0.003)				
Front row	(reference) Rate = 1.58 per 1,000 hrs			
Back five	1.13	0.81	0.40	3.17
Halves	1.29	0.64	0.45	3.70
Inside back	1.11	0.82	0.45	2.74
Outside back	2.26	0.04	1.03	4.98

Table 3.58: Lost time head and face injuries

The body regions head, face and neck were combined to analyse all and missed game injury rates by headgear (randomisation and compliance), player position, level of play, grade and season. The overall rate of head, face and neck injury was 19.2 per 1,000 hours for all injuries and 2.9 per 1,000 hours for missed game injuries.

For all injuries to the head, face and neck significant differences in injury rates were observed when rates were calculated for the randomised arm of the study (table 3.59). The control group had the highest rate with the IRB arm having the lowest rate (IRR = 0.71). When the analysis was repeated for compliance no significant differences were observed.

There were marginally significant differences, $0.1 > p > 0.05$, for analyses of player position and grade. The back five and $4^{th}/5^{th}$ grades had the greatest rates of injury by player position and grade, respectively. No significant differences were observed with season or level of play. The trend indicated lower injury rates for the U13 and U15 age groups.

Analyses of rates of missed game injuries for the head, face and neck showed no significant effects for headgear, either randomisation or compliance, level of play, grade, player position and season.

Variable	IRR	p-value	95% CI	
Randomisation group (comparisons among 3 groups, p=0.09)				
Control	(reference) Rate = 21.31 per 1,000 hrs			
Modified	0.95	0.79	0.63	1.42
IRB	0.71	0.12	0.47	1.09
Compliance (comparisons among 3 groups, p=0.43)				
Control	(reference) Rate = 17.70 per 1,000 hrs			
Modified	1.19	0.38	0.81	1.76
IRB	1.15	0.19	0.93	1.43
Player position (comparisons among 5 groups, p=0.06)				
Front row	(reference) Rate = 18.07 per 1,000 hrs			
Back five	1.25	0.03	1.02	1.53
Halves	1.08	0.60	0.80	1.47
Inside back	0.85	0.28	0.62	1.15
Outside back	0.93	0.58	0.71	1.21
Grade (comparisons among 4 groups, p=0.07)				
1st	(reference) Rate =18.34 per 1,000 hrs			
2nd	1.04	0.74	0.84	1.28
3rd	0.96	0.78	0.71	1.30
4th/5th	1.32	0.07	0.98	1.77
Level (comparisons among 4 groups, p=0.25)				
Colts	(reference) 2.38 per 1,000 hrs			
Opens	1.01	0.97	0.68	1.49
Under-15	0.86	0.49	0.56	1.32
Under-13	0.73	0.17	0.46	1.14
Season				
2002	(reference) 19.02 per 1,000 hrs			
2003	1.01	0.91	0.81	1.27

Table 3.59: Head & neck & face injuries (all): Univariate analysis (Rate ratios analysed using Poisson regression with robust standard errors calculated to allow for randomization by team)

3.6 Summary of RCT Trial and Headgear Effects

The following is a point summary of the findings of the randomised controlled study regarding the effectiveness of headgear.

1. An RCT study of padded headgear was conducted in Sydney, Australia, in 2002 and 2003. There were three arms in the study: controls, IRB approved headgear and modified headgear. Eighty teams participated in the study in each year in the following age groups: under 13s, under 15s, school opens (under 18) and colts (under 21). There were 1976 players in 2002 and 1955 players in 2003. The median number of games per participant was nine.
2. Injuries at the game and those resulting in a player missing a game were recorded, as were player participations, game time, and headgear wearing for each participant in the study. The focus was on head injuries.
3. Analyses of the effect of headgear on head injury and concussion showed no significant effects. Headgear neither decreases nor increases the rate of head injury or concussion significantly. Two non-significant trends emerged, however, it must be stressed that other factors also influence return to play decisions after head injury. The trends are:
    a. Players wearing the modified headgear had the lowest rate of head injury resulting in a missed game. The incidence rate ratio for concussion for modified headgear wearers was 0.43 compared to no headgear (reference) and IRB headgear 1.1. This suggests that the severity of the head injury or concussion was reduced for modified headgear wearers compared to players either wearing IRB approved headgear or no headgear.
    b. Second, players wearing IRB approved headgear had a slightly higher rate of head injury resulting in a missed game than those not wearing headgear
4. Statistically significant relationships were observed with regards to head injury rates and other independent variables. Players in the under 13 age group had the lowest rate of head injury resulting in a missed game. The halves and outside backs had the highest rate of concussion resulting in a missed game.
5. Headgear use was not correlated with an increase in the overall rate of injury, however an analysis of combinations of head, face and neck injury identified significant differences in injury rates. These were:
    a. The rate of all neck injuries was greatest for headgear wearers. The modified headgear wearers had a greater rate of both all and missed game neck injuries, however, the rate was only significant for all neck injuries. Players not wearing headgear had the lowest rates of all and missed game injuries;
    b. The comparison of neck injury rates, all and missed games, for randomisation showed that the IRB headgear arm of the study had a statistically significant lower rate of injury compared to the other two arms;
    c. The front row, followed by back five had the highest rates of all neck injury, by player position ($p < 0.01$). The back five had the highest rate of all facial

injury, and the back five and halves had the highest rates of all head and neck injury. Interestingly, the outside backs had the highest rate of missed game head and face injuries ($p=0.003$). Therefore the forwards sustain more injuries, but the outside backs more severe head and facial injury; and,

d. 4^{th} and 5^{th} grades had the highest rate of head/face and neck injury by grade.

6. The grouping of head and facial injury with neck injury appears to hide the differences in injury rates that are observed for analyses of headgear, player position, grade and level of play. This reinforces what is known biomechanically that the mechanisms of neck injury are different to the mechanisms of the head or facial injury.

CHAPTER 4

RESULTS – ATTITUDES SURVEYS

Surveys of players using a standardised questionnaire were conducted in 2002 and 2003. The surveys were conducted at the beginning and end of each season. The data were combined and the most relevant results are presented in the following sections. Further analyses are planned with the survey information.

4.1 Pre-Season Surveys (2002 and 2003)

A total of 1,414 players participated in the pre-season survey. In 2002 there were 679 participants and in 2003 there were 732 participants (table 4.1).

Year of Survey							
not entered		2002		2003		Total	
n	%	n	%	n	%	n	%
3	.2%	679	48.0%	732	51.8%	1414	100.0%

Table 4.1: Numbers of participants in pre-season surveys.

The participants reflected a typical cross-section of players by position in a team (table 4.2).

What position do you normally play?	Year of Survey			
	2002	2003	2002-2003	
	n	n	n	%
Not Recorded	16	14	30	2.1%
Fullback	76	82	158	11.2%
Halfback	39	44	83	5.9%
Centres	89	57	146	10.3%
Prop	91	108	199	14.1%
Number 8	69	38	107	7.6%
Second Row	63	65	128	9.1%
Five Eighth	43	53	96	6.8%
Wing	50	70	120	8.5%
Flanker	109	162	271	19.2%
Hooker	34	39	73	5.2%
Total	679	732	1411	100.0%

Table 4.2: Player positions for players that participated in the pre-season survey.

