FOOTBALL INJURIES OF THE HEAD AND NECK

National Health and Medical Research Council
NHMRC

ISBN 0 644 42711 6

The objective of the National Health and Medical Research Council is to advise the Australian community on the achievement and maintenance of the highest practicable standards of individual and public health and to foster research in the interests of improving those standards.

This document is sold through the Australian Government Publishing Service at a price which covers the cost of printing and distribution only.

National Health and Medical Research Council documents are prepared by panels of experts drawn from appropriate Australian academic, professional, community and government organisations. NHMRC is grateful to these people for the excellent work they do on its behalf. Often, such work is performed in addition to other substantial work commitments.

Publications and Design (Public Affairs)
Commonwealth Department of Human Services and Health

Cover by AGPS Design

Drawings reproduced from photographs with permission from The Canberra Times/The Chronicle

Produced by the Australian Government Publishing Service

Terms of reference and membership

Terms of reference and membership of the NHMRC Panel on head and neck injuries in football

1. To inquire into head and neck injuries resulting from participation in the sport of football (all codes) and to suggest ways of minimising injuries.
2. To report to the Public Health Committee.

Canberra-based core panel

Dr Ray Newcombe, Neurosurgeon (Chair)

Dr Robert Reid, Sports Physician

Dr Robert Smethills OAM, Medical Officer, ACT Rugby Union

Ms Virginia Dove, Public Relations Officer, NHMRC

Ms Claire Brady (Executive Secretary, September 1993 - July 1994)

Ms Sandra Twist (Executive Secretary, July 1994 - November 1994)

Medical consultant panel

Dr John Crompton, Neuro-ophthalmologist

Dr Paul Curtin, Plastic and Reconstructive Surgeon

Dr Nathan Gibbs, Sports Physician, Medical Officer, Australian Rugby League

Dr James Harrison, Epidemiologist, National Injury Surveillance Unit, Australian Institute of Health and Welfare

Dr Siri Kannangara, Rheumatologist, Medical Officer, Australian Soccer Federation

Dr Geoffrey Klug, Paediatric Neurosurgeon

Dr Paul McCrory, Sports Physician, Medical Officer, Australian Football League

Dr Glen Merry, Neurosurgeon, Chair, Trauma Committees of Royal Australasian

College of Surgeons and Neurosurgical Society of Australasia

Dr Cate Storey, Neurologist, Australian Association of Neurologists

Dr Geoffrey Vanderfield, Neurosurgeon, Medical Officer, Australian Rugby Football Union

Dr Roger Vanderfield OBE, member of the International Rugby Football Board, former international referee

Dr John Yeo AO, Spinal Injury Rehabilitation

Contents

Preface

The genesis of this report stemmed from ongoing head and spinal injuries in football in the 1992 season. There was a need for revision of the situation and the development of a program of education and research to prevent or minimise the occurrence of such injuries. The draft report was well in hand at the beginning of the 1993 season when there was a spate of injuries which attracted much attention. The report is therefore timely.

Significant progress in the reduction of injuries has of course been made in the last two decades. In the mid 1980s specific attention was given to spinal injury in rugby, with appropriate changes being made to good effect. All codes have been assiduous in developing training and safety programs and in reducing illegal play that might lead to injury. Further efforts in this regard however are required. In this report an attempt is made to develop a common approach to the management of concussion and of more severe head injury. Standards of care across the codes for cervical spine and spinal cord injury are also desirable. The support that the draft document received from all of the football administrations and medical organisations concerned is gratifying.

There have been previous calls for appropriate centralised injury registers, which to date have not been put in place. It is hoped that such tools for research will be implemented following publication of this report.

Many experienced sports physicians and others interested in sports injury have contributed to this report. Those who have studied the scientific aspects of football and coaching have made their contribution. I am particularly grateful to the members of the expert panel for the time and effort they have put into the development of this document.

To keep players on the field and enjoying football in its various forms is the aim. It is hoped that administrators, umpires, referees, trainers, coaches and players will all try to apply the recommendations to the particular codes with which they're concerned.

Ray Newcombe

1 September 1994

Abbreviations

AFL	Australian Football League
ARFU	Australian Rugby Football Union Ltd
ASF	Australian Soccer Federation Ltd
ASMF	Australian Sports Medicine Federation
CAMS	Confederation of American Motor Sport
CT	Computed Tomography
CNS	Central Nervous System
DAI	Diffuse Axonal Injury (of brain)
DSST	Digit Symbol Substitution Test
EEG	Electro-encephalograph
EMST	Early Management of Severe Trauma
FIFA	Federation Internationale de Footbal Associations
GCS	Glascow Coma Score
HIV	Human Immunodeficiency Virus
LMO	Local Medical Officer
LOC	Loss of Consciousness
MRI	Magnetic Resonance Imaging
NAFC	National Australian Football Council
NFL	National Football League
NHMRC	National Health and Medical Research Council
NMDS	National Minimum Data Set
NOCSAE	National Operations Committee for Standards for Athletic Equipment
NSWRL	New South Wales Rugby League
NSWRU	New South Wales Rugby Union
NZFSM	New Zealand Federation of Sports Medicine

PASAT	Paced Auditory Serial Addition Test
PTA	Post-traumatic Amnesia
RITAB	Recreation Industry Training Advisory Body
SCI	Spinal Cord Injury
VAFA	Victorian Amateur Football Association
VFL	Victorian Football League
VISS	Victorian Injury Surveillance System
VSFL	Victorian State Football League

Recommendations

1. Management and administrative arrangements

(a) The official in charge of a football game should have the power to stop the game if a serious injury has occurred. Training to a sports-first-aid-standard certificate is desirable for all referees and umpires to enable them to conduct their administrative responsibilities.

(b) At every football venue, at every level, in every age group, the aim should be to have trained personnel, ie a person qualified in sports first-aid, and appropriate first-aid equipment for head/neck injuries.

(c) The frequency, duration and resetting of rugby union scrums, including a limitation on the number of times a scrum is reset, should be reviewed.

(d) Training and safety programs to reduce both illegal play and the effects of accidental injury should be continually promoted. Illegal play, especially above the line of the shoulder, is a major contributor to head and neck injury and should be severely punished.

(e) Player interchange which allows early intervention to assess injury should be considered by codes where this is not currently allowed.

(f) Appropriate practices and education to reduce the risk of blood contamination in contact/collision sports should be adopted in all football codes. Immunisation against hepatitis B is strongly recommended.

(g) Guidelines for the recognition of concussion and spinal injury should be promulgated to referees and umpires to enable them to conduct their administrative responsibilities.

(h) The guidelines should be widely distributed to all clubs, coaches, medical practitioners and hospitals and reinforced with an education campaign.

(i) Common guidelines for concussion should be adopted by all codes. Retrospective grading of concussion, if utilised, should also be by a system agreed to by all codes.

2. Data collection

(a) There should be a national registry of deaths, brain injury with permanent functional disability, and cervical spine injury (spinal injury with or without cord involvement) established, to commence data collection at the beginning of the 1995 football season.

(b) Such reporting or notification of injury should be the responsibility of each individual code of football. Initial reporting should occur at the completion of each game.

(c) Since concussion is so important, it is recommended that this be targeted for prospective research using uniform data coding. Guidelines for the management of concussion are recommended for adoption by all codes. Certification of recovery should be by a medical practitioner.

3. Equipment

(a) The use of custom-made mouthguards in contact sports, including football (all codes), is strongly recommended.

(b) Australian standards for mouthguards need to be developed.

(c) Possible obstacles to players such as goal posts, boundary fences and television cameras should be covered with soft material to reduce the possibility of serious injury should a player collide with any of these.

(d) Appropriate first-aid equipment designed to cope with head and neck injuries should be on-site wherever a football match is being played.

4. Research and education

(a) Qualified sports trainers should have additional training in sports injury prevention and management. All football code administrators should encourage training and education as offered by the National Sports Trainers Scheme.

(b) Programs of prevention of head and neck injuries should include:

(i) research into the selection of a player for a position according to body type;

(ii) education of players, coaches, administrators and sports trainers; and

(iii) research into specific aspects of fitness training, including neck muscle strengthening.

(c) Research into the use of soft head protectors or scrum caps to reduce injuries of the scalp, ears and face should be developed. Design criteria and manufacturing standards for such head protectors need development.

(d) Research should be undertaken to determine whether standardised soft head protectors reduce brain injury without creating other hazards.

(e) Video recordings of illegal conduct and play which results in injury in football games should be made readily available for research purposes.

(f) A central fund for specific research into the prevention and management of head and neck injuries in football should be established. In addition, administrators of each code should be encouraged to direct additional funds towards safety measures and the care of injured players.

Executive summary

Injuries to the head and neck can be sustained in most sports, but this is more likely in the body contact/collision sports. Given the high participation rate in football in Australia, the risk of injury from football is nevertheless not as great as many would believe.

Apart from a prospective study on school rugby union, there is an absence of good overall data on injuries in football. Although useful for elite grades of football, injury studies on elite footballers cannot give a true representation of the risk of injury across the board. As a result, there is a need for uniform data collection and a national injury register in Australia.

When discussing head injuries sustained in collision sports, a distinction needs to be made between the terms 'mild' or 'minor head injury' and 'mild concussion'. Similarly, concussion means different things to different people. Definitions with qualifications of these differences are outlined in this report.

Head injury where consciousness is lost for a few minutes may be sufficient to cause measurable impairment of brain function for a variable period following injury.

Diagnosis on the field and management of brain injury is not simple for non-medical personnel. Players should not continue to play after they have been concussed. A defined procedure for referees, umpires and sports first-aid attendants is recommended in the text and is also provided in Appendix A.

The timing of returning to training and to play is also difficult to determine. Guidelines for the management of concussion are recommended in the text and are again presented in Appendix A.

Most head injuries in football are minor. On the other hand, any head injury can be followed by complications. These injuries are more likely to occur after direct impact injury.

Courses in early management of severe trauma have been promoted within Australia for medical officers likely to have to deal with trauma in an isolated setting. Similarly, guidelines for the care of head and spinal injuries have been produced by the Neurosurgical Society of Australasia and the Royal Australasian College of Surgeons.

The early management of severe closed head injury requires the establishment of a baseline against which changes in the neurological condition can be compared.

Lacerations and contusions of the face are common in football. They appear to occur with greater frequency in elite and senior football. The risk of transfer of infectious

diseases via bleeding wounds requires special precautions. Eye injuries include periorbital bruising and laceration, corneal abrasions, hyphaema, vitreous haemorrhage, retinal oedema (*commotio retinae*) and tears.

Fractures of the nose are common. Fractures of the zygoma and mandible are more common than fractures of the orbit or maxilla. The high elbow in tackles is a common mechanism leading to such injuries.

The use of custom-fitted mouthguards and avoidance of high tackles are important factors in prevention. Mouthguards provide protection of the teeth, jaws and adjacent soft tissues. Mouthguards can also reduce the rate of concussion.

Neck injuries that may occur in football include soft tissue musculoskeletal injury, brachial plexus injury, cervical spine injury and spinal cord injury.

Scrum injury, tackling injury, ruck and maul injury and open play accidents are analysed. Substantial progress has been made towards prevention of these injuries by rule/law change, compliance, player selection and training, and general public awareness.

In Australia, the various codes of football do not require that participating athletes wear helmets. The paucity of evidence related to the use of helmets in football played in this country makes analysis of the risks and benefits of helmet use difficult. Soft head protectors and scrum caps appear to reduce lacerations and other soft tissue injuries and may lessen intracranial forces on impact. The view has been expressed that such soft helmet equipment should weigh no more than 80 grams. Further research into this area should be encouraged.

Available comparative data for the various codes are presented in the text. From these data, it appears that concussion is more prevalent in the rugby codes and Australian football than in soccer. Further data concerning the incidence of all types of head and neck injuries in all codes have been included together with views concerning training and research. Administrative arrangements to minimise injury have also been noted.

Modified rules and laws for younger players reduce the risk of injury. Modified rules/laws also provide better training for young players which in turn may help to reduce the risk when players reach senior grades.

In the management of school-age players, school teachers may need to be taught sports first-aid, in particular for managing concussion and other head and neck injuries. There is a similar need in junior non-school competitions, where it is desirable to have a sports first-aid trained attendant (or sports trainer or medical officer).

Data collection for further research is very important. Specific data bases for head and neck injuries are listed.

Research and education remain important regarding applications of rules and laws, types of foul play, player fatigue and equipment.

Illegal play is a major contributor to head and neck injuries and should be severely penalised. Elite players, in particular, have a responsibility to set an example for younger players and should be heavily punished for breaching the rules/laws.

1 Football injuries of the head and neck

1.1 Introduction

Injuries to the head and neck can be sustained in most sports, but this is more likely in the body contact/collision sports. These injuries range from the minor to the catastrophic, from the exceedingly common to the extremely rare, and the occasionally bizarre injury.

Some authors have noted that sport-related head injury accounts for approximately one-tenth of all head injuries presenting to hospitals and specialised neurosurgical units (Lindsay *et al.* 1980). Neurosurgical units treat more severe injuries. According to figures collected over the last ten years at the Royal Adelaide Hospital's neurosurgical unit, approximately 4.3 per cent of patients admitted had a 'sport related head injury'. (This figure does not include 'sport related neck injuries' as they would have been admitted to the spinal injury unit.) (North 1994)

Of 9,825 footballers treated at hospital emergency departments in Brisbane South Region from 1988 to 1993, 635 (6.5 per cent) sustained intracranial or spinal cord injuries. Of these, 133 (20.9 per cent) had fractured skulls and nine (1.4 per cent) had fractured necks (McCall 1994).