Players were asked whether they normally wore protective equipment. Sixty-four percent of players reported always wearing protective equipment (table 4.3). Players were asked to indicate form a list when they wore a particular type of equipment. Table 4.4 shows that 90% of players reported wearing mouthguards in games, while few players wore shoulder pads or taped their joints.

		Year of Survey			
		2002	2003	Total	
		n	n	n	%
Do you normally wear protective equipment	Not Recorded	11	11	22	1.6%
	Always	465	434	899	63.7%
	Often	81	133	214	15.2%
	Sometimes	55	82	137	9.7%
	Rarely	31	38	69	4.9%
	Never	36	34	70	5.0%

Table 4.3: Players' use of protective equipment.

Equipment	When equipment used	% of Players
Headgear	Training	1%
	Games	26%
	Both	35%
	Never	38%
Shoulder pads	Training	0%
	Games	22%
	Both	11%
	Never	67%
Mouthguards	Training	1%
	Games	25%
	Both	65%
	Never	9%
Taping of joints	Training	1%
	Games	19%
	Both	8%
	Never	72%

Table 4.4: Details of protective equipment use.
2002 and 2003 data were combined (n=1410).

With regards to mouthguards 37% of players wore a 'boil and bite' type of mouthguard, 55% wore a dentist supplied and fitted mouthguard and 8% reported not wearing mouthguards.

4.1.1 Headgear Wearers

In total 60% of players reported having worn headgear for the majority of the previous season (table 4.5). This indicated a high pre-existing headgear wearing rate in rugby in Sydney, independent of the study.

		Year of Survey			
		2002	2003	total	
		n	n	n	%
Did you wear headgear last season	Not recorded	23	13	36	2.6%
	Yes	385	462	847	60.1%
	No	270	257	527	37.4%

Table 4.5: Headgear wearing history.

Players that had worn headgear in the previous football season were asked to nominate from a list the two most important reasons for wearing headgear. Only 1,192 reasons were provided, indicating that not every player provided two reasons. The responses were combined and the proportion of headgear wearers who provided a specific response was calculated as a percent of the number of headgear wearers. The two most important reasons were "I feel safer when I wear headgear" and "I don't want to get an injury" (table 4.6).

Two most important reasons for wearing headgear	% of Players
I feel safer when I wear one	55%
I don't want to get an injury	52%
I like to	17%
I have had a previous injury	12%
Coaches advice	2%
Medical advice	2%
My school makes me	1%
Everyone in my team does	0%
Other	0%
My favorite player wears headgear	0%

Table 4.6: Players' reasons for wearing padded headgear.
(1,192 responses from 847 players in 2002 and 2003)

Headgear wearing players provided responses using a 5 point scale to questions regarding the effects of headgear on their performance and their beliefs regarding the benefits of wearing headgear. The results are presented in table 4.7. Sixty percent of players believed that headgear could always or often prevent injury and 80% of players felt always or often safer wearing headgear. Interestingly, 66% of headgear wearing players believed that they could always or often play more confidently and tackle harder (55%).

		Year			
		2002	2003	Total	
When wearing headgear…		n	n	n	Table %
Do you think headgear can prevent injuries	Always	58	81	139	15.9%
	Often	170	214	384	43.8%
	Sometimes	149	172	321	36.6%
	Rarely	11	17	28	3.2%
	Never	2	2	4	0.5%
Do you feel safer?	Always	174	187	361	41.4%
	Often	136	187	323	37.1%
	Sometimes	66	91	157	18.0%
	Rarely	9	12	21	2.4%
	Never	5	4	9	1.0%
Do you play more confidently?	Always	136	143	279	32.0%
	Often	119	170	289	33.1%
	Sometimes	84	111	195	22.4%
	Rarely	26	30	56	6.4%
	Never	26	27	53	6.1%
Do you feel you can tackle harder?	Always	110	133	243	27.9%
	Often	103	143	246	28.2%
	Sometimes	87	108	195	22.4%
	Rarely	35	51	86	9.9%
	Never	54	47	101	11.6%
Does your head become a target?	Yes	28	22	50	5.8%
	No	360	458	818	94.2%

Table 4.7: Attitudes of players who wore headgear in the previous season regarding on-field performance and safety (n = 847 players).

The results presented in table 4.8 show that for players who regularly wore headgear at the time of the surveys, weight and comfort were not major issues. Players reported that their heads felt hotter while wearing headgear. Players were also not subject to negative comments while wearing headgear, but headgear was grabbed during a tackle.

When wearing headgear…		Year			
		2002	2003	Total	
		n	n	n	Table %
Does your head feel uncomfortable?	Always	14	9	23	2.6%
	Often	26	43	69	7.9%
	Sometimes	118	131	249	28.6%
	Rarely	141	183	324	37.2%
	Never	90	116	206	23.7%
Does your head feel hotter?	Always	82	105	187	21.5%
	Often	116	146	262	30.1%
	Sometimes	130	156	286	32.9%
	Rarely	45	47	92	10.6%
	Never	16	27	43	4.9%
Does your head feel heavier?	Yes	46	62	108	12.5%
	No	339	418	757	87.5%
Has it been grabbed during a tackle?	Yes	175	177	352	40.3%
	No	215	306	521	59.7%
Have you experienced negative comments	Yes	30	32	62	7.1%
	No	360	450	810	92.9%

Table 4.8: Attitudes of players who wore headgear in the previous season (n = 847 players) regarding comfort.

The features that make players select a particular type of headgear are shown in table 4.9. Those players that had worn headgear in the previous year were asked to nominate two reasons. However, not every player provided two reasons, which explains why the percentages do not sum to 200%. Cost and appearance were the two most important reasons that informed selection of headgear.

What features make you select a brand of headgear ?	Its looks and appearance	52%
	How much it costs	35%
	Information about its safety performance	28%
	How heavy it feels	25%
	The size of the headgear	11%
	Its colour	9%
	If a national or state representative wears it	4%

Table 4.9: Rating of features that headgear wearers use to inform their choice of headgear (n=847 players).

4.1.2 Non-Headgear Wearers

Players that reported not wearing headgear were asked to identify the two most appropriate reasons from a list that explained their decision not to wear headgear in the previous season. Tables 4.10 and 4.11 provide a summary of the responses for 2002 and 2003 combined. The players indicated that headgear was too hot and uncomfortable. Players indicated that they might commence wearing headgear if they became injured or they received medical advice. The reasons given are compatible with the reasons given by players who already wear headgear as they relate to injury prevention and safety. The responses indicate that players associate headgear with injury management or prevention. Peer or team pressure does not appear to be a factor that would influence a player to wear headgear.

Two reasons why headgear was not worn	% of players
It is too hot	39%
It is too uncomfortable	38%
I don't like it	22%
I don't need to	11%
They are too expensive	9%
It is too heavy	5%
They don't work	3%
Only wimps wear them	3%
No-one else in my team does	0%

Table 4.10: Reasons why players do not wear headgear (n=527).