Boxing injuries have been the subject of a detailed recent report (NHMRC 1994). In boxing, the head is a 'legitimate' target for blows. In other sports, head injury occurs as an accidental or indirect consequence of play, eg American football (Kelly *et al.* 1991), Rugby union, Rugby league, Australian football (Australian Rules), soccer, equestrian events, hockey, cricket, squash and golf.

A general review of the issues concerned with head and spinal injury in sport has been published by the Australian Sports Medicine Federation.

The four major football codes in Australia attract large numbers of participants (about one million - see table below) and larger numbers of spectators. These codes of football are played by persons of all ages and levels of skill.

Approximate number of participants 1993 (in regular competition)

Australian football	382,745 2,820 females
Rugby union	150,666 500 females
Rugby league	147,148 350 females
Soccer	Over 300,000 males 24,000 females

Competitions derived from the main football codes, such as touch, tag football and some veterans competitions, do not come under the aegis of the main football bodies. American football has an increasing number of participants.

Active sports carry the risk of injury in spite of efforts to increase fitness, good play and coaching. The risk of injury from football is nevertheless not as great as many would believe.

Since the 1970s, sports administrators, coaches, players, trainers and interested medical practitioners have been aware of the increasing incidence of injuries to the head and neck. This may be related to the increasing number of participants, methods and coaching practices, increased body size and bulk of certain players, foul play and the win at all costs ethos that appears to have pervaded a section of our football codes.

Football administrators have met the challenge of making the game safer by changing the rules/laws of the games, by banning certain types of dangerous play, increasing the penalties of such play and by having different rules/laws for different age groups. Research into the causes of head and neck injuries has also been encouraged in various codes of football.

These changes appear to have reduced the risks of injury. Due to the small number of severely injured players, the statistics regarding these catastrophic injuries may be misleading.

1.2 Football injuries in Australia

An ongoing Australian study, that now spans 25 seasons of football, is being conducted by Davidson on schoolboy rugby injuries (Davidson 1987, 1993). This study records every schoolboy rugby injury that has occurred at Newington College (NSW). This data collection is one of the most important pieces of research undertaken in football as it has good long-term information which has led to recommendations and guidelines for that important group in the community.

Apart from this comprehensive study, there is an absence of good overall data on injuries in football.

Recent studies by Seward & Patrick (1992) on Victorian Football League (VFL) injuries, Gibbs (1994 in press) and Seward *et al.* (1993) provide timely and valuable statistics of football injuries at an elite level. A study by McMahon *et al.* (1993) looking at the impact of modified rules on injury incidence also provides important statistics. These studies, however, have indicated that data collected on elite level players cannot give a true representation of risk of injury across the board and acknowledge that there is a need for uniform data collection and a national injury register in Australia.

Participation by women in all codes of football is increasing. Any future data collection system must include female participants.

In addition, in order to achieve accurate statistics, there needs to be an adequate and specific definition of injuries. For example, an injury sustained to the head may be recorded as 'head injury' and not as one including, for example, an eye laceration or facial fracture. 'Injury to the head' in injury surveillance data does not equate to concussion or to head injury involving the brain.

Medical associations that are affiliated with different football codes are prominent at the elite sporting level and are becoming more prominent at other levels. The medical associations provide an important role in all football codes in reducing injury. It is a concern of this Panel that there are football games played throughout the country, in particular district grade football, which are not attended by any medical or trained personnel. All games should be attended by suitably trained personnel with regard to injury.

In terms of the incidence of injury in football games, several submissions received for this inquiry indicate that the existing rules/laws within codes are adequate but that it is the application of the rules/laws that is the problem and the important issue for on-going review.

The referee or umpire should have the administrative responsibility for injury care on the field. This serious responsibility should be supported by additional trained personnel wherever possible, as the referee or umpire is not expected to treat injuries. In this situation, clubs and administrators should be aware of the difficult insurance and litigation aspects of such sporting injuries.

1.3 Head and neck injuries in football

In this report head and neck injuries include all types of injuries, from minor injuries such as lacerations, contusions and 'mild concussion' to catastrophic injuries of the eye, brain and spinal cord. Minor injuries are common but fortunately catastrophic injuries are rare.

The management and recognition of concussion are very important. Concussion is common in football. Therefore a uniform approach across all football codes to the prevention and mangement of concussion is desirable.

Football codes vary in intensity of contact between players. While the level of contact in soccer is relatively low, in rugby it is high enough by its nature for it to be

referred to as a collision sport rather than simply a contact sport. For the purposes of this report, a distinction needs to be made between those football codes with a low incidence of contact, ie soccer, and those football codes such as Rugby league and Rugby union, where there is a high incidence of contact/collision during the game.

Concerns have been expressed regarding the high proportion of players commencing a new season with either current or chronic injury (all body sites but including a significant number with injuries to the head). This, coupled with the pressures to remain on the field when injured, returning to active participation before rehabilitation is complete, and being prepared to play against medical advice, suggests there is an urgent need to review attitudes and procedures regarding the management of injury (Chalmers 1994).

A preliminary analysis of sports injuries in New Zealand using multiple data bases shows the high incidence of injury in the football codes played in New Zealand and the relatively high proportion of injuries to the head and neck (Hume and Marshall 1994).

1.4 Summary

For the purposes of this report, head and neck injuries include all types of injuries, from minor injuries such as lacerations, contusions and 'mild concussion' to catastrophic injuries of the eye, brain and spinal cord.

Injuries to the head and neck can be sustained in most sports, but this is more likely in the body contact/collision sports. Given the high participation rate in football in Australia, the risk of injury from football is nevertheless not as great as many would believe.

Apart from the prospective study on school Rugby union by Davidson (1993), there is an absence of good overall data on injuries in football. Although useful for elite grades of football, injury studies on elite footballers cannot give a true representation of the risk of injury across the board. As a result, there is a need for uniform data collection and a national injury register in Australia.

Recommendations

At every football venue, at every level, in every age group, the aim should be to have trained personnel, ie a person qualified in sports first-aid, and appropriate first-aid equipment for head/neck injuries.

Qualified sports trainers should have additional training in sports injury prevention and management. All football code administrators should encourage training and education as offered by the National Sports Trainers Scheme.

Reporting or notification of injury should be the responsibility of each individual code of football. Initial reporting should occur at the completion of each game.

Since concussion is so important, it is recommended that this be targeted for prospective research using uniform data coding. Guidelines for the management of concussion are recommended for adoption by all codes. Certification of recovery should be by a medical practitioner.

2 Concussion (Mild head injury)

2.1 Definition

Head injury with loss of consciousness of less than five minutes, or post-traumatic amnesia of less than one hour is usually referred to as 'mild' or minor.

Mild or minor head injury and mild concussion do not mean the same thing. All concussive injuries, mild, moderate or severe concussion, are all encompassed within the term minor head injury.

MILD HEAD INJURY encompasses much more than MILD CONCUSSION

The two terms are not interchangeable.

'Concussion' means different things to different people. In the most widely cited definition, concussion has been defined (Committee on Head Injury Nomenclature of the Congress of Neurological Surgeons 1966) as a 'clinical syndrome characterised by an immediate and transient post-traumatic disturbance in neural function, such as alteration of consciousness, disturbance of vision or equilibrium'.

Several important points follow from this definition. First, concussion can result in a wide variety of neurological symptoms and does not necessarily result in loss of consciousness. Second, concussion is usually a transient phenomenon and does not result in immediately detectable structural damage. This may not be true of repeated episodes. There is also a spectrum of injury from 'mild concussion' to severe diffuse axonal injury (severe head injury).

Mild head injury may result in short-term disability. If the injury is repeated, long-term disability may result. It is important for the health of the players and the reputation of the game that the risks are minimised.

Nearly all mild to severe concussions are mild head injuries. When discussing these problems, there must be a universal system of describing the injuries and level of concussion. Confusion in these descriptions causes problems in follow-up and the ability to make reasonable suggestions for possible rule/law changes that may help decrease the number and severity of concussions and head injuries.

Tables 2.1, 2.2 and 2.3 have been designed to assess the comparison of published literature on this topic and would not be recommended for use in prospective studies. Future reports should specify symptoms and the duration of post-concussive symptoms but should not necessarily attempt to grade head injuries since there is such a wide variation in the way gradings are used.

Table 2.1

Retrospective comparisons in grading of diffuse head injury and concussion

Head injury	Some gradings previously in use	Loss of consciousness	Observed post trauma amnesia range
Mild (Minor) Head Injury (Concussion)	Borderline concussion (Grade 0)	None (Dazed) (GCS 14 or 15)	Up to 1 hour
	Mild concussion (Grades I and II)	None (drowsiness, confusion, blurred vision, giddiness, vomiting etc) (GCS 9–13)	2–3 Hours
	Moderate concussion (Grades III and IV)	0–2 minutes (No eye opening, Not obeying commands, Not able to form words) (GCS < 9)	Up to 6 hours
	Severe concussion	2–5 minutes	
Moderate Head injury	Severe concussion Mild DAI	> 5 minutes to 6 hours (GCS < 9)	24 hours
Severe Head injury (Diffuse Axonal Injury)(DAI)		> 6 hours (GCS < 9)	Several days to several weeks or longer
	Mild DAI	(Gennerelli 1986) Coma from 6–24 hours	

Table 2.1 (cont.)

Head injury	Some gradings previously in use	Loss of consciousness	Observed post trauma amnesia range
Severe Head Injury (Diffuse Axonal Injury)(DAI) (cont.)	Moderate DAI	Coma lasting > 24 hours, no concomitant brain stem signs, ie decerebration or decortication	
	Severe DAI	Coma lasting > 24 hours, prominent motor signs of brain stem dysfunction	

NB: This table may be useful in comparison of published literature but would not be recommended for use in prospective studies. The gradation of head injuries is a continuum and some axonal injury may occur in mild and moderate cases. 'Mild', 'moderate' and 'severe', if used, need to be very clearly defined.

Table 2.2

Comparison of football codes' gradings of concussion

Loss of Consciousness (Time)	Australian Football	Rugby league	Rugby union
Nil	Player showing signs & symptoms of concussion: Headache confusion & disorientation Loss of consciousness Loss of memory Double vision Giddiness or unsteadiness Vomiting – is removed from game	**Grade 0** Head struck or moved rapidly Not stunned or dazed Subsequent headache & difficulty in concentration **Grade I** Stunned, dazed Initially no loss of consciousness or amnesia 'Bell rung' Sensorium clears quickly in less than 1 minute **Grade II** Headache Cloudy sensorium longer than 1 minute No loss of consciousness May have tinnitus or amnesia May be irritable, confused hyperexcitable, dizzy	**Mild** Confusion & disorientation Double vision, giddiness unsteadiness
Less than 1 minute		**Grade III** Loss of consciousness of less than 1 minute Not comatose (ie arousable with noxious stimuli) Demonstrates Grade II symptoms during recovery	**Moderate** Loss of consciousness Vomiting

Table 2.2 (cont.)

Loss of Consciousness (Time)	Australian Football	Rugby league	Rugby union
1–2 minutes		**Grade IV** Loss of consciousness of greater than 1 minute Not comatose Demonstrates Grade II symptoms during recovery	**Moderate** Less than 4 minutes remove from game for immediate medical attention
2–5 minutes			**Severe** Exceeding 4 or 5 minutes immediate referral to hospital

NB: There are no available gradings for soccer.

Table 2.3

Comparison of different concussion classification systems

Cantu	Kulund	Kolb	Hugenholz	Nelson	Torg	Ommaya & Gennarelli
Grade 1 (Mild) No LOC PTA <30 min	**Mild** Stunned or dazed No confusion, dizzyness, nausea or visual changes Intact coordination	**Grade 1** No LOC Stunned or dazed PTA<30 min Mild headache	**Mild** Transient or no LOC PTA<1 hour	**Grade 0** Bell rung Headache	**Grade 1** Bell rung LOC Transient confusion PTA Unsteady gait	**Grade 1** Confusion No amnesia No LOC
Grade 2 (Moderate) LOC<5 min PTA 30 min – 24 hr	**Moderate** LOC, RGA Confusion, dizzyness Rapid recovery	**Grade 2** LOC 10 sec – 5 min Confusion Disorientation PTA>30 min RGA	**Moderate** LOC<5 min PTA>24 hrs	**Grade 1** Stunned or dazed No LOC, PTA, RGA Recovery < 1 min	**Grade 2** PTA Vertigo	**Grade 2** Confusion PTA only No LOC
Grade 3 (Severe) LOC>5 min PTA>24 hr	**Severe** Longer LOC PTA, RGA	**Grade 3** LOC>5 min PTA>24 hr Confusion Headache Dizzyness	**Severe** LOC>5 min PTA>24 hr	**Grade 2** No LOC Confusion > 1 min PTA, Headache +/- irritability	**Grade 3** PTA and RGA Vertigo	**Grade 3** Confusion PTA + RGA No LOC
				Grade 3 LOC<1 min Not comatose Grade 2 symptoms during recovery	**Grade 4** Transient LOC	**Grade 4** Paralytic coma Confusion PTA + RGA
				Grade 4 LOC>1 min Grade 3 symptoms during recovery	**Grade 5** Coma	**Grade 5** Coma
					Grade 6 Death	**Grade 6** Death

References:

Kolb J., 1989 'Cerebral concussion', *Sports Training, Med and Rehab*, No. 1, pp. 165–171.
Hugenholz H., Richard M., 1983 'Onsite management of athletes with head injury', *Phys Sportsmed*, No. 11, pp. 71–78.
Nelson W., Jane J., Gieck J., 1984 'Minor head injury in sports', *Phys Sportsmed*, No. 12, pp. 103–107.
Torg J., 1991 'Athletic Injuries to the Head, Neck and Face', 2nd Ed, Philadelphia, Lea and Febiger.
Kulund D., 1982 'The Injured Athlete', Philidelphia, J, Lippincot and Co.
Cantu R., 1992 'Cerebral concussion in sport', *Sports Med*, No. 14, pp. 64–74.
Ommaya A., Gennarelli T.A., 1974 'Cerebral concussion and traumatic unconsciousness', *Brain*, No. 97, pp. 633–654.