Two reasons why player would begin to wear headgear	% of players
If I had an injury	46%
Advice from medical staff	43%
If my school/coach made me	15%
If my parents made me	10%
If they were better designed	8%
If they did not cost too much	7%
If the rest of the team wore them	1%

Table 4.11: Reasons why a player might decide to start wearing headgear (n=527).

4.1.3 Factors influencing attitudes towards headgear

Survey data from 2002 and 2003 were combined and analysed according to factors that might influence a player's decision to wear headgear, eg. age group, position in team, and grade. There were 847 players who reported wearing headgear in the previous season and the majority completed all appropriate questions.

Table 4.12 presents headgear use against player position. In general, the loose forwards (no. 8 and flankers) exhibited the highest wearing rates, with forwards wearing headgear more so than backs. School age players had the higher relative wearing rates compared to colts (table 4.13).

	Players who wore headgear during previous season	
Position	**n**	**Proportion of players in that position wearing headgear (%)**
Number 8	83	81.4
Second row	93	75.6
Hooker	52	73.2
Prop	130	68.1
Flanker	179	67.3
Centre	78	55.3
Fullback	80	52
Five eighth	46	47.9
Wing	56	47.1
Halfback	39	47

Table 4.12: Player position and relationship to headgear usage.
All age groups combined (n=836)

Position	Players who wore headgear during previous season	
	n	Proportion of players in that level (%)
Association side	94	57.7
Australian representative	18	58.1
Colts	137	53.3
NSW representative	79	64.2
School A's	340	68.0
School B's	102	62.2
School 1st 15	34	69.4
Not stated	6	46.2

Table 4.13: Highest level played and relationship to headgear usage (n=810)

There was a reduction in the proportion of players who believed that headgear could always or often prevent injury from 70% of 12-13 year olds to 54% of players aged over 18 years (table 4.14). There was also a decline in the proportion of players who expressed that they always or often felt safer while wearing headgear from 83% of 12-13 year olds to 70% of players aged over 18 years.

Age in years	% of Respondents				
	Always	Often	Sometimes	Rarely	Never
12-13 (n=201)	23.4	46.8	25.3	4.0	0.5
14-15 (n=225)	15.1	47.5	34.7	1.8	0.9
16-18 (n=264)	11.7	42.1	41.3	4.5	0.4
> 18 (n=124)	13.7	39.5	45.2	1.6	0

Table 4.14: Players' responses preseason to the question "Do you think headgear can prevent injury?" (n=814).

Age in years	% of Respondents				
	Always	Often	Sometimes	Rarely	Never
12-13 (n=200)	48.5	34.5	12.0	4.0	1.0
14-15 (n=224)	45.5	37.1	13.8	1.4	2.2
16-18 (n=263)	35.0	40.7	20.9	2.6	0.8
> 18 (n=123)	35.8	34.1	28.5	1.6	0

Table 4.15: Players' responses preseason to "Do you feel safer wearing headgear?" (n=810)

The proportion of players who reported always or often playing more confidently while wearing headgear reduced slightly from 69% for 12-13 year olds to 63% for those aged over 18s (table 4.16). A reduction in the players who reported always or often being able to tackle harder while wearing headgear was observed from 61% of 12-13 year olds to 46% of those of 18 (table 4.17).

Age in years	% of Respondents				
	Always	Often	Sometimes	Rarely	Never
12-13 (n=201)	33.8	34.8	19.9	4.5	7.0
14-15 (n=225)	34.2	32.4	18.7	7.6	7.1
16-18 (n=264)	30.3	30.7	26.9	6.8	5.3
> 18 (n=123)	31.7	30.9	24.4	7.3	5.7

Table 4.16: Players' responses preseason to "Do you play more confidently if you are wearing headgear?" (n=813)

Age in years	% of Respondents				
	Always	Often	Sometimes	Rarely	Never
12-13 (n=199)	33.2	28.1	19.1	8.0	11.6
14-15 (n=225)	32.0	28.9	20.9	5.8	12.4
16-18 (n=264)	25.0	26.5	24.2	12.5	11.8
> 18 (n=123)	23.6	22.0	26.8	13.8	13.8

Table 4.17: Players' responses preseason to "Do you feel that you could tackle harder while wearing headgear?" (n=811)

With regards to player comfort while wearing headgear, as a proportion of the age group fewer younger players reported that headgear made their head feel hotter or heavier than the older players (tables 4.18 and 4.19). A greater proportion of older than younger players also reported that opponents tried to pull the headgear off or that they were targeted because they wore headgear (tables 4.20 and 4.21).

Age in years	Frequency of players answering "Yes"	Proportion (%)
12-13 (n=197)	15	7.6
14-15 (n=222)	23	10.4
16-18 (n=263)	38	14.4
> 18 (n=122)	25	20.5

Table 4.18: Players' responses preseason to "Did your head feel heavier while wearing headgear?" (n=804)

Age in years	% of Respondents				
	Always	Often	Sometimes	Rarely	Never
12-13 (n=200)	20.5	21.0	30.5	18.5	9.5
14-15 (n=224)	19.6	32.6	30.4	11.2	6.2
16-18 (n=263)	23.9	28.9	37.3	7.2	2.7
> 18 (n=122)	26.2	36.1	32.8	4.1	0.8

Table 4.19: Players' responses preseason to "Did your head feel hotter while wearing headgear?" (n=809)

Age in years	Frequency of players answering "Yes"	Proportion (%)
12-13 (n=201)	31	15.4
14-15 (n=225)	75	33.3
16-18 (n=263)	141	53.6
> 18 (n=123)	78	63.4

Table 4.20: Players' responses preseason to "Were there any instances when the opposition grabbed your headgear?" (n=812)

Age in years	Frequency of players answering "Yes"	Proportion (%)
12-13 (n=200)	8	4.0
14-15 (n=222)	12	5.4
16-18 (n=263)	13	4.9
> 18 (n=123)	13	10.6

Table 4.21: Players' responses preseason to "Do you feel your head becomes a target for opposition players when you wear headgear?" (n=808)

In summary, the younger the player the more confidence they have in the injury prevention potential of headgear, the more they believe that it might assist their performance, and the less headgear is uncomfortable compared to older players.

4.2 End of Season Survey

End of season surveys were conducted in 2002 and 2003. The reduction in the number of respondents compared to pre-season was due to the great difficulties involved in bringing the players together once the season had finished, or during the last few training sessions, when the coaches did not want distractions. An insert was also included for players who had worn the modified headgear during the season.

4.2.1 2002 Season

322 players completed the 2002 end-of-season survey. As for the other surveys, not every respondent completed each question. In table 4.22, 58% of players agreed or strongly agreed that headgear wearers were less likely to be injured and 49% disagreed or strongly disagreed that headgear wearers could play harder, ie. they believed they could not play harder. They also believed that experienced players also needed to consider wearing headgear.