2.2 Mechanism of concussion

The most important mechanism which produces concussion is sudden change in the rate of movement of the head (acceleration or 'deacceleration'). Forces transmitted to the brain cause shearing stresses in brain tissue which damage nerve fibres, and sometimes sever blood vessels. This change in the rate of movement of the head may occur when the head is free to move and is generated either by direct impact, ie from a knee or boot, or from the rapid change of movement of the head contacting the ground in a tackle or fall.

The other cause of injury is direct impact with the head relatively fixed. A shock wave is propagated through the brain and can cause damage in its path. In addition the impact may cause a depressed fracture, especially if the blow is in the temporal region, where the bone is thinner, and this may result in local damage to the brain.

Acceleration stress can affect any part of the brain. When it involves the deeper brain nuclei and the brain stem it results in unconsciousness. Shearing in other areas causes a variety of effects which may become apparent later - impairment of concentration, of memory, of speech, or of function of the minor hemisphere, irritability and lack of insight. It is important to recognise that these elements of damage occur independently of each other, and that whilst the clinical diagnosis of concussion is usually made from the most obvious feature – loss of consciousness – other damage can occur without this happening.

Direct impact with the head fixed also produces damage, both local and remote. It is less likely to cause unconsciousness and experimentally it requires about ten times the force to produce concussion when the head cannot move. The risk of intracranial haemorrhage is however higher.

When the head is struck, force is transmitted to the skull and the brain suffers violent acceleration: being a jelly-like organ surrounded by displaceable fluid, it has some capacity for linear movement within the skull, and there may also be swirling movement within the brain and consequent sudden deformation (Holborn 1943, 1945). Acceleration may be linear or rotational, since the head is able to pivot on the joints of the neck.

Sudden acceleration may tear the bridging veins that run from the brain to the venous sinuses, resulting in bleeding into the sub-dural space (Gennarelli & Thibault 1982). Acceleration may also damage nerve cells and fibres in the brain. Analogy with other causes of head injury suggests that angular acceleration is especially likely to cause cerebral damage (Gennarelli 1983).

A brief knockdown, due to the loss of postural stabilising reflexes, including vestibular function, or being set off balance by a sudden shift of the centre of gravity, is to be distinguished from concussive knockout.

Severe acceleration injury is uncommon in football. When consciousness is lost, it is usually for not more than seconds to a few minutes. An injury where consciousness is lost may be sufficient to cause measurable impairment of brain function for a variable period (Gronwall & Wrightson 1974).

Players with obvious concussion will usually leave the field. Some players with only brief unconsciousness or confusion have in the past been allowed to continue to play, or have insisted on doing so.

Sometimes such players have appeared to play without obvious disability. In this state, however, they may be a liability to themselves or their team. They are likely to be mildly confused, and because of clumsiness they are prone to further injury. The independence of orientation and amnesia is quite important (Ewing *et al.* 1980).

2.3 Diagnosis on the field

There is no simple key upon which non-medical personnel can diagnose or manage brain injuries. The immediate priorities of management remain the basic first-aid principles of 'airway, breathing and circulation' (see 3.4.2) then a full medical and neurological assessment should follow. Whilst concussed, athletes should not continue athletic participation (McCrory 1994).

Players who are knocked out cold present little difficulty in diagnosis. In most cases they will recover quickly and, in a few minutes, pass through the familiar stages of confusion, sometimes with aggression, to a reasonably coherent state. The function of the physician will then be to make sure that there is appropriate observation to detect any of the immediate complications. This observation should last for a minimum period of four hours and should not cease until orientation is normal, the player can walk heel to toe and balance on one foot, headache is tolerable and there are no gross neurological abnormalities. Observation is usually most easily arranged by referral to a hospital emergency department.

Diagnosis may not be so straightforward if there has been no obvious loss of consciousness, but only some unsteadiness and confusion. The most useful tests are those of memory, orientation, coordination and balance.

In testing memory, the examiner should concentrate on events in the last minutes before the injury and also short-term recall since the injury.

Orientation should also be checked for time, date and place. It is important, however, not to focus only on orientation as there is evidence to suggest that deficits

in recent memory are more indicative of concussion than disorientation (Dicker, Maddocks & Saling 1992).

Ataxia (loss of balance) can be tested by walking heel to toe, and coordination by finger to nose tests.

The length of post-traumatic amnesia (PTA) is an index of severity of brain injury. This lasts until there is reliable continuous memory as well as orientation. Formal test protocols such as the Westmead PTA scale assist in determining whether a player remains 'in PTA' or not.

On the field and in the dressing room, the use of the Digit Symbol Substitution Test (DSST) checked against the individuals's pre-injury data has been found to be useful (Maddocks, Dicker & McCrory 1993). This is a widely used neuropsychological test from the Wechsler Adult Intelligence Score Revised Manual (Wechsler 1981) which is a measure of speed of information processing.

Though some of these tests are important in the doctor's surgery and the accident department, they may not be practical on the field - a doctor may not be immediately available, and the game cannot wait. An administrative decision is therefore needed.

Because it is important that players should not continue after they have been concussed, and that they should follow a well defined management procedure for their own safety, it is essential that the referee should have a definite administrative procedure for dealing with possible concussion.

Wrightson (1993) suggested that the following guidelines (Box 2.1) should be adopted for use by referees.

Box 2.1

Concussion

Notes for referees, umpires and coaches

There has been concussion if:

- The player is seen to have been unconscious for even the shortest time;
- The player was unresponsive for even the shortest time – ie did not open his eyes, speak or get up at once;
- The player was confused for even the shortest time – didn't know what to do, which way to play, where he was;
- The player was unsteady on his feet, reeling or unable to hold the ball;
- The player showed spasms or convulsions; or
- The player had giddiness, double vision or vomiting.

The player must be able:

- to tell you: the time, the day, the month, the year the name of the other team the score and how long the game has been going; and
- to walk steadily heel to toe;

Concussion often destroys judgment.
Do not allow a player to influence you.
The player's health – and the reputation of the game – is at stake

Off the field:

It should be policy that it is a part of team discipline that players accept that after being concussed they must be seen by a doctor immediately, either at the site of the match or by being taken to the surgery or hospital by a responsible person. After this has been arranged, whatever local arrangements there are for management of mild head injury should be followed and the immediate responsibility of the game administrator ceases.

2.4 Return to training and match play

The timing of returning to training and to play is difficult to determine. Players who have lost consciousness should stay off the field for a significant period. In Rugby union, there is a mandatory period of three weeks. Players and clubs may tend to minimise the effects of concussive injuries and may put undue pressure on club doctors to allow an early return to play.

While some players may, in the absence of a mandatory rule, be considered fit to return to play in a shorter time, other players may need considerably longer time to be sufficiently recovered to return to play. Ideally, clearance from medical officers should be obtained in all situations prior to resumption of training and playing. It seems appropriate to 'err' on the side of caution, particularly in the absence of adequate medical cover and especially in younger grades.

A mandatory period of no play for three weeks has been found to be a reasonable period of time in Rugby union and is easy to administer. Shorter periods are applied in some codes. Medical officers in other codes exercise their discretion. In non-elite games other than Rugby union there are no guidelines for the management of concussion and this is a cause for concern. The practice of allowing a concussed player back to play on the same day of the concussive episode is difficult to justify without medical supervision. Ideally there would be a uniform approach to the management of concussion between the codes and across the grades. When there is no medical officer present, a mandatory exclusion period for definite concussion seems desirable.

There is probably no risk in continuing with moderate physical exercise throughout this period after injury, providing the player feels well enough to do so. Specific game training on the field is not advisable because coordination is often impaired for a time and the risk of injury is higher, and there may be some temptation to tackle or invite the risk of contact injury. Another consideration is whether the player is still slow in his reactions and therefore might be a liability to the team and a danger to himself. This is likely to be the case if the player still has problems with concentration or memory, psychomotor speed, speed of information processing and decision-making ability, or some of the other signs of a post-concussion syndrome. An enthusiastic player may however not want to admit this. The doctor may be quite satisfied from the general demeanour and performance in routine tests of coordination such as finger-nose, rapid patting, heel to shin, one leg standing and heel to toe walking. Simple tests of memory are probably not of sufficient sensitivity and objectivity. If the doctor has doubts, there is probably little more that he or she can do in the consulting room and reference to a neuropsychologist may be helpful.

It is preferable that the doctor who sees the player has some specific knowledge of the problems of sports concussion. A consistent policy is important, and though players must retain the right to be treated by the doctor of their choice, it would be worth considering whether, for administrative purposes, they should be required to see a nominated practitioner in addition to their own doctor, if necessary.

It is recognised that the definition of the mildest concussion may prove difficult. While confusion or loss of consciousness may be a guide, it is difficult when there is no loss of consciousness and minimal confusion which clears quickly.

There is also some distinction to be made between being 'initially dazed' and being confused on a prolonged basis.

Clinical assessment by experienced medical personnel is the main criterion for a return to play. A mandatory exclusion period is useful in ensuring a conservative approach. The absence of abnormality on computed tomography (CT) or magnetic resonance imaging (MRI) does not mean that the player is ready to return. Such

studies might exclude focal injury. Neuropsychological testing has been demonstrated to be useful as an objective measure of recovery following concussion (Gronwall & Wrightson 1974; Maddocks & Dicker 1988; Maddocks & Saling 1991).

'Simple tests of memory may not be of sufficient sensitivity and objectivity to enable effective decision-making. The player's performance in more sensitive psychometric tests is necessary to assess the cognitive effects of concussion.

The use of one psychometric sub-test of an intelligence scale, the Digit Symbol Substitution Test (DSST), checked against the individual's pre-injury performance is becoming widespread. However it is important this test not be used in isolation as a diagnostic measure. The sensitivity of the DSST is lost under some conditions. Experienced players who are very motivated to get back on the field as quickly as possible after injury deliberately slow their response speed when baseline measures are taken in order that their post concussion measures compare favourably. Alternate forms of the DSST need to be used in subsequent test sessions to avoid practice effects. Practice in the same form of the test would produce more skilled performance that could mask the underlying post-concussive condition.' (Geffen & Cremona-Meteyard 1994)

The view of this Panel is that detailed guidelines on the identification and management of concussion should be available at all levels of play from the Under 7s to elite players.

Guidelines for the management of concussion, developed by the Australian Rugby Football Union Ltd. and approved by the International Rugby union Board, provide a good basis for adoption by all football codes (see guidelines or end of this chapter).

When all symptoms of concussion have ceased and everything is normal, there should be a test to ensure that symptoms do not recur with exertion (eg running). This can be carried out at a training session. If symptoms do not recur, the player is probably ready to resume match play.

2.5 Long-term problems

There is some evidence that there may be some long-term effects, particularly in terms of attentional processes and information processing rate, from a single head injury, even if there has not been actual loss of consciousness. The issue is still debatable. Gronwall and Wrightson (1974) reported that a small number of patients note residual concentration and memory problems following a minor concussion and that these are accompanied by objective changes in cognitive functioning. They reported 5 patients of 80 whose information processing ability had not returned to normal 35 days post-concussion.

Maddocks, Saling & Dicker (1993 Unpublished) reported that patients who had been concussed showed no residual effects on information processing speed.

Cremona-Meteyard & Geffen (1994) reported changes in visual attention which persisted for at least one year following mild head injury in Australian rules footballers.

If there are further head injuries, the loss may be cumulative and eventually there may be sufficient impairment of function for everyday activities to be affected. The extent to which this occurs is also controversial (Gronwall & Wrightson 1975; Wrightson 1993; Cremona-Meteyard & Geffen 1994; McCrory 1994; and Maddocks, Saling & Dicker 1993 Unpublished). There appears to be a spectrum according to the severity and number of concussive episodes. For example, Gronwall and Wrightson studied patients with post-traumatic amnesia (PTA) for from one to 24 hours; Cremona-Meteyard & Geffen studied subjects with a loss of consciousness for from two to 20 minutes; whereas studies by McCrory and Maddocks involved more patients who were concussed **with no** loss of consciousness, than patients **with** loss of consciousness (which was usually brief).

In addition, the abovementioned studies on long-term effects from a single head injury and those on cumulative effects are not directly comparable in terms of the neuropsychological tests used. For example, Maddocks, Saling and Dicker were reporting only on the DSST. In contrast, Gronwall and Wrightson (1974, 1975) have focused on the use of the Paced Auditory Serial Addition Test (PASAT). Both can be seen as tests of information processing speed. The DSST, however, involves a component of psychomotor speed as it includes a section of copying symbols. In contrast the PASAT, described in detail in Gronwall and Wrightson (1974), involves auditory verbal attentional processes. It is a more demanding test due to the mental tracking component and reliance on sustained attention. Maddocks, Saling and Dicker emphasised that the DSST should **not** be used in isolation when considering concussion management (although some medical officers have tended to do this). Furthermore, the findings of Cremona-Meteyard & Geffen (1994) are based on tests of visuospatial attention which are not easily correlated with these other tests.

Even where there was some compatibility of test selection, the populations tested were dissimilar. For example, in subsequent work, Maddocks, Dicker and McCrory (1993) used the PASAT in conjunction with the DSST and a choice reaction time task to show no significant cumulative effects of concussion suffered in Australian rules football on attention and speed of information processing. While Gronwall and Wrightson (1974, 1975) had found such effects, they focused on a population of accident trauma victims but included some sporting injuries. Their studies showed that the nature of the persisting effects is the same (Gronwall & Wrightson 1974, 1975; Wrightson & Gronwall 1981a, 1981b).

The studies are not comparable in terms of post-concussion timing of test administration.

The seemingly controversial findings may reflect the variations in methodology.

Tysvaer performed retrospective studies involving retired Scandinavian soccer players (Tysvaer, Storli & Bachen 1989; Tysvaer & Lochen 1991). Although cognitive deficits were noted, significant methodological problems flaw the studies – notably, the lack of pre-injury data, statistical bias and inadequate control subjects. Approximately 40 per cent of the control group were found to be neuropsychologically impaired! The authors conclude that the deficits noted in the former soccer players were explained by repetitive trauma such as heading the ball. The pattern of deficits is equally consistent with alcohol-related brain impairment, a

variable which was not considered in the studies. To date, there has been no replication of these findings by other groups. The question of whether repeated heading of the ball causes long-term effects has not been answered.

It may be reasonable to consider withdrawing a player from contact sport for the rest of the season if there has been a second moderate or severe concussion. If the player has more than two moderate or severe concussions, the player should be counselled to change to a non-contact sport.

The ending of match play after three concussions, or any other arbitrary number, may not be acceptable to the player. An alternative might be psychological testing for cerebral function and reserve, but such an approach needs to be viewed with caution in view of the apparent controversies in the literature.

2.6 Summary

There is a difference between 'mild' or 'minor' head injury and 'mild' concussion. Similarly, concussion means different things to different people. A definition and qualification of these differences are outlined in this chapter.

Head injury where consciousness is lost for a few minutes may be sufficient to cause measurable impairment of brain function for a variable period following injury.

Diagnosis on the field and management of brain injury is not simple for non-medical personnel. Players should not continue to play after they have been concussed unless checked by an experienced medical officer. A defined procedure

for referees, umpires and sports first-aid attendants is recommended and is also presented in Appendix A.

The timing of returning to training and to play is also difficult to determine. The following guidelines for the management of concussion are recommended.

The following guidelines on concussion are adapted from those of the International Rugby Football Board (IRFB). In particular, changes have been made to the IRFB guidelines for return to competition. This Panel recommends that the following guidelines be adopted by all codes.

Concussion guidelines

Concussion occurs when, after a blow to the head, there is brain injury with some immediate disturbance of brain function. Signs and symptoms of this may include:

- confusion and disorientation;
- loss of consciousness;
- loss of memory;
- double vision;
- giddiness or unsteadiness;
- vomiting; and
- headache.

A player showing any of these signs or symptoms should be removed from the field and referred to a medical practitioner and should not be allowed to engage in further play until fully recovered.

Immediate medical attention is essential where there is loss of consciousness.

Loss of consciousness for a period exceeding 4 or 5 minutes as a result of a blow to the head would be indicative of a more severe injury, therefore, the player should be immediately referred to a hospital for further attention.

Post-Conclussive sypmtoms include:

- headache (with or without exertion);
- lethargy;
- fatigue;
- irritability;
- poor concentration;
- giddiness;
- nausea and vomiting especially in children; and
- post-traumatic amnesia (PTA) (gap in memory – memory loss after injury).

Whether a player is in PTA or not can be readily tested by a simple daily assessment. The gap in time between injury and continuous memory afterwards is important. Some questions which are useful are:

- How old are you?;
- What is your date of birth?;
- What month are we in?;
- What time of day is it? (morning, afternoon or night);
- What day of the week is it?;
- What year are we in?; and
- What is the name of this place?

Return to competition

Players who have suffered concussion with or without loss of consciousness:

- should not participate in any match or training session until they are fully recovered* and no longer have post-concussive symptoms, and have been cleared by a thorough medical examination (including examination of the central nervous system). During this period off, alcohol must be avoided;
- should undertake a non-contact exertional training session, when asymptomatic. This is to ensure that such exertion does not provoke a recurrence of symptoms; and
- should not be given a medical clearance until after this training session.

Warning

Complications, potentially serious, may occur in the 24 hours after a seemingly slight head injury. Accordingly, deterioration of consciousness after apparent recovery or the onset of symptoms such as headaches, increasing drowsiness, blurred vision and vomiting require immediate medical assessment.

*Some football codes have chosen a mandatory exclusion time for players with concussion and this has been found to be administratively acceptable.

3 Severe head injuries

3.1 Introduction

Head and neck injuries are responsible for 50 per cent of trauma (not necessarily football) deaths in Australia. In football, sporadic deaths have been reported and are fortunately rare.

Most head injuries are minor. On the other hand, any head injury can be followed by one of the major low-incidence but high-risk complications. The classical complications are extradural, subdural or intracerebral haemorrhage. They occur with acceleration injuries, due to shearing of blood vessels, and are more likely after a direct impact injury, and especially if this has been sufficient to cause a fracture.

Less well-recognised is the rare complication of acute cerebral swelling. After what may seem to have been a minor head injury the player recovers, but then minutes to an hour later deteriorates rapidly, becoming deeply unconscious. The pathology is not properly understood, but it appears to be due to a vascular instability and hyperfusion (McQuillen, J., McQuillen, E. & Morrow 1988). It has been described in some detail in the literature on American football injuries and also in head injury in children. Its occurrence is well recognised in Australia and New Zealand. Though this syndrome is uncommon, its dramatic and tragic consequences make it an important consideration in both management and policy making.

It is worth noting that there is evidence that viral infections such as infectious mononucleosis may also predispose to this syndrome, and those with such conditions should not be allowed to play.

An epileptic fit is not uncommon in children after minor head injury. Although such a fit is usually followed by a rapid and full recovery, a CT scan is usually recommended to ensure there is no intracranial haemorrhage.

Traumatic induced migraine is well noted, especially in children, and may be confused with headache due to an expanding intracranial lesion.

Evidence regarding the potential for cumulative damage from concussion relates only to individuals who sustain a second concussive injury prior to recovery from their initial injury. There is no evidence that sustaining several concussions over a sporting career will necessarily result in permanent damage. The evidence that a second impact soon after the first (second impact syndrome) increases the risk of cerebral swelling, also remains contentious. In this situation, an apparently minor

head injury followed by a second impact results in the immediate development of malignant cerebral oedema which is usually fatal.

From reviewing the few scattered case reports (Saunders & Marburgh 1984; McQuillen, J., McQuillen, E. & Morrow 1988; Kelly *et al.* 1991), it is unclear whether the initial impact was in fact an unrecognised catastrophic injury mimicking concussion and the second impact merely brought the problem to medical attention. In these anecdotal cases, the reported players typically were not fully medically assessed at the time of their initial injury. Since the players were still symptomatic from the initial injury when they sustained the second impact, a conservative policy advocating medical assessment after all head injuries and a 'safety first' policy of not returning to play while symptomatic should alleviate concerns.

3.2 Classification

Injury of the calvarium and brain may be classified as:

Skull and blood vessel damage

1. Craniofacial fractures
2. Extra-cerebral haemorrhage
3. Intra-cerebral bleeding

Brain cell damage

1. Direct contusional injury
2. Hypoxic/ischaemic injury
3. Mechanical diffuse injury.

3.3 Education

The Royal Australasian College of Surgeons has promoted courses in Early Management of Severe Trauma (EMST). These courses provide training in a system of trauma management for any medical officer likely to have to deal with trauma in an isolated setting. Australia is a vast country and distances to travel to care for such trauma may be great.

The following factors are significant in rural neurotrauma: isolation and distance, medical facilities, level of neurosurgical competence, delay in definitive care, and administrative organisation.

The Neurosurgical Society of Australasia and the Royal Australasian College of Surgeons have published conjointly a set of guidelines for the care of head and spinal injuries in rural and remote areas entitled 'The management of acute neurotrauma in rural and remote locations' (1992). Many of these principles also apply to sporting trauma and form the basis for the following guidelines for the management of severe football-related head injury.

Clinical factors which may adversely influence the outcome (death and disability) in any severe head injury in sport include:

- severity of primary injury;
- intracranial complications;
- hypoxaemia;
- hypercarbia;
- hypotension;
- prolonged prehospital time;
- admission to inappropriate hospital;
- delayed or inappropriate interhospital transfer/retrieval; and
- delay in definitive surgical treatment.

3.4 Management

At every football venue, at every level, in every age group, the aim should be to have trained personnel, ie a person qualified in sports first-aid, and appropriate first-aid equipment for head/neck injuries.

3.4.1 Prehospital care of severe head injury

The following factors require attention: airway, breathing, control of haemorrhage, prevention and treatment of shock, avoidance of factors which can either precipitate or aggravate raised intracranial pressure (the head-down position, hypoxia, hypercarbia, vomiting), recognition of serious associated injuries especially spinal injury, effective communications and transport. It is essential to obtain and maintain adequate brain oxygenation and cerebral perfusion. All of these measures serve to reduce deterioration in brain and spinal cord function after injury.

3.4.2 Position of the unconscious patient

The LATERAL position is indicated for airway control. This does not apply in a patient with a suspected spinal injury, where the supine position is usually the position of choice, with the airway controlled and manual inline immobilisation is maintained by an attendant. The lateral position is described as a position in which an unconscious victim lies on one side with the weight supported by the under shoulder, hip and the upper knee, which is at right angles to the hip. The face is turned slightly downwards to allow the tongue to fall forwards so that saliva or vomit will drain away.

On the field and in a stretcher-carry off the field, the trained attendant (fifth person) MUST walk at the player's head maintaining the airway and maintaining manual inline support of the head and neck.

3.4.3 Tracheal intubation

In certain circumstances, tracheal intubation may be needed if the airway is inadequate. Tracheal intubation should be performed only by a competent medical practitioner or by an ambulance officer specially trained and certified in this potentially dangerous procedure.

3.4.4 Spinal injury

It is important to emphasise that, in a patient with suspected cervical spine injury with an obstructed airway, the immediate risk of hypoxia takes priority over the potential risk of spinal instability. If the person is unconscious, the tongue may passively fall backward, occluding the oropharynx. Airway patency can be restored by either the modified jaw thrust manoeuvre or by pulling the mandible forward (without inadvertently extending the neck) and then inserting an oropharyngeal airway over the tongue, whilst an assistant maintains the head in the neutral or inline position.

In line with regular guidelines for EMST, the mnemonic 'ABC' – **(a) airway with cervical spine control; (b) breathing; (c) circulation** – should be adhered to.

A semi-rigid cervical collar such as the 'Stifneck' collar should be applied as soon as practical after cervical injury is suspected.

3.4.5 Glasgow Coma Score (GCS)

The early management of severe closed head injury requires establishment of a baseline against which changes in the neurological condition can be compared. Apart from an accurate history and examination, however, the level of response identified by the GCS is useful.

This score examines three areas of behaviour: eye opening, response to voice and motor responses. The score can be quantitative with 3 being the lowest score and 15 normal. A score of 8 or less implies a severe head injury (assuming that non-neurosurgical causes of coma have been treated) and suggests that the patient is non-eye opening, non-verbal and is not following commands. Patients with a Glasgow Coma Score of less that 9 generally should be intubated and ventilated.

The Glasgow Coma Score for adults consists of:

Eye opening (E)

spontaneous	4
to speech	3
to pain	2
none	1

Response to voice (V)

orientated	5
confused conversation	4

inappropriate words	3
incomprehensible sounds	2
nil	1
Best motor response (M)	
obey	6
localises	5
withdraws	4
abnormal flexion	3
extension	2
nil	1
Coma score (E+V+M)=	3–15

3.4.6 Guidelines for computed tomography

A CT head scan has been recommended in the following circumstances:

1. GCS < 9 after resuscitation.
2. Neurological deterioration, ie 2 points or more on the GCS, hemiparesis, squint.
3. Drowsiness or confusion (GCS 9-13 persisting > 2 hours).
4. Persistent headache, vomiting.
5. Focal neurological sign.
6. Fracture - known or suspected.

In this list, persistent drowsiness, confusion or headache are the most common sequelae of football head injury.

3.4.7 Admission to hospital

Criteria for admission to hospital with head injury are:

1. confusion or any other decreased level of consciousness.
2. neurological symptoms or signs, including persistent headache, vomiting.
3. difficulty in clinical assessment - eg epilepsy.
4. other medical conditions.
5. skull fracture.
6. abnormal CT brain scan.
7. responsible observation not available outside the hospital.
8. children in whom full recovery may be uncertain.

A person whose loss of consciousness was brief (less than five minutes) and who does not exhibit any of these criteria need not be admitted if a period of more than four hours has elapsed since impact. However, this presupposes that the player can

be observed at home by someone able to detect increasing headache and/or drowsiness, and to act responsibility by arranging urgent admission. Players who have been concussed should be advised not to consume alcohol.