	% of Respondents				
Attitude Questions	**Strongly agree**	**Agree**	**Neither agree or disagree**	**Disagree**	**Strongly disagree**
Do you think headgear wearers are less likely to get injured	15.9	41.4	30.9	8.6	3.2
Do you think wearing headgear restricts performance	7.0	21.7	29.3	29.3	12.7
Do you think headgear wearers can play harder	3.8	12.8	34.5	28.8	20.1
Would you rather risk injury than wear headgear	2.6	9.3	18.8	36.1	33.2
Experienced players do not need to wear headgear	1.6	2.8	12.8	41.4	41.4

Table 4.22: Players' attitudes to headgear usage (n=314)

About fifty percent of players reported that all players, regardless of age, should wear headgear during games (27 to 31% undecided). There was less support for wearing headgear at training.

Age group and situation	(%)		
	Yes	No	Undecided
Players aged 18 years and over during games	50.0	19.2	30.8
Players aged 18 years and over during training	27.3	40.6	32.1
Players under 18 years during games	52.2	20.9	26.9
Players under 18 years during training	29.1	37.6	33.3

Table 4.23: Should headgear be worn in the following circumstances (n=312)

Two hundred and three players (63 %) wore headgear in season 2002. These players were asked to choose from a designated list their two most important reasons for wearing it. There were 313 reasons documented. Again, the percentages do not add to 200%, due to the failure of each respondent to provide two answers. Table 4.24 displays the reasons chosen for headgear use. The two most commonly reported reasons were "I don't want to get an injury" (29 %) and "I feel safer when wearing one" (27 %). These are consistent with the pre-season surveys.

Reasons	n	%
Parents make me	28	9.0
I don't want to get an injury	90	28.8
School makes me	2	0.6
Everyone on my team does	2	0.6
Coaches advice	2	0.6
Feel safer when wearing one	85	27.2
Previous injury	32	10.2
I like to	54	17.3
Favourite player wears headgear	1	0.3
Medical advice	1	0.3
It was free	14	4.5
Part of university study	2	0.6

Table 4.24: Reported reasons for protective headgear use (n=313)

Of the 203 players who wore headgear during the 2002 season, 185 of them completed the part of the survey dealing with their headgear usage experiences and beliefs. Forty-five percent of players believed that headgear could always or often prevent injury and 66% felt always or often safer wearing headgear (table 4.25).

Headgear usage beliefs	% of Respondents				
	Always	Often	Sometimes	Rarely	Never
Do you think headgear can prevent injury?	8.1	36.8	45.9	7.0	2.2
Have you experienced any communication difficulties while wearing headgear?	1.6	11.9	31.4	29.7	25.4
Did your head feel heavier while wearing headgear?	2.7	8.2	20.6	31.0	37.5
Did your head feel hotter while wearing headgear?	27.2	30.4	32.6	6.5	3.3
Do you feel safer wearing headgear?	33.0	33.0	27.5	4.3	2.2
Do you play more confidently if you are wearing headgear?	33.7	29.9	21.7	8.7	6.0
Do you feel that you could tackle harder while wearing headgear?	24.9	23.2	27.0	9.2	15.7

Table 4.25: Headgear usage beliefs from the end of season survey. (n=185)

Seventy-seven percent of players did not believe that headgear affected the way they played rugby (table 4.26). The same proportion did not believe that they could tackle another player who wore headgear harder. Players did report that other players tried to pull off the headgear (46%), but did not believe that their head was a target for the opposition because they were wearing headgear (89%).

Headgear beliefs and experiences	Yes	No
	%	
Did the headgear affect the way you play?	23.2	76.8
Were there any instances where opposition players grabbed or pulled the headgear off?	45.9	54.1
Have you ever experienced negative comments about wearing headgear?	5.4	94.6
Do you feel your head becomes a target for opposition players when you wear headgear?	10.8	89.2
Do you think headgear improves overall match performance?	47.0	53.0
Do you feel you can tackle someone else harder if they are wearing headgear?	22.7	77.3

Table 4.26: Headgear usage experiences. The percent (%) of responses for each question are presented)

The 115 players who did not wear headgear in season 2002 were asked to give two reasons for this. Overall, there were 173 reasons reported for not wearing headgear (table 4.27). The two most commonly reported reasons were "too hot" (30.1%) and "too uncomfortable" (26.6%). This is similar to the pre-season survey. Only 12% believed that headgear "didn't work".

Reasons	n	%
Too heavy	10	5.8
Too uncomfortable	46	26.6
Too hot	52	30.1
They don't work	21	12.1
Too expensive	7	4.0
I don't like it	27	15.6
No-one else in team does	1	0.6
I don't need to	4	2.3
Only wimps wear them	2	1.2
Others	3	1.7

Table 4.27: Most important reasons why non-users did not wear headgear (n=173)

Seventy-six (76) of the players who did not use headgear reported reasons they would commence wearing headgear. The most commonly reported reason was "If I had an injury" (68.4%).

4.2.2 2003 Season

Two hundred and fifty-four (254) players completed the 2003 end-of-season survey. Even though different strategies were tried in 2003 to obtain more respondents, the number was not increased compared to 2002. The reasons for this are unknown. Perhaps there was a waning interest from the clubs and schools that had otherwise provided two years of solid cooperation.

Sixty percent of players at the end of the 2003 season agreed or strongly agreed that headgear wearers were less likely to get injured (table 4.28). Only 35% of players agreed or strongly agreed that headgear wearers could play harder.

Headgear usage beliefs	% of Respondents				
	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
Do you think headgear wearers are less likely to get injured	20.5	39.8	23.3	12.4	4.0
Do you think wearing headgear restricts performance	9.3	14.9	27.0	30.7	18.1
Do you think headgear wearers can play harder	15.0	20.2	30.8	17.0	17.0
Would you rather risk injury than wear headgear	9.0	9.8	20.9	24.6	35.7
Experienced players do not need to wear headgear	4.5	4.9	13.8	29.3	47.5

Table 4.28: Players' attitudes to headgear usage

In 2003, 45% of players reported that players aged over 18 years should wear headgear in a game, compared to 55% who believed that players under 18 years of age should wear headgear during a game (table 4.29).

One hundred and one players (59.4% of those surveyed) wore headgear in the 2003 season. Of these, 15 (9.9%) were wearing headgear for the first time. Their beliefs and attitudes at the end of the 2003 season are reported in table 4.30. Around 50% of players believed that headgear always or often prevented injury and allowed them to tackle harder.

Age group and situation	(%)		
	Yes	No	Undecided
Players aged 18 years and over during games	44.6	22.7	32.7
Players aged 18 years and over during training	23.5	46.3	30.2
Players under 18 years during games	54.5	17.6	27.9
Players under 18 years during training	28.4	43.2	28.4

Table 4.29: Responses of players to question: “Should headgear be worn in the following circumstances ?’