3.4.8 Neurosurgical consultation

Neurosurgical consultation is recommended in the following circumstances:

1. Skull fracture with confusion, decreased level of consciousness, epilepsy, focal neurological signs or any other neurological symptoms or signs.
2. Deterioration in neurological status, eg a worsening in conscious state (2+ points on GCS), fits, increasing headache, new CNS signs.
3. Confusion or other neurological disturbance (GCS 9-13) without fracture but transport time to neurosurgery of more than two hours.
4. Persistent coma (GCS < 9).
5. Compound depressed skull fracture.
6. Suspected base of skull fracture, eg blood and/or clear fluid from nose or ear, periorbital haematoma, mastoid bruising.
7. Abnormal finding on CT scan.

3.4.9 Assessment of amnesia

Formal test protocols such the Westmead PTA Scale assist in determining whether a player remains in PTA or not (see figure 3.1). The scale gives not only an indication of severity of the injury but also a cognitive outcome following the injury. This test, validated by Shores *et al.* (1986), provides an operational definition of post-traumatic amnesia and a standardised procedure for the measurement of post-traumatic amnesia.

WESTMEAD P.T.A. SCALE

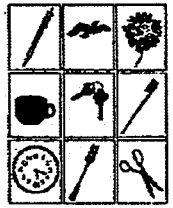
Westmead and Parramatta Hospitals
and Community Health Services

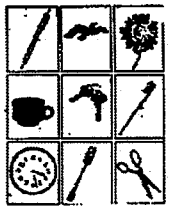
P.T.A. may be deemed to be over on the first of 3 consecutive days of a recall of 12

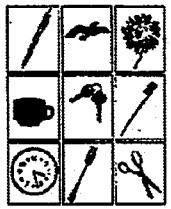
Title	Family Name	M.R.N.		
Given Names		C.M.O.		
Address	Street	Age	Sex	H.I.S.
Suburb	Postcode	Adm. date		

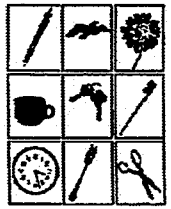
A = Answer S = Score (1 or 0)

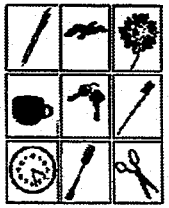
DATE			
1.	How old are you ?	A	
		S	
2.	What is your date of birth ?	A	
		S	
3.	What month are we in ?	A	
		S	
4.	What time of day is it ? (morning, afternoon or night)	A	
		S	
5.	What day of the week is it ?	A	
		S	
6.	What year are we in ?	A	
		S	
7.	What is the name of this place ?	A	
		S	
8.	Face	A	
		S	
9.	Name	A	
		S	
10.	Picture I	A	
		S	
11.	Picture II	A	
		S	
12.	Picture III	A	
		S	
TOTAL			

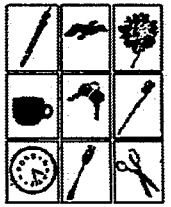












MR-120

Figure 3.1: Westmead post-traumatic amnesia scale

3.5 Summary

Most head injuries in football are minor. On the other hand, any head injury can be followed by one of the major low-incidence but high-risk complications. These injuries are more likely to occur after a direct impact injury.

At every football venue, at every level, in every age group, the aim should be to have trained personnel, ie a person qualified in sports first-aid, and appropriate first-aid equipment for head/neck injuries.

Courses in early management of severe trauma have been promoted within Australia for medical officers likely to have to deal with trauma in an isolated setting. Similarly, guidelines for the care of head and spinal injuries have been produced by the Neurosurgical Society of Australasia and the Royal Australasian College of Surgeons.

The early management of severe closed head injury requires the establishment of a baseline against which changes in the neurological condition can be compared.

4 Craniofacial injuries

4.1 Soft tissue injuries of the face and scalp

There are many more lacerations to the head than more serious head injuries. Lacerations are a significant problem in Rugby league and Rugby union but less so in soccer and Australian football. Players with lacerations are usually able to complete the match.

Lacerations and contusions of the face and scalp are the most common forms of 'head injury'. They greatly outnumber serious head injuries. Most of these require only local treatment and, although dramatic in appearance, do not have serious consequences.

Bleeding from face and scalp wounds is dramatic because of the prominent blood supply to this area. Lacerations and contusions heal rapidly, with few long-term sequelae.

In a recent study of football injuries in Australia at the elite level by Seward *et al.* (1993), head and facial lacerations were the most common in both Rugby league (28.5 per cent) and Rugby union (37.3 per cent), compared with Australian football (14.4 per cent). In Rugby league, the study showed that forwards were more likely to receive head and facial lacerations than backs. It is possible that since lacerations are more obvious on the field, the incidence of lacerations may appear higher than it actually is.

Moderately extensive lacerations can occur as a result of head-to-head clashes or trampling beneath sprigged boots. These injuries are usually superficial and are not associated with such features as tissue loss, degloving or facial nerve injury. These injuries are noted in the literature pertaining to football injuries when they are a cause for seeking medical attention and/or the absence from sporting activities for a period of more than seven days. As they seldom require hospital admission they generally do not figure in the normal hospital record retrieval systems.

Data collected from hospital emergency rooms, covering sports injuries at all levels, indicate that soft tissue injuries to the face and scalp are more common in Australian football and rugby than in soccer (table 4.1). In Australian football, the proportion varies little with age. Rugby, however, shows an increased proportion among adults, indicating that risk increases with age. It is uncertain whether this is due to strength and weight differences or differences in rule or styles of play.

Table 4.1

Face and scalp soft tissue injuries presenting to emergency rooms monitored by the National Injury Surveillance Unit (NISU)

Code	Children		Adults	
	As a % of all soft tissue injuries	As a % of all injuries	As a % of all soft tissue injuries	As a % of all injuries
'Australian football	10	4	12	4
Rugby	7	4	11	8
Soccer	7	3	6	4

Source: National Injury Surveillance Unit 1994

4.2 Blood loss and contamination

The Australian Sports Medicine Federation's (ASMF) policy on infectious diseases (1992) makes particular reference to blood-borne infectious diseases such as HIV (AIDS) and hepatitis B and C. These diseases can be transmitted during body contact and collision sports where there is broken skin or mucous membranes and: infected blood, saliva (not for HIV), or semen and vaginal fluids.

The policy acknowledges that there is no evidence that sweat/urine and tears will transmit hepatitis B or HIV. The Panel notes that the NHMRC does not currently recommend overall vaccination against hepatitis B.

The question has been asked whether players who are known to be HIV, hepatitis B or C – positive should be playing football at all. A decision on this matter is outside the terms of reference for this panel.

The ASMF recommends the following practices to reduce the risk of transmitting infectious diseases on the field:

- All open cuts and abrasions must be reported and treated immediately.
- **Players**

1. It is all participants' responsibility to maintain strict personal hygiene as this is the best method of controlling the spread of these diseases.
2. It is strongly recommended that all participants involved in contact/collision sport and playing under adult rules/laws be vaccinated against HEPATITIS B.
3. All participants with prior evidence of these diseases are strongly advised to obtain confidential advice and clearance from a doctor prior to participation.

- **Team areas**

1. It is the Clubs' responsibility to ensure that the dressing rooms be clean and tidy. Particular attention should be paid to hand-basins, toilets and showers. Adequate soap, paper hand-towels, brooms, refuse disposal bins and disinfectants must be available at all times.
2. Communal bathing areas (eg spas) should be strongly discouraged.
3. The practices of spitting and urinating in team areas must not be permitted.
4. All clothing, equipment and surfaces contaminated by blood must be treated as potentially infectious. Household bleach in a 1:10 solution may be used to wash contaminated areas and white clothing should be soaked in 1:10 solution of bleach for 30 minutes before washing. Bleach should be rinsed off after use. Coloured clothing should be soaked in disinfectant for 30 minutes then washed at high temperature on a long cycle.
5. Sharing of towels, shaving razors, face washers and drink containers must not occur.
6. It is strongly recommended that all personnel working in contact/collision sport team areas should be vaccinated against HEPATITIS B.
7. In all training areas, open cuts and abrasions must be reported to the coach and treated immediately.

- **Referees and game officials**

1. Officials must report all open cuts and abrasions to medical staff at the first available opportunity.
2. It is strongly recommended that those who officiate in body contact and collision sports should be vaccinated against HEPATITIS B.
3. All contaminated clothing and equipment must be replaced prior to the player being allowed to resume play.
4. If bleeding should recur, the above procedures must be repeated.
5. If bleeding cannot be controlled and the wound securely covered, the player must not continue in the game.
6. Those handling bleeding players should wear disposable rubber or plastic gloves. Resuscitation bags or disposable mouth-to-mouth devices should be available.

- **Education**

There is an obligation upon all relevant sporting organisations to provide suitable information on the associated risk factors and prevention strategies against these diseases. Additional information may be obtained from team doctors or State Health Departments.

The safe handling of contaminated clothing, equipment and surfaces must be brought to the attention of all players and ancillary staff.

Although Hepatitis B vaccination is usually effective in raising immunity to hepatitis B, it provides no protection against other blood-borne diseases such as HIV. Vaccination must not result in any relaxation of hygiene standards.

It must be noted that recent law changes in football codes allow for substitution of players so that bleeding wounds can be dealt with. This action accompanied by the principles of the ASMF policy may significantly decrease the risk of transmitting blood-borne diseases such as hepatitis and HIV in all codes.

4.3 Eye injuries

Sports-related eye injuries are costly to the individual and the community in terms of visual loss, specialist clinic and in-patient hospital costs and in time lost from work. Many eye injuries can be prevented by supervision of play, the enforcement of game rules/laws and the use of eye protection devices (Stock & Cornell 1991). Modern eye protection devices incorporate high-impact-resistant polycarbonate lenses in a sturdy frame with a wide flange to prevent the lenses being dislodged. They are available for use in many sports, but player acceptance in football is unlikely to be obtained.

Sturdy frames might protect the players' eyes, but may be a source of injury to other players in contact sports. In non-contact sports, safety glasses should be used by players where there has been a previous eye injury or surgery and, in particular, by players who have had permanent corneal weakening operative procedures such as refractive radial keratotomy. Consideration should be given to such players being advised not to play football.

Football players who require refractive correction usually find that contact lenses give better vision without the problems of dislodgment of spectacles, steaming up of the lenses and so on. However, jolts to the head and local ocular minor injuries can result in dislodgment and loss of contact lenses.

137 consecutive patients with facial fractures resulting from sporting activities were treated by the Department of Plastic and Reconstructive Surgery at the Royal Adelaide Hospital in the three-year period ending June 1992. There was intent to injure in 11 per cent of the cases (Lim *et al.* 1993). Australian rules football was the causative sport with 72 of the patients (52.6 per cent), rugby with eight of the patients (5.8 per cent) and soccer with seven of the patients (5.1 per cent). This compares with 14.6 per cent from cricket, 6.6 per cent from horse-related activities and all others 15.3 per cent.

Orbitozygomatic fractures were seen in 62 per cent of the patients overall and in 58.3 per cent of those playing Australian football. These injuries produced wide-ranging ocular injuries from periorbital bruising and laceration, to corneal abrasions, hyphaema, vitreous haemorrhage, retinal oedema (*Commotio retinae*) and tears. Orbital wall fractures produced ocular motility problems with resultant double vision which at times required secondary corrective surgery.

Ideally, ophthalmological screening should be performed on all patients with facial fractures as the overall incidence of ocular damage is almost 5 per cent (Crompton & Hammerton 1994) (see table 4.2). In practice, however, all patients that have suffered a fracture of an orbital wall must be referred to an ophthalmologist as this group has a much higher incidence of ocular trauma.

Any patient with facial fractures who has ocular symptoms such as defective vision, double vision, pupillary problems, proptosis and any other matter of visual concern should also be referred.

Table 4.2

Ocular injuries in a series of 839 adults with facial fractures

Type of injury	Number of patients
Anterior segment	
Corneoscleral abrasions/lacerations	4
Hyphaema	10
Severe chemosis with infection	1
Increased intraocular pressure	1
Posterior segment	
Vitreous haemorrhage	3
Retinal oedema/tear/haemorrhage	10
Commotio retinae	3
Choroidal haemorrhage/rupture	1
Optic nerve damage	5
Penetrating globe injury (followed by enucleation)	3
Total	41

Source: Crompton 1994 (unpub)

4.4 Injuries of facial skeleton

4.4.1 Fractured nose

The vast majority of nasal fractures are simple closed fractures. They require active treatment only if displacement occurs. There is no doubt that a significant proportion of nasal bone fractures are unreported. Treatment involves admission to hospital, reduction of the fracture and external fixation under a brief general anaesthetic. Hospital stays would generally not exceed 24 hours. Body contact sport within a period of four weeks may result in refracture.

4.4.2 Fractured zygoma

The zygoma is displaced from its bony attachments to the facial skeleton, resulting in loss of 'cheek bone' prominence and partial loss of sensation on the side of the

face. There may be disturbance of vision and restriction of jaw movements. Treatment is required if the bone is significantly displaced and this involves hospital admission for two to three days. The bone is reduced and fixed under a general anaesthetic. Body contact sport should be avoided for at least four weeks.