Headgear…	% of Respondents				
	Always	Often	Sometimes	Rarely	Never
Prevented injury	10.7	40.3	38.9	6.7	3.4
Caused communication difficulties	4.7	18.8	32.9	25.5	18.1
Made my head feel heavier	6.0	12.1	18.1	33.6	30.2
Made my head feel hotter	23.2	33.3	26.5	9.5	7.5
Affected the way I play	3.4	8.7	20.8	31.5	35.6
Restricted play	1.3	6.0	12.8	34.9	45.0
Decreased peripheral vision	2.0	6.0	25.5	28.2	38.3
Caused negative comments	3.4	4.7	10.1	23.0	58.8
Allowed me to tackle harder	21.0	33.8	21.6	12.8	10.8

Table 4.30: Responses of headgear wearing players to questions regarding headgear features, their attitudes and behaviours.

4.2.3 Experiences with Modified Headgear

4.2.3.1 2002

Of the 151 players wearing headgear that participated in the end of season survey, 31(20.5%) had worn the modified headgear that year. Table 4.31 summarises their experiences with this modified headgear. There were 25 players using the modified headgear who had worn headgear in the past and they were asked to compare the modified headgear to the one they had used previously. With regards to comfort, 20% reported that it was more comfortable and 48% reported that it was the same. Fifty-six percent reported that the headgear was more effective than the standard headgear while 44% reported that the performance was the same. Twenty-three players stated that they would continue wearing the modified headgear and would not return to using the standard headgear.

Experience with modified headgear	% of Respondents				
	Always	Often	Sometimes	Rarely	Never
Difficulty speaking	0	0	13.8	13.8	72.4
Uncomfortable head	3.3	10.0	26.7	36.7	23.3
Heavy head	6.9	10.3	13.8	17.3	51.7
Hot head	13.4	20.0	40.0	13.3	13.3
Restricted vision	0	3.5	24.1	24.1	48.3
Restricted play	0	0	17.3	31.0	51.7
Poor peripheral vision	3.5	3.5	17.2	37.9	37.9
I took more risks in play	3.3	36.6	16.7	26.7	16.7

Table 4.31: Experience when using the modified headgear (2002)

4.2.3.2 2003

Seventy players who had played in the modified headgear study arm were given a brief survey to complete. Forty-seven percent had worn the modified headgear during the season, 23% had worn IRB approved headgear and the remainder had worn no headgear. The players' responses were fairly balanced, eg. 32% believed that the modified headgear had allowed them always or often to take more risks, while 41% responded rarely or never (table 4.33). Communication, weight, vision and comfort were considered fine, however 50% of players believed that the modified headgear was always or often hot.

Headgear….	% of Respondents				
	Always	Often	Somet-imes	Rarely	Never
Allows me to take more risks in play	11.8	20.6	26.5	17.6	23.5
Impairs peripheral vision	5.9	5.9	17.6	26.5	44.1
Restricts play	8.8	2.9	5.9	32.4	50.0
Restricts vision	5.9	2.9	17.6	20.6	52.9
Is hot	12.8	33.3	35.9	7.7	10.3
Is uncomfortable	10.8	13.5	21.6	27.0	27.0
Makes it Difficult to speak	8.1	5.4	13.5	27.0	45.9
Is heavy	8.8	11.8	8.8	41.2	29.4

Table 4.32: General attitudes towards modified headgear.

Table 4.33 shows that the modified headgear compared favourably to other headgear in terms of performance, but not so in terms of comfort Slightly more than half the players considered wearing the modified headgear in the 2004 season.

	Attitude	n	%
How does modified headgear compare to other headgear in terms of comfort?	No response	5	15.2
	More comfortable	7	21.2
	Same comfort	12	36.4
	Less comfortable	9	27.3
	Total	33	100.0
How does modified headgear compare to other headgear in terms of Protection?	No response	6	18.2
	More protection	20	60.6
	Same protection	7	21.2
	Less protection	0	0.0
	Total	33	100.0
How can headgear be improved?	No response	5	15.2
	Increased ventilation	10	30.3
	Better moulding to the head	8	24.2
	Increased padding	2	6.1
	Alteration to the chinstrap	3	9.1
	Changes to the earholes	0	0.0
	Make the headgear lighter	5	15.2
	Total	33	100.0
Will you continue to wear modified headgear?	No	14	42.4
	Yes	19	57.6
	Total	33	100

Table 4.33: Comments regarding modified headgear (2003 end of season). The responses were from players wearing modified headgear during the 2003 season.

4.2.4 2002-2003 End of Season Surveys Combined

The following tables were compiled from the end-of-season survey data for both 2002 and 2003 seasons. They were stratified by age. The aim of surveying the players at the end of season was to assess whether there were changes in their attitudes after wearing headgear for a season.

Players beliefs regarding the likelihood of a player being injured while wearing headgear remained largely unchanged between the pre and end of season surveys (table 4.34). However, there was a substantial change in players' beliefs that they could tackle harder while wearing headgear (table 4.35). There was a reduction in those strongly agreeing that they could tackle harder across all age groups after a season wearing headgear.

	% of Respondents				
Age in years	**Strongly agree**	**Agree**	**Neither agree or disagree**	**Disagree**	**Strongly disagree**
12-13 (n=99)	24.2	42.4	22.2	7.1	4.1
14-15 (n=79)	21.5	45.6	22.8	7.6	2.5
16-18 (n=101)	10.9	36.6	37.6	10.9	4.0
> 18 (n=123)	13.0	43.1	26.8	13.0	4.1

Table 4.34: Player's response when shown the following statement post season "Do you think headgear wearers are less likely to be injured?"

	% of Respondents				
Age in years	**Strongly agree**	**Agree**	**Neither agree or disagree**	**Disagree**	**Strongly disagree**
12-13 (n=99)	18.2	17.2	33.3	16.2	15.1
14-15 (n=79)	5.1	24.0	35.4	20.3	15.2
16-18 (n=101)	3.0	16.8	34.7	27.7	17.8
> 18 (n=123)	6.5	9.8	34.1	26.0	23.6

Table 4.35: Player's response when shown the following statement post season "Do you think headgear wearers can play harder?"

4.3 Summary of Attitudes and Beliefs Regarding Headgear

1) A total of 1,414 players participated in the pre-season survey. In 2003 there were 679 participants and in 2003 there were 732 participants. A total of 576 players participated in the end of season survey (322 in 2002 and 254 in 2003)

2) Eighty percent of players reported always or often wearing protective equipment. Ninety percent of players wore a mouthguard and 60% had worn headgear for the majority of the previous season.

3) The main reasons given for wearing headgear were that the players always or often felt safer wearing headgear and they did not want to be injured. Sixty percent of players believed that headgear could always or often prevent injury and 80% of players felt always or often safer wearing headgear. Interestingly, 66% of headgear wearing players believed that they could always or often play more confidently and tackle harder (55%). Cost and appearance were the two most important reasons that informed selection of headgear

4) With regards to age related attitude differences, the younger the player the more confidence they had in the injury prevention potential of headgear, the more they believed that that it might assist their performance, and the less headgear was uncomfortable compared to older players. In general, the loose forwards (no. 8 and flankers) reported the highest wearing rates, with forwards wearing headgear more so than backs. School age players had higher relative wearing rates compared to colts

5) The main reasons that players reported for not wearing headgear were that headgear was too hot and uncomfortable. Players who had not worn headgear indicated that they might commence wearing headgear if they became injured or they received medical advice. The reasons given were compatible with the reasons given by players who were already wearing headgear as they related to injury prevention and safety.