4.4.3 Fractured maxilla or mandible

Fracture often results in painful derangement of the dental occlusion, contour deformity and loss of sensation to sections of skin, lips and teeth. In such cases, admission to hospital is required to reduce and fix the fractures under a general anaesthetic. There are two main treatment modalities: intermaxillary fixation (jaw wiring) and rigid bony fixation devices (bone plates). These techniques may be used independently or in combination. Generally three or more days are required in hospital and the teeth are usually wired together for about six weeks. During that time only a liquid diet is possible. A fractured maxilla is a distinctly unusual result from a football injury but, following treatment, body contact sport can often be resumed after eight weeks. A fractured mandible, however, should not be exposed to football trauma for at least three months.

4.4.4 Dental injury

Unlike other injuries, natural healing and repair processes will not restore damaged teeth. Individual teeth may be avulsed or so severely fractured that extraction is the only recourse. Prosthetic replacement of teeth, crowns and bridgework is costly and the resultant appliances are relatively fragile. Devitalised teeth gradually become more brittle with the passage of time and more liable to fracture.

4.5 Epidemiology of maxillofacial injuries in football

4.5.1 Lacerations of the scalp and face

To compare various studies it is necessary to introduce the concept of 'player/games'. A single player over the average season of 25 games yields the statistic of 25 player/games. A rugby team of 15 players will yield 375 player/games over the same period. The frequency of lacerations requiring medical attention appears to vary between reports but is clearly much more common at senior and elite levels than in junior football.

1. Seward *et al.* (1993). A review of injury in senior-level football players.

   Australian football: 299 players yielded 18 lacerations . . .
   one per 415 player/games.

   Rugby league: 312 players yielded 35 lacerations . . .
   one per 222 player/games.

   Rugby union: 135 players yielded 27 lacerations . . .
   one per 125 player/games.

   (Assuming 25 games per season).

2. Myres (1980). A review of injuries from senior-level Rugby union during the 1979 season.

   221 games yielded 93 lacerations . . .
   one per 36 player/games.

3. Alexander, Kennedy, M & Kennedy, J. (1979). Reviewed injuries from three senior grades of a single NSW country Rugby league club.

   (Assuming 25 games) 10 lacerations . . .
   one per 97 player/games.

4. Davidson (1987). A review of schoolboy Rugby union injuries over a 17-year period involving 93 780 player/games.

   114 lacerations recorded . . .
   one per 823 player/games.

Protective headgear reduces the incidence and severity of lacerations and other soft tissue injuries (see chapter 6).

4.5.2 Maxillofacial fractures

There are relatively few studies which link maxillofacial injuries to a specific number of players and games. The results of these studies are difficult to interpret. The risk of such injury generally appears to be low but the injury rate fluctuates widely between studies.

1. Myres (1980)

Rugby union 1979

Injury	Games	Injury rate player/games
Fractured nose	10	1 per 331
Fractured mandible	3	1 per 1,103

2. Alexander, Kennedy, M. & Kennedy, J. (1979)

Rugby league

Injury	Games	Injury rate player/games
Head & neck fractures & dislocations	9	1 per 8

3. Davidson (1987)

Schoolboy Rugby union

Injury	Games	Injury rate player/games
Fractured nose	18	1 per 5,210
Fractured maxilla	4	1 per 23,445
(No fractured mandibles recorded)		

4. Kay *et al.* (1990)

A retrospective questionnaire on surgery of maxillofacial injuries in 99 players from a single Scottish 1st Division Rugby union club (64 per cent response rate from players)

Injury	Games	Injury rate player/games
Fractured nose	28	1 per 844
Fractured mandible	3	1 per 7,875
Lost teeth	12	1 per 1,958
Lacerations	25	1 per 945

5. Sane & Ylipaavalniemi (1987)

A comprehensive study of soccer players in Finland from 1979 to 1982 involving all registered players (approximately 50,000 per year). There is no information regarding number of games played per season.

Injury	Average per season	Injury rate player/games (assuming 20 games per season)
Fractured nose	18	1 per 55,000
Fractured zygoma	3	1 per 333,333
Fractured maxilla	1	1 per 1,000,000
Fractured mandible	2	1 per 500,000
Dental injury	170	1 per 5,882

6. Hill, Crosher & Mason (1985)

A review of 130 players with dental and facial injuries collected over a five year period. Approximately equal numbers of fractured zygomas were seen in both soccer and rugby players. A greater number of mandibular fractures were seen in rugby players.

4.5.3 Contribution of football to the total hospital experience of maxillofacial injuries

1. Lim *et al.* (1993)

Review from South Australia of 137 sports-related facial fractures

These cases were collected over four years (1989–1992). The 137 cases (16.3 per cent) were extracted from a total of 839 patients with maxillofacial fractures. Of the 137 sports-related cases, Australian football was responsible for 72 cases (52.6 per cent), soccer was responsible for seven cases (5 per cent) and rugby was responsible for eight cases (6 per cent).

For the football-derived injuries, distribution of fractures was as follows:

Zygoma	36%
Mandible	28%
Nose	2%
Orbit	6%

2. Westmead Hospital (1991 unpub.)

Football was responsible for 60 cases (6.8 per cent) out of 874 cases admitted with maxillofacial fractures. The distribution of the 60 cases was as follows:

Zygoma	27
Mandible	21
Nose	12
Maxilla	0

Prevention: The use of mouthguards is discussed in 6.2. The high elbow tackle is thought to contribute significantly to maxillofacial fractures of this nature.

4.6 Summary

Lacerations and contusions of the face are common. They appear to occur with greater frequency in elite and senior football. The risk of transfer of infectious diseases via bleeding wounds requires special precautions. Eye injuries include periorbital bruising and laceration, corneal abrasions, hyphaema, vitreous haemorrhage, retinal oedema (*Commotio retinae*) and tears.

Fractures of the nose are common. Fractures of the zygoma and mandible are more common than fractures of the orbit or maxilla. The high elbow in tackles is a common mechanism leading to such injuries.

The use of custom-fitted mouthguards and avoidance of high tackles are important factors in prevention.

Recommendations

The use of custom-fabricated mouthguards in contact sports, including football (all codes), is strongly recommended.

Research into the use of soft head protectors or scrum caps to reduce injuries of the scalp, ears and face is supported. Design criteria and manufacturing standards for such head protectors need development.

Appropriate practices and education to reduce the risk of blood contamination in contact/collision sports should be adopted in all football codes. Immunisation against hepatitis B is strongly recommended.

5 Neck injury

5.1 Soft tissue Injury

It is not easy to provide adequate support of the head and neck in order to provide adequate rest until musculo-ligamentous injuries are healed. For example, a sprained ankle may be rested by non-weight-bearing; however, weight-bearing of the head on the neck occurs in any position other than the recumbent position.

A supportive collar may only provide temporary and limited assistance. Manipulative therapy is as inappropriate as it would be for an ankle sprain.

5.2 Injuries of nerve roots and brachial plexus

In rugby codes, players after scrummage and tackling may complain of shoulder and arm paraesthesiae (abnormal sensations) which are sometimes painful. This 'stinger' or 'burn' injury is usually transient. It is thought to relate to brachial plexus stretch, especially of the upper trunk.

Brachial plexus injuries in football usually occur in tackles where the tackler's shoulder is distracted from the neck by forceful downwards pressure on the shoulder. This results in a direct traction injury, rarely causing root avulsion but a stretch injury to the plexus in the supraclavicular region. Shoulder dislocations which occur in the same manner may cause a plexus injury which usually has its maximum effect on the axillary nerve.

Management is usually conservative but investigations, predominantly electrical studies and magnetic resonance imaging (MRI), may be required if recovery does not occur within seven to eight weeks. Rarely are football injuries severe enough to consider surgery. Surgical exploration is indicated if the investigations reveal evidence of persistent nerve/muscle damage at about 10 weeks. Since there is a wide variation, assessment on an individual basis is essential.

These injuries require medical assessment. The best treatment is rest and physiotherapy. Early return to play causes a prolongation of symptoms.

5.3 Cervical spine injury

Injuries without spinal cord involvement are much more common than spinal cord injury (SCI) and are also poorly recorded, as noted above. Neurosurgical, orthopaedic and sports medicine clinics see such cases fairly frequently; however, more accurate data are needed.

Minor subluxation of the facet joints (posterior intervertebral joint or zygo-apophyseal joints) causes localised pain. Pain in the head, shoulder, arm or inter-scapular region may also occur. Capsular strains, subluxation and facet fractures occur. Injuries of this type may contribute to later development of osteoarthritic change.

Intervertebral disc injuries include tears of the fibres of the annulus (capsule), injuries near this in the disc rim and disruption of the nucleus pulposus with degeneration and prolapse. Disc herniation or prolapse leads to spinal cord or nerve root compression. Shoulder and arm pain, headache and interscapular pain occur. Fractures and fracture dislocations of a wide variety are known. Dislocations associated with facet joint and disc disruption are more common and are potentially more serious than vertebral body fractures alone. Fractures may be missed on plain cervical spine radiographs, and CT scans and/or MRI may be required to demonstrate the extent of cervical spinal column injury.

5.3.1 Scrum injury

There has been much written in the medical literature concerning injuries to the cervical spine during Rugby union football. Most articles relate to acute injuries involving the spinal cord. There is growing evidence that significant morbidity arises from Rugby union in the form of non-cord injuries to the cervical spine, of both an acute and chronic nature (Broughton 1993; Hughes & Fricker 1994; Scher 1990). Sports medicine practices are frequently attended by past and present rugby players who have clinical and radiological evidence of premature degeneration of the cervical spine. Front-row forwards seem to be by far the most commonly affected group among rugby players. The degenerative changes are evident in some players aged in their early 20s.

Figure 5.1 illustrates examples of the direction of force at the time of injury sustained in a scrum in rugby players.

The scrum exhibits a consistent left-directed force on all front-row forwards during the sustained pushing phase of the scrum (Milburn 1993). The cervical spine of front-row players is forward flexed and laterally flexed to the left by the force of binding with an opponent. The cervical spine is then rotated as the player strains to see the in-coming ball.

With regard to mechanism, both axial loading and rotation forces or a combination of these two are important in cervical spine injury.

Torg *et al.* (1979) as a result of a biomechanical analysis of those injuries resulting in cervical spine fracture-dislocation have disclosed a previously unrecognised

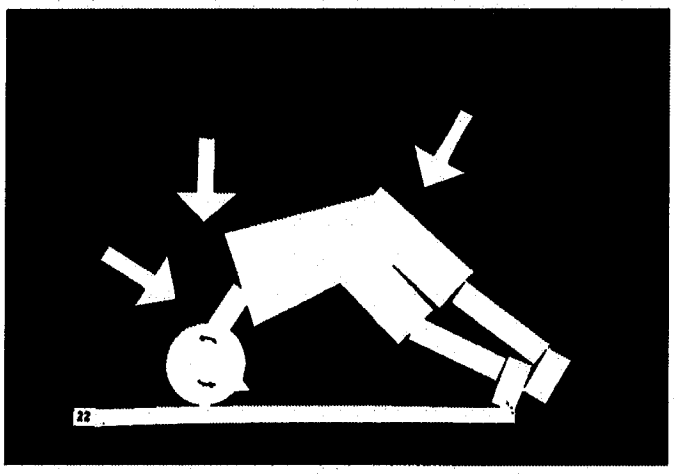
mechanism: nonaccidental loading of the straightened cervical spine reacting to maximum axial compressive deformation as a segmented column.

The axial load mechanism has been shown to be important in the mid cervical spine segment (Torg *et al.* 1991a) and in the tear drop fracture resulting from players in American football attempting to make a tackle in which the initial contact is made with the top or crown of the helmet (Torg *et al.* 1991b).

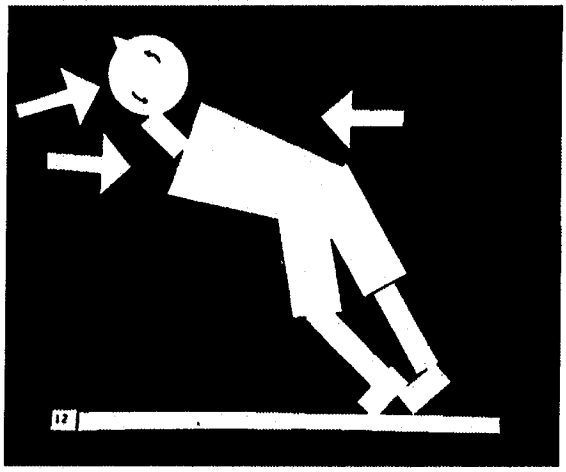
A similar mechanism may exist in rugby if players use the unhelmeted head in a tackle.

Hughes and Fricker (1994 in press) conducted a prospective survey of injuries to first-grade Rugby union players in the Australian Capital Territory (ACT). Of five injuries recorded which required players to miss the equivalent of a season of rugby, three were non-cord injuries to the cervical spine of front-row forwards. The findings of acute intervertebral disc injury in several cases were consistent with Scher's (1990) finding that the most affected regions of the cervical spine were C5/6 and C6/7.

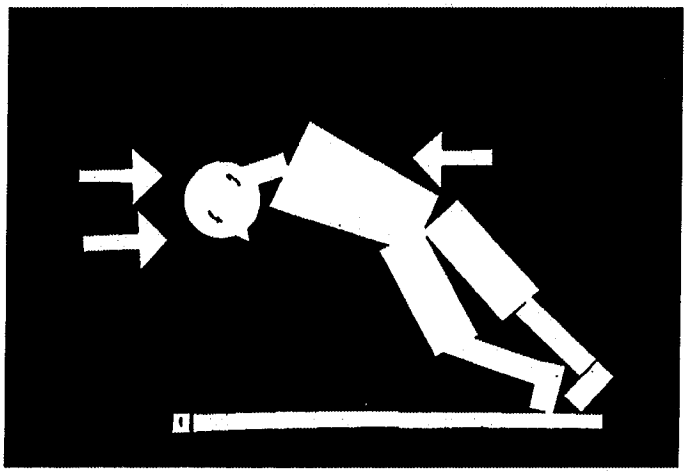
Figure 5.1: Diagrams identifying examples of direction of force at the time of scrum injury in players admitted to the Spinal Unit at Royal North Shore Hospital (Yeo 1986).