6) Players' beliefs regarding the likelihood of a player being injured while wearing headgear remained largely unchanged between the pre and end of season surveys However, there was a substantial change in players' beliefs that they could tackle harder while wearing headgear. There was a reduction in those strongly agreeing that they could tackle harder across all age groups after a season wearing headgear. Therefore, exposure to impacts while wearing headgear might calibrate the wearer's behaviour and attitudes.

7) The players' responses, both headgear wearers and others, indicated that players associated headgear with the objective of injury management and prevention. However, this was coupled with players' headgear selection being governed price and looks, and the trend for players to report that they can tackle harder and play more confidently while wearing headgear.

CHAPTER 5

VIDEO ANALYSIS

Games involving teams in the study were videotaped in 2002 and 2003. Fifty-three games were recorded each year. This chapter presents an outline of the main results of the video analysis. There is a wealth of information in the video analysis and further consideration will be given as to the best method for communicating the results to the IRB. For example, a DVD of examples of poor skill execution and injuries has been compiled. In order to maintain a focus on the topic of headgear effectiveness and to restrain the size of the report this chapter is brief.

A database was written in which events were coded during review of each game. Each game was reviewed and two main sets of data were compiled. First, injury and knock down events were coded (as well as poor technique and good technique examples), second, the number of phases of play were counted per game. The following is a summary of the results.

Table 5.1 shows that the majority of verified injuries and knock down events occurred in the tackle, followed by the ruck and maul. These accounted for about 85% of all injury and knock down events. A knock down event was one in which the player was knocked over and did not get up to resume play immediately. In some cases, team officials spoke to the player, but these were not identified as injuries by the primary data recorders. It is not unusual for a player to be knocked over and after a brief pause to commence playing again, and this does not necessarily indicate that they were injured. The tackle, maul and ruck involve high energy impacts.

	Injury/Risk	
Phase of play	**n**	**%**
Tackle	103	71.53
Ruck	13	9.03
Maul	8	5.56
General Play	8	5.56
Scrum	7	4.86
Kicking the ball	1	0.69
Half Way Restarts	1	0.69
Charge Down	1	0.69
22 Metre Restart	0	0.00
Lineout	0	0.00
Unknown	2	1.39

Table 5.1: Injury and knock down events by phase of play from 106 games in 2002 and 2003 (all grades etc). Total number of events (injury or knock down is 144)

The area of the player struck during the impact was identified. Even with video, it was often difficult to view an injury event and identify all aspects clearly (table 5.2). The head and neck were the region struck most frequently (18%) followed by the shoulder (15%) and face (13%). The ground (19%) and shoulder (11%) were the two most frequent known objects that struck an opponent resulting in him being injured or knocked down (table 5.3).

	Injury/Risk	
Area Struck	**n**	**%**
Head and Neck	26	18.1
Shoulder	22	15.3
Face	19	13.2
Abdomen	11	7.6
Lower leg and foot	8	5.6
Knee	6	4.2
Forearm and hand	4	2.8
Upper leg/thigh	3	2.1
Upper arm	2	1.4
Elbow	2	1.4
Pelvic Region	1	0.7
Unknown	41	28.4

Table 5.2: Injury and knock down events: body region struck on injured or knocked down player. Total number of events (injury or knock down is 144)

	Injury/Risk	
Striking object	**n**	**%**
Ground	27	18.75
Shoulder	16	11.11
Knee	10	6.94
[redacted]	9	6.25
	9	6.25
	8	5.56
	7	4.86
	6	4.17

CHAPTER 6

DISCUSSION

A study to measure the effectiveness of headgear in reducing injury in rugby union football was undertaken during 2002 and 2003 in Sydney, Australia. A randomised controlled trial was undertaken as this represents the most rigorous study design with regards to measurement of the effectiveness of injury interventions. There were three arms in the study: controls, IRB approved headgear and modified headgear. Eighty teams participated in the study in each year in the following age groups: under 13s, under 15s, school opens (under 18) and colts (under 21). The study size exceeded that planned in the original proposal.

In addition to assessing the effectiveness of headgear, all injuries sustained by the study sample were recorded and analysed for this report. Surveys of the players' attitudes and experiences with headgear and other protective equipment were conducted at the start and end of each season. A cross section of games involving teams in the study were videotaped and analysed as well. The main results have been presented in chapters 2 to 4. This discussion will focus on the issues of head injury and headgear.

Almost 2,000 players participated in the study in each year and the median number of games per participant was nine. There was a large movement of players in and out of teams participating in the study. Some players, eg. in the colts teams, simply discontinued playing rugby, or in other teams were demoted to the C or D grades and therefore out of the study cohort. Instead of recruiting a cohort at the start of the season and not allowing new players to be added, players were recruited into the study as they participated in a study team. This decision was made as experience in rugby had shown that teams, in particular school teams, did not settle until the start of the 'official' competition. As the 'official' school competitions are usually only five to six games, it would have been necessary to continue the study for four to five years to obtain a sufficient level of player game exposures. Player consent and headgear distribution occurred primarily at the beginning of the season and half way through the season. For schools, the half way point was their return from the July holidays, at which point teams had stabilised. The recording of player participations, injuries and headgear use at each game meant that all necessary aspects of exposure and outcomes could be measured.

The average number of games per team per year was twelve, however this varied depending on age group and success in the competition. Colts teams play a two round competition and school teams normally play between eight and twelve games in a year. The total number of player game participations with complete information on headgear use was 30,316 and 31,899 with specific game time information.

The identification, definition and measurement of injury is a vexed topic in sports injury research as indicated in chapter one. Two definitions were used in this study. The first was a game injury. Players who reported an injury and either received attention or left the field were recorded as being injured. In some cases these were trivial injuries, eg. a blood nose, and in other cases they included fractures and dislocations. Injuries resulting in a

player missing a game were also recorded. This involved recording the players in the following game, identifying who was missing from the previous week, obtaining a reason for the player absence (injury, demotion, sickness or other) and following up to obtain the injured body region, nature of injury and injury event. There was a higher proportion of unknown data for missed game injuries compared to game injuries, however, the unknowns are unlikely to include any head, neck or facial injury. The game injuries and missed game injuries are two overlapping sets of injuries. It is possible for someone to complete a game of football without reporting an injury, but miss the following week due to an injury, generally musculoskeletal, that occurred the previous weekend. This is unlikely, however, for concussion.

Concussion was assessed using a very open definition, in brief a head impact associated with symptoms including headache, dizziness, nausea, loss of consciousness or amnesia. Where possible these symptoms were recorded. These methods had been used by McIntosh and McCrory in previous studies (4,5). The study was not funded to use neuropsychological tests at the field, nor was it possible to employ medical specialists to attend every game in the study. Return-to-play decisions following concussion are influenced by a number of factors, the symptoms and severity of the concussion being two important factors.