21 years Prop-blind side Scrum

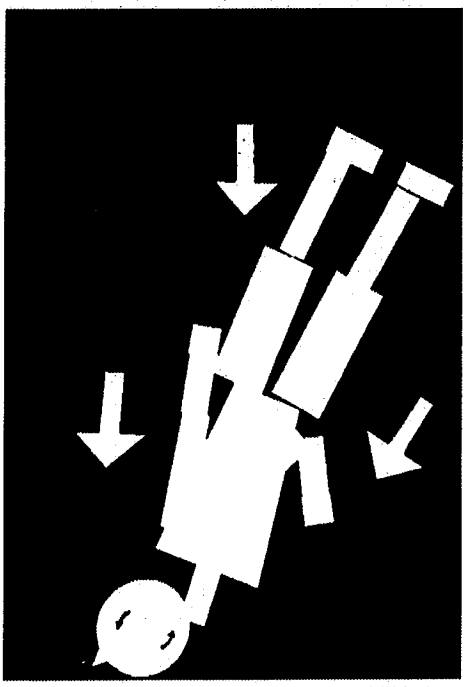


23 years Hooker Scrum

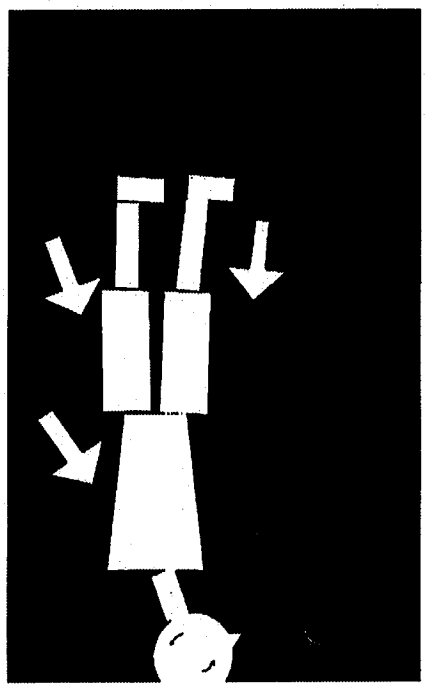


16 years Prop-loose head Scrum

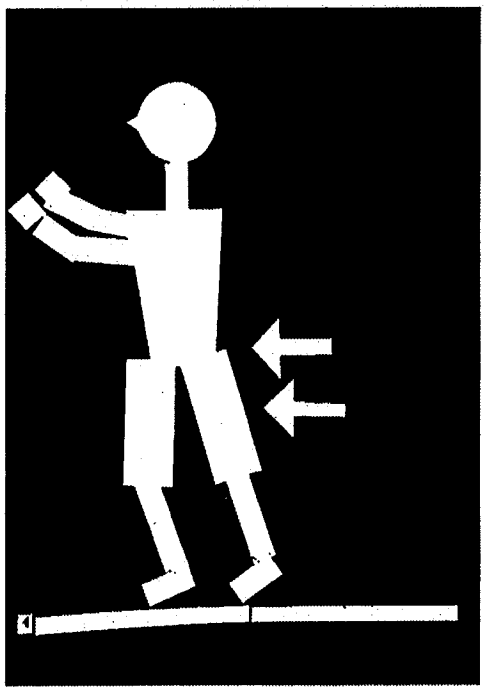
Figure 5.2: Diagrams identifying examples of direction of force at the time of tackle injury in players admitted to the Spinal Unit at the Royal North Shore Hospital (Yeo 1986).



16 years Winger Tackle



20 years Second Row Tackle



18 years Centre Tackle

It is interesting to note that the affected players in the study by Hughes and Fricker (1994 in press) all had left-sided pathology. In Rugby union, because there is no opposition to the left of the loosehead prop, the player in this position may experience more lateral flexion and may have an increased risk of degenerative disc and facet joint disease. On the other hand, the tighthead prop has a relatively fixed position in protraction and flexion, and therefore may be more prone to spinal cord injury. In this position, there is less ability to cope with abnormal forces in, for example, a collapsing scrum. The overbinding position of a tighthead prop accentuates this problem.

The Australian Rugby Football Union in 1985 amended Law 20(2) at Under 19 level to require front rows to adopt a 'crouch-touch-pause-engage' sequence during engagement. The engagement sequence, 'crouch-pause-engagement' was subsequently introduced at senior level in 1988. These rules have decreased the speed of engagement. The 'crouch-pause' law has necessitated forward packs from both teams being closer together prior to engagement, thereby reducing the speed and momentum generated at scrum engagement.

5.3.2 Tackling injuries

Unfortunately, injuries can and do occur from seemingly legal tackles. In rugby, many of the serious injuries seem to occur to the tackler through hitting his opponent head first. In order to reduce the frequency of tackle injuries, it is necessary for all players to be physically prepared to protect themselves from injury. It is also essential that players are aware of the correct techniques for tackling and the risk of injury (to the tackler and to the tackled player) if the tackle is not executed properly, ie correct head positioning in rugby is an essential component of a safe tackle. Good coaching and practice are essential.

Although the so-called 'spear tackle', stiff arm and head high tackles and 'round-the-neck' have been long outlawed, high tackles on the neck or head appear to be a common mechanism of cervical spine injury.

Figure 5.2 illustrates examples of direction of force at the time players sustained injuries as a result of various tackles. Figure 5.3 provides a good illustration of what is known in Australia as a 'spear tackle'. This type of play usually results in the tackled player being injured. In American football, a 'spear tackle' is when a tackling player uses his head to 'ram' or 'spear' the opposing player. In this instance, it is the tackling player that usually sustains serious injuries.

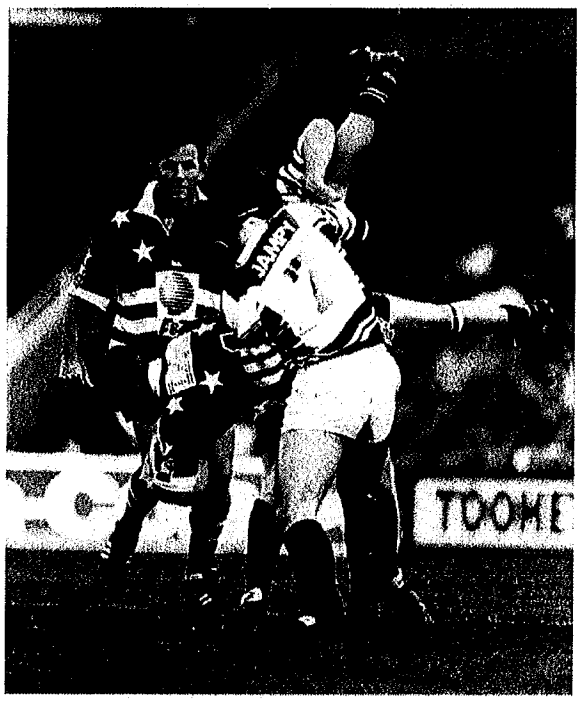
Milburn (1994) notes that some contemporary techniques used in Rugby league expose the tackled player to risk of head and spinal injury. These include the ball carrier ducking under a potentially high tackle, multiple tackles (particularly when the ball carrier is obviously held in a tackle), and tacklers making no attempt to grasp the ball carrier and, instead, attempting to stop the player by using a shoulder charge. The latter two techniques expose the ball carrier to 'whiplash' type injury.

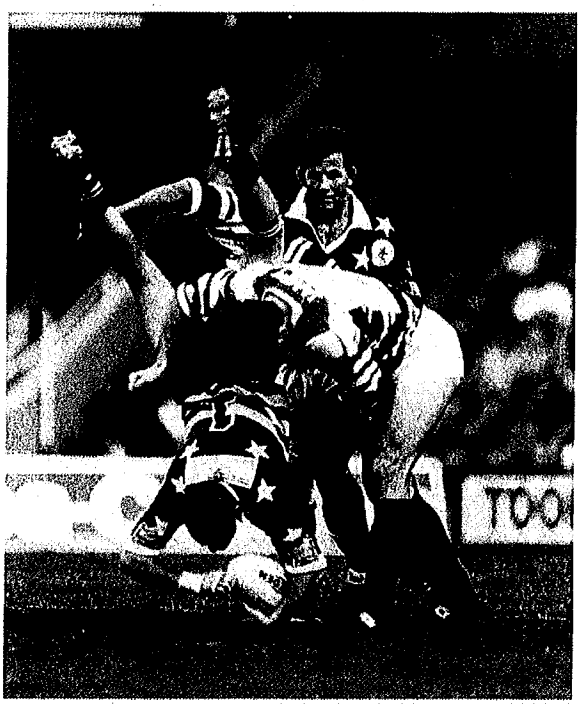
In one submission received by this inquiry, in 1993 an Australian football player suffered a fracture of the fourth cervical vertebrae. The injury was treated by a heavy brace for some time and then a softer collar. Although this incident was said to be a

delayed tackle, review of the video showed that there appeared to be no 'dangerous' play. Such accidental tackles in legal play are difficult to prevent.

Recording the precise mechanism of cervical spine injury is important in diagnosis. Sometimes axial loading and lateral flexion forces cause fracture but pain may be minimal. Trauma 'stress induced analgesia' occurs for a time in some players, as it does in soldiers on the battlefield. Diagnosis may be difficult in facet joint and pedicle fractures. CT may be needed to show fractures not revealed by plain radiograph.

Figure 5.3: An example of spear tackling taken during the 1994 World Sevens Rugby.





Photos: J. Town, *The Daily Telegraph Mirror*, Saturday, Feb 5 1994
(reproduced with permission from Mirror Australian Telegraph Publications).

5.3.3 Ruck and maul injuries

Cervical spine injuries sustained in a ruck and maul appear to be more frequent than scrum and tackling injuries. Fortunately, charging into rucks and mauls has been outlawed in Under 19 Rugby union laws since 1985. Controlled, de-powered engagement of the scrum has also been introduced in Under 19 laws. Since this change, there has been one spinal cord injury in 1993 (associated with a tackle then maul). The head-down position after a tackle or diving for a ball places the player at risk. Similarly, contact with other players converging on a loose ball may put a player at risk. Accidental axial loading and flexion injuries of the cervical spine occur from such impacts.

5.3.4 Management of spinal injuries

Notes for referees and umpires on spinal injuries, similar to those for concussion, may help to improve 'on-field' management of spinal injuries (where there may be

Box 5.1:

Spinal injury
Notes for referees, umpires and coaches

There has been a spinal injury (until proven otherwise) if:

- the player is unconscious;
- the player has prominent neck pain;
- the player has no sensation or has pins and needles, in any limb; or
- the player is weak or cannot move the limbs below the site of the injury.

Note: If the player has received a prominent impact above the collar bone, the possibility of a spinal injury needs to be considered.

5.3.5 Management on the field

Whenever cervical spine injury is suspected: after protecting the airway (in line with regular guidelines for EMST), the head should be immobilised with the attendant's hands and maintained in the 'neutral position', ie aligned with the spine. Inadvertent movements of the neck must be prevented. It is particularly important not to flex the neck. For a stretcher-carry off the field, a minimum of five people is recommended – one at each corner and one holding the patient's head and neck. The direction of travel for the injured player is feet first.

The preferred means of rapidly and safely immobilising the neck from flexion and extension is to apply a semi-rigid cervical collar, such as 'the Stifneck'. Lateral cervical immobilisation also needs to be maintained. This can be accomplished using

blanket rolls, blanket halo, Russell Extrication Device (RED) or other types of immobilisation boards. For further details of the on field and pre-hospital management of head and spinal injury see Item 3.4.

5.3.6. Transfer after removal from field

Neurological deterioration may occur during transport (Toscano 1988). Wherever possible, patients with major spinal cord injury should go direct to Spinal Units from the field. Other patients with neck injury need to be assessed in the nearest appropriate medical facility with access to radiological equipment.

In many instances, initial care in a general hospital will also be indicated before transfer to a Spinal Unit is practical for patients that have suspected spinal cord injury.

Before transportation to hospital, the following important matters should be confirmed:

1. The airway is clear and 'guaranteed'.
2. Ventilation (either spontaneous or assisted) is satisfactory. Supplemental oxygen is being administered. Endotracheal and other tubes are securely attached to the patient.
3. Neurologic assessment is completed and documented.
4. The entire spine has been immoblised securely for transport in devices suchas the Russell Extrication Device and Stifneck collar.

Before transport between hospitals (to a Spinal Unit) the following important matters should be confirmed:

1. The airway is clear and 'guaranteed'.
2. Ventilation (either spontaneous or assisted) is satisfactory. Supplemental oxygen is being administered. Endotracheal and other tubes are securely attached to the patient.
3. Neurologic assessment is completed and documented.
4. Chest X-ray is completed, examined and preferably reported by a radiologist.
5. Blood pressure is stable and intravenous lifelines are established.
6. The stomach has been decompressed with a naso-gastric tube.
7. Urinary bladder drainage has been established.
8. The entire spine has been immoblised securely for transport in devices such as the Russell Extrication Device and Stifneck collar.
9. Pressure on the skin over bony prominences has been relieved.
10. The Spinal Unit has accepted the patient and the Retrieval Team notified.
11. When removing clothes they should be cut off in order to avoid unnecessary spinal movement.