Teams were randomised into each arm of the study. After randomisation, players in each team in one of the headgear arms, and those included during the season, were provided with either the standard or modified honeycomb headgear. Players in the control arm were not provided with headgear, but could have chosen to continue to wear headgear or have started to wear headgear during the study. While the aims of the study were explained to the players and they were encouraged to wear the headgear allocated to them, players ultimately decided to wear the headgear as they saw fit.

For example, while 36% of the player-game exposures were for players randomised to the modified headgear arm of the study, only 11% of the total game exposures were for players observed by the primary data recorders wearing the modified headgear. In contrast, 29% of player-game exposures were in the IRB approved (standard) headgear arm, and in 46% of exposures IRB approved headgear was observed to be worn. Players provided informal feedback that the modified headgear was too stiff and therefore uncomfortable. Players were encouraged to wash the headgear and wear it at training in order to improve comfort. Players also provided informal feedback during 2002 that they found the modified headgear too hot, but the season was quite warm. It was our experience that when players persevered with wearing modified headgear, that it became 'worn in' and comfortable. However, many players were not willing to wait. Therefore, the analysis of injury rates across the study arms is less informative with regards to headgear effectiveness than the analysis of injury rates based on compliance information, ie. based on observed patterns of headgear use and related injuries.

Randomisation was performed on a team basis without consideration for the number of games each team might participate in during a season. While there is an even spread of teams across the four age groups and between the study arms, there is a bias in terms of exposure towards the older players. Player game exposures in the colts accounted for 41%

of all player game exposures, compared to 25% for under 18s and 17% for the under 15s and 17% for the under 13s.

The overall rates of injury calculated for the study are within the range reported in chapter one. The rate of all game injuries was calculated as 64 per 1,000 player game hours, and the rate of injuries resulting in a missed game was 21 per 1,000 player game hours. The distribution of injury across body regions, nature of injury and injury events were similar to those reported in chapter one. The body region with the highest proportion of injury was the shoulder (13%), followed by the head (13%), face (12%), knee (10%) and ankle (9%). The overall proportion of concussions was 11% which is similar to Targett (22) and Davidson (16). Therefore, the results are generally consistent with the trends reported in the literature. Naturally, the exact injury definition and exposure measurement method will influence the rates and patterns of injury measured in any study. A very detailed and labour intensive approach was taken in this study. The measurement of game injuries is possibly more inclusive of 'injuries' than other studies, as many benign injuries were included, but this was counterbalanced by the analysis of missed game injuries.

When the head injury and concussion data were analysed on an 'intention to treat' basis there was no statistical difference between rates of concussion for the three arms of the study, but those players allocated to the IRB headgear arm had the lowest relative rate of injury and those allocated to the modified headgear arm had the highest compared to controls. There was also no statistically significant difference in rates of concussion or head injury based on actual headgear wearing patterns. The incidence rate ratios show that those players observed wearing modified headgear had a similar injury rate to those observed not wearing headgear, and those observed wearing IRB headgear had an incidence rate ratio of 1.11 compared to no headgear for concussion.

No significant differences in head injury or concussion as defined by a missed game were observed using either an intention to treat analysis or an analysis using compliance data, ie. measured headgear wearing patterns. A non-significant lower rate of concussion and head injury resulting in a missed game was found for those players observed wearing the modified headgear. The incidence rate ratio for modified headgear wearers was 0.43 compared to no headgear, and approximately 0.4 compared to IRB wearers. In other words, there was less than half the rate of missed game head injury or concussion for those wearing modified headgear, but due to the sample size and exposure issues discussed earlier, this difference was not significant. Players wearing IRB approved headgear had a slightly higher rate of head injury resulting in a missed game than those not wearing headgear, but this was not significant.

Univariate analyses of the relative rate of head injury, concussion and head injury resulting in missed games were performed for the following factors: player position, grade, level and season. Except for the effect of grade on head injury rate, with 3rd grade having the lowest incidence rate ratio, no other statistically significant effects were observed. The results reinforced the observed trends that the rate of injury, including concussion, head injury and head injury resulting in missed games, was lowest for the U13 players, with the rate of concussion the highest for U15 players. Halves and outside backs had the highest incidence rate ratio and player position was marginally significant ($p=0.1$) with respect to concussion. Front row players had the lowest rate of concussion.

Multivariate analyses, using Poisson regression, of head injury rates and rates of head injury resulting in missed games, using the independent variables randomisation or compliance and age group did not reveal any significant relationships, but reinforced the univariate finding that the relative rate of head injury resulting in a missed game was lower for players wearing the modified headgear after taking into account age group.

Headgear use on its own was not correlated with an increased overall rate of injury. A multivariate analysis of rates of all injuries by observed headgear use and adjusted for age group/level of play, indicated a significant increase in the overall injury rate for wearers of the standard IRB headgear ($p < 0.05$). The level of play adjusted incidence rate ratio was 1.16 compared to the reference of no headgear worn. Players in the colts or in the back five had the highest injury rates. Players in the under 13s had the lowest rate of injury, either game or missed game injury ($p < 0.005$), and specifically lower rates of head and facial injury. With regards to missed game injuries, inside backs had a significantly higher rate of injury than other player positions ($p < 0.05$).

Analysis of the rates of head, neck and facial injury found significantly higher rates of neck injury for players wearing either the modified or IRB approved headgear types. The analysis based on randomisation found that the IRB arm of the study had the lowest rates of all and missed game neck injuries, however when actual wearing patterns were considered non-wearers had the lowest rates of neck injury. The rates of neck injury for modified and IRB headgear wearers were 2.59 and 1.40 times greater than non-wearers for all injuries, and 2.1 and 3.0 times greater than non-wearers for missed game injuries, respectively. The latter were not significant.

The relationships between neck injury and headgear use might have been confounded by the observation that the forwards had higher rates of neck injury than backs. Due to the small number of neck injuries, it was not possible to analyse neck injury and headgear use after adjusting for player position.

The observation regarding neck injury and headgear is of concern, even though no serious injuries occurred to the neck and the overall rates were low: 3.3 per 1,000 hours for all neck injuries and 0.8 missed game injuries per 1,000 hours. Analyses showed that headgear did not prevent head injury or concussion, although there was a non-significant trend for lower rates of missed game head injuries for headgear wearers. Therefore, it is possible that headgear either modified the impact forces in a way that was more hazardous for the neck, or that players were less cautious regarding their head position in a tackle, for example. The latter point is discussed below in the context of the video analysis and player attitude surveys. From a biomechanical perspective it is unlikely that the headgear would have of itself affected the impact dynamics so that the neck was injured. The only minor potentially 'negative' effect of attenuating impact energy is that the duration of the impact is increased, however this occurs in combination with a reduction in impact force. As stated in the introduction and chapter 2 the level of force reduction is limited.

Players in the forwards had greater rates of neck injury than backs and the back five and halves had the greatest rates of head and facial injury. However, the outside backs had the highest rate of missed game head and face injury. The forwards and halves are involved more frequently at the breakdown than backs, while outside backs are often involved in higher speed impacts in open play, either as tackler or ball carrier.

The main cause of injury in rugby is an impact event, usually a tackle. Even after the frequency of tackles was considered, they were still associated with the greatest rate of injury. Therefore, future rugby injury research might focus on improving players' skills in the tackle. A great deal of video related skill and event data have been collected, analysed and collated that are not presented in this report. These data show good and poor-dangerous examples of tackles and other phases of play. The amount of tackle related injury that could be reduced is unknown, as the tackle represents the skill in which high energy transfer is most likely to occur in rugby. Even with 'textbook' skills, it may not be possible to eliminate tackle related injury. In brief, the factors that appear most relevant are body height and head position for all parties in the tackle. Addressing the tackle is a positive step that should attract interest, as improving the skill may both improve competitiveness and reduce injury.

Fourteen hundred and fourteen (1414) players participated in the pre-season surveys and 576 in the end of season surveys in 2002 and 2003. There was a high reported use of mouthguards (90%) in the sample surveyed. Sixty percent of players reported that they had worn headgear for the majority of the previous season. Thus, there was a high pre-existing headgear wearing rate in the sample studied. The reported use of headgear in the previous season was similar to the measured pattern of headgear use, as 57% of player game exposures occurred with players wearing headgear.

Players reported that the main reasons for wearing headgear were that they felt safer and they did not want to be injured. Sixty percent of players believed that headgear could always or often prevent injury and 80% of players felt always or often safer wearing headgear. Interestingly, 66% of headgear wearing players believed that they could always or often play more confidently and tackle harder (55%)[1], although the video analysis did not appear to support these as on field behaviours. Cost and appearance were the two most important reasons that informed selection of headgear.

Players chose not to wear headgear because they found it hot or uncomfortable, but indicated that they might commence wearing headgear if they became injured or they received medical advice. The reasons given are compatible with the reasons given by players who already wear headgear as they relate to injury prevention and safety. Therefore, players perceive headgear as providing protection against injury. The perception that they could tackle harder appeared to be influenced by playing football for a season with headgear. There was a reduction in those strongly agreeing that they could tackle harder across all age groups after a season wearing headgear. Therefore, exposure to impacts while wearing headgear might calibrate the wearer's behaviour.

The concern that the players might modify their on-field behaviour because they perceive that headgear provides a protective benefit emerges from the survey results. The review of the game video did not appear to provide any evidence that this actually occurred. Players wearing headgear appeared to be no more likely to exhibit poor skills or take risks than those not wearing headgear. However, it is clearly difficult to quantify this type of

[1] In response to this observation regarding players tackling harder in headgear, one experienced coach suggested that this would be a reason to make all his players wear headgear !

behavioural change. It could be conjectured that the increased rate of neck injury for headgear wearers may be related to players demonstrating less caution in a tackle, for example.

Considering the findings related to the effectiveness of headgear and the reported attitudes regarding headgear, there is a potential, so far unknown and untested, for headgear wearers to nullify any protective benefit they may have gained from headgear, by tackling harder or being more reckless. Headgear attenuates only a limited amount of impact energy, so that if the impact characteristics, eg. energy, are increased, headgear will not protect the head. Extrapolating this point further, headgear designers could simply end up 'chasing their tails', ie. improving performance, only to see players hit harder. This again might have been a factor in neck injury rates for headgear wearers. There is indirect evidence for this form of risk compensation from American football.

Head protection in American football, possibly coupled with poor skills development and team training, was considered the main cause of spinal cord injury related to spear tackling in the 1970s. The spear tackle is one in which the player dives head first (spears) into the ball carrier. A recent study of concussion in helmeted American football players (53) found that the head's change in velocity, an index of impact severity, in concussive impacts was on average 7.2 m/s compared to 5 m/s for players uninjured in a head impact. In McIntosh and McCrory's (4) study of concussive impacts in professional football in Australia, drawing cases largely from Australian football, the average change in velocity of the injured player's head was 4.5 m/s. One could speculate that the difference in impact speeds and head loading between the unhelmeted player in Australia and the helmeted American football player reflects in part the performance of the helmet, ie. helmeted players know that they can engage in higher energy impacts without being injured. Extrapolating further, it could be argued that players simply increase the impact severity and ultimately leave the injury rate unchanged. Compared to American football, rugby union does not have a history of fatal or severe head injuries that might require consideration for the introduction of a hard shell American football type helmet. Further, this issue can be addressed by providing appropriate information to players and coaches regarding the performance of padded headgear and ensuring that players understand the limits to the performance of headgear. These observations are also true for neck injury.

CHAPTER 7

CONCLUSIONS

1) No statistically significant differences were found between the rates of head injury or concussion, either for game injuries or missed game injuries, between players wearing no headgear, IRB standard headgear and the modified headgear. This was the case with analyses based on randomisation (intention to treat) and observed use of headgear. A non-significant lower rate of concussion and head injury resulting in a missed game was found for those players observed wearing the modified headgear. The incidence rate ratio for modified headgear wearers was 0.43 compared to no headgear, and approximately 0.4 compared to IRB wearers;
2) Headgear use on its own was not correlated with an overall increased injury risk. However, a multivariate analysis of rates of all injuries by observed headgear use and adjusted for age group, indicated a significant increase in the rate of injury to all body regions for wearers of the standard IRB headgear ($p < 0.05$). The age adjusted incidence rate ratio was 1.16 compared to the referent of no headgear worn;
3) Players wearing either the IRB or modified headgear had significantly higher rates of neck injury than players not wearing headgear. The rates were higher for missed game injuries too, but not significant. The combination of player perceptions and behaviours regarding headgear and insufficient energy attenuation may be contributing factors for this phenomenon;
4) Players in the colts or in the back five had the highest injury risks in general. Players in the under 13s had the lowest risk of injury, either game or missed game injury ($p < 0.005$). With regards to missed game injuries, inside backs had a significantly higher rate of injury than other player positions ($p < 0.05$);
5) Players perceive headgear as providing protection against injury. Players reported that the main reasons for wearing headgear were that they felt safer and they did not want to be injured. Sixty percent of players believed that headgear could always or often prevent injury and 80% of players felt always or often safer wearing headgear. Interestingly, 66% of headgear wearing players believed that they could always or often play more confidently and tackle harder (55%). Players chose not to wear headgear because they found it hot or uncomfortable, but indicated that they might commence wearing headgear if they became injured or they received medical advice;
6) The concern that the players might modify on field behaviour because they perceive that headgear provides a protective benefit emerged from the survey results. The review of the game video did not appear to provide any evidence that this actually occurred. This issue can be addressed by providing appropriate information to players and coaches regarding the performance of padded headgear and ensuring that players understand the limits to the performance of headgear; and,
7) No significant protective effects for headgear were observed, which confirms previously expressed views on headgear.

CHAPTER 8

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CHAPTER 9

APPENDICES