The Russell Extrication Device is made in Australia and has been shown to be highly effective in the immobilisation and transport of patients with spinal injury (Cohen *et al.* 1990).

The Jordon frame is also an Australian device which allows lifting, without 'moving' the patient, but is not an immoblisation device.

The 'scoop-stretcher' is a lifting device that is beginning to be used widely in elite football.

5.3.7 Return to play after neck injury

In some circumstances return to play is safe after injury provided there is no continuing neurological impairment and medical confirmation that healing has occurred. This would include an adequate range of movement and strength and confirmation of cervical spine stability. Modern cervical spinal injury management including surgery does not preclude a return to competition in some instances. The decision to return to play should be made by an expert in the management of this type of injury in association with clear discussion with the patient regarding future risks.

5.3.8 Aftermath of cervical spine injuries

Neurosurgical and sports medicine clinics often see former football players who have cervical spondylosis or cervical disc injury.

Scher (1990) performed plain X-ray examinations of the cervical spine on 150 asymptomatic rugby players, half of whom were forwards. There was evidence of degeneration of the cervical spine in 40 of the rugby players, nine of these being less than 25 years of age. Of the 40 affected players, 30 (75 per cent) were 'tight forwards' (front-row and locks). In all age groups studied (20-25 years, 25-30 years, 30-35 years) there was a far higher incidence of degenerative disease among rugby players than age-matched controls. Further studies are needed in Australia.

5.4 Spinal cord injury

The number of injuries involving spinal cord injury is low and therefore a statistical analysis may be unreliable. Such injuries should be looked at individually. This Panel recommends that a national data collection system is required and notes most of the elements for this are in place and could be easily coordinated.

Rugby union and Rugby league are the two games where there is most risk of injury of the vertebral column. The number of spinal cord injuries from all forms of sport rose from 46 in 1988 to 54 in 1989 and 56 in 1990. All injuries were in males, with the exception of three diving accidents and one accident in horse riding. It is of note that in 1990 eight males became quadriplegic as a result of playing football but no details of the codes or mechanisms of injury were collected. Hence the problem remains a major one, with far reaching financial implications (Coolican & Taylor 1993).

There was an alarming increase in major spinal cord injury in schoolboy footballers (Rugby union and Rugby league) in the early 1980s in NSW. Taylor and Coolican (1987) reviewed 107 footballers who suffered a spinal cord injury between 1960 and 1985. Eight died and half recovered some degree of motor function. In Rugby union,

collision at scrum engagement rather than scrum collapse was the main factor. Front-row forwards, especially the hooker, were most at risk. Significant injury was more likely in the tighthead prop rather than the loosehead prop. Tackles were responsible in Rugby league while collision of players was the main mechanism in Australian football. Illegal play was responsible for 20 per cent of injuries in that study. The peak incidence was towards the end of the football season but the stage of the match did not seem to influence the likelihood of injury.

Data for spinal cord injuries in South African rugby players come from a 30 year survey of admissions to the Spinal Unit at the Conradie Hospital in Cape Town, the source of the original study of spinal cord injuries in rugby players (Editorial, British Medical Journal 1977; Scher 1977). The most recent analysis of those data (Kew *et al.* 1991) showed that the annual number of admissions of Rugby union players with spinal cord injuries rose progressively during the 1980s, with a peak incidence of 12 admissions in 1989. In the last four seasons (1990–1993), there have been a further 31 spinal cord injuries in rugby players, a total which is lower than the 37 such injuries in the four preceding seasons (Noakes & Jakoet 1994 Unpublished).

Power scrummaging has been identified as a major factor, rather than scrum collapse. Competitiveness towards the end of a season is thought to also be a factor associated with more aggressive play. The absence of this factor in training is thought to be a major reason why injuries occurred almost entirely at matches. Media and spectator encouragement in this competitive atmosphere is thought to contribute to the more aggressive styles of play.

The Panel commends the Australian Rugby Football Union for the change to the laws of scrum engagement (crouch, touch, pause, engage) sequence and for discouragement of players being put in positions for which they are not prepared. Collection of further data is required to show the incidence of spinal cord injury from scrummage since this change.

There are, at present, a number of education programs for the prevention of spinal cord injury being presented to schools and football clubs, for example, the Spinal Awareness and Prevention Program presented by a team of wheelchair athletes (Coordinator/Lecturer: Ms. Donna Ritchie, 600 Victoria Road, Ryde NSW – Ph: 808 9202/9270).

Audio/visual cassettes on prevention and player preparation are available from both Australian Rugby union and Rugby league organisations.

It is essential that these programs be financially supported, encouraged and expanded. Some success in reducing the incidence of spinal cord injury through the presentation of these programs appears to have occurred, and coordination of these programs should be encouraged.

5.4.1 Prevention of spinal cord injury

Rugby union has recommendations regarding the selection of players for certain 'specialist' positions: front-row forwards/hooker. There are also laws in place that a player in these positions can only be replaced (if an injury occurs during a game requiring replacement) by other specialist players of these positions.

Rugby league distinguishes to some extent between forwards (especially front-row forwards) and backs. This is not thought to be a great problem as the scrum is de-emphasised (ie has been depowered) in Rugby league.

Australian football and soccer do not appear to have specialist positions for selection purposes.

Congenital cervical spinal canal stenosis may also be a factor in raising the risk of spinal cord injury. A plain lateral cervical spine radiograph may be misleading in the identification of this rare condition. CT myelography more accurately shows whether or not there is sufficient space around the spinal cord in doubtful cases. Sagittal and axial T1 MRI images are sufficiently accurate to assess the amount of space for the spinal cord and are non-invasive. MRI is therefore now generally recommended (Herzog *et al.* 1991).

Yeo's (1986) study on spinal injuries recommends that footballers should attempt to build up their own 'inbuilt' splint mechanism by concentrating on strengthening and improving the strength of the neck muscles. In rugby, front-row players with short, thick necks should undertake strength training of the neck muscles. This is thought to 'splint' the neck to cope with both rotational and axial loading. Taylor & Coolican (1988) dispute that this 'inbuilt splint mechanism' exists and assert that many of the spinal cord injuries from rugby occur with the mechanism of axial loading of the cervical spine, where strong neck musculature could not be expected to make any difference to the injury. Those injuries that occur due to hyperflexion in which the player has sufficient time to reflexly or voluntarily extend his neck could be expected to be reduced by a neck strengthening program.

In motorcyclists, it has been shown that a full-face helmet transmits forces to the clavicles, attenuating the axial loading through the cervical spine from the head (Yeo 1979).

During tackling and in rucks and mauls in rugby 'eyes open and head up' should be standard coaching practice to reduce the risk of cervical spinal injury from axial loading.

A national register of spinal cord injuries resulting from football is the only way the frequency of such injuries can be scrutinised, the public kept informed and the effectiveness or otherwise of rule/law changes evaluated.

Epidemiological data for cervical spine injuries in football but without spinal cord damage have never been gathered in this country. It is considered practical to attempt data collection for these injuries from 1990 onwards. It is further suggested that the registry encompass all sports and not football alone. This has not been previously attempted in Australia.

5.5 Summary

Neck injuries that may occur in football include soft tissue musculoskeletal injury, brachial plexus injury, cervical spine injury and spinal cord injury.

Scrum injury, tackling injury, ruck and maul injury and open play accidents are analysed. Substantial progress has been made towards prevention of these injuries by rule/law change, compliance, player selection and training and general public awareness.

Recommendations

There should be a national registry of deaths, brain injury with permanent functional disability, and cervical spine injury (spinal injury with or without cord involvement).

Programs of prevention of head and neck injuries should include:

(i) research into the selection of a player for a position according to body type;

(ii) education of players, coaches, administrators and sports trainers; and

(iii) research into specific aspects of fitness training, including neck muscle strengthening.

Guidelines for the recognition of concussion and spinal injury should be promulgated to referees and umpires to enable them to conduct their administrative responsibilities.

At every football venue, at every level, in every age group, the aim should be to have trained personnel, ie a person qualified in sports first-aid, and appropriate first-aid equipment for head/neck injuries.

The frequency, duration and resetting of Rugby union scrums, including a limitation of the number of times a scrum is reset, should be reviewed.

6 Head and neck protection

6.1 Head protection

The role of a helmet is to absorb the forces and decelerate the blow at the point of impact, distribute the focal impact over a larger area, withstand surface abrasion and to protect the bone and soft tissue from injury (for instance, lacerations). There are a number of potential risks of inappropriate helmet use in football. An ineffective helmet may provide the wearer with a false sense of security, and hence not prevent the damage for which it is presumably worn.

Helmets thus must be sport-specific to be effective. The demands of an individual sport must be researched and then an appropriate helmet configuration, shock-absorbing material and outer surface must be constructed.

The use of helmets increases the size and mass of the head. This may result in an increase in brain injury by a number of mechanisms. Blows that would have been glancing become more solid and thus transmit increased rotational force to the brain. These forces result in shearing stresses on neurones which may result in concussion and other forms of brain injury. Poorly designed helmets may obscure peripheral vision.

6.1.1 Protective head gear in football

The use of protective head gear in sport has attracted a considerable degree of interest in the sports medicine literature. Helmets of different types and qualities have been developed for athletes engaged in sports as diverse as American football, ice hockey, baseball, boxing, alpine skiing, cycling and motor sports. Some sports, such as American football (gridiron), require helmets with face masks in order to protect the facial area and teeth. In Australia, the various codes of football make no requirement that participating athletes wear helmets. Concern has been raised, especially by parents of children participating in contact sport, of the value of introducing helmets as a vehicle for increasing safety in those sports. The paucity of evidence related to the use of helmets in the various codes of football played in this country makes analysis of the risks and benefits of helmet use difficult. Information must be extrapolated from the more general application of helmet design as it is applied to other sports.

6.1.2 Mechanisms of head injury

The mechanism of the production of an injury to the head is complex. It involves not only the effects of a direct impact on the skull and its coverings but, more importantly, the effects of the relative motion of the brain within the skull in response to that impact. This relative motion of the brain creates the shearing and rotational forces on the individual neurones which results in axonal stretching and diffuse brain injury (Holburn 1943; Gennerelli 1986). Shearing forces generated at impact may also directly disrupt the intracranial vascular tree resulting in haemorrhage. The direct impact to the skull vault or facial bones may result in fractures of these structures. Concussion differs from the more severe diffuse axonal injury in that it represents the mild end of the spectrum of head injury, where the symptoms are transient and the injury does not necessarily result in structural brain damage.

6.1.3 Helmet design

Helmets are designed to serve a number of functions. They absorb the force and decelerate the blow at the point of impact, resist impact-induced deformation, withstand surface abrasion and distribute the focal impact over a larger area. There is experimental evidence that cycling and ice hockey helmets achieve at least part of these aims (Ryan 1991; Mills 1990). There are additional data (Reid 1975) which suggest that United States (US) American football helmets are biomechanically efficient in laboratory testing in achieving these intended objectives.

In the US, catastrophic head and neck injuries have declined since the wearing of NOCSAE (National Operations Committee for Standards for Athletic Equipment) – certified helmets in American football was made compulsory at all levels of play in the early 1970s (Torg 1982; Hodgson 1975). It is important to note, however, that other changes in the game such as rule changes (eg banning 'spear' tackles – an impact with the vertex of the head) occurred at the same time and may explain the observed reduction in head injury rates.

The area of head-to-head impact experienced on the field of play is impossible to monitor via technology, at this point in time. Simulated head-to-head impacts however, in a laboratory setting, with cadaver and/or anthropomorphic test dummy technology, indicate that low-level concussion, laceration and bruising occur at about 300 G. The use of soft head protection lowers the impact of a head-to-helmet contact by 10 to 35 per cent (270–195 G), depending on the product used (Morrison & Young 1993).

In situations where both heads are outfitted with soft head protectors, the reduction in impact is now decreased by 15 to 60 per cent (255–125 G), again product dependent (Morrison & Young 1993).

A great deal more research must occur in the area of repetitive impacts and the durability of products. The soft head protectors may have an opportunity to provide protection on repeated contacts without significant reduction in safety capacity. This work is yet to be performed (Morrison & Morrison 1994).

6.1.4 Types of helmets

In general, two types of helmet exist: a rigid-shell and a soft material design. The latter is the main type proposed for football in this country.

6.1.5 Rigid-shell helmets

The hard outer shell protects the head by distributing the impact loads over a larger area including the inner liner of the helmet and the head. The shells are made of fibreglass or injection moulded plastic. The inner liner of the helmet is usually some form of polystyrene (EPS) or polypropylene, both of which are available in various densities and thicknesses. In sports such as Australian football, the rugby codes and soccer, rigid helmets are impracticable and potentially injurious to the other participants.

6.1.6 Soft head protectors and scrum caps

Soft head protector helmets are usually a one-piece moulded structure composed of polypropylene of sufficient density and resilience to attenuate the impact and reduce the force of a blow transmitted to the brain. These are unsuitable for use in soccer because the ball is 'headed'. A scrum cap or a headband without reinforcement may be worn to protect against soft tissue injury in rugby. Taping of the ears to prevent cauliflower ear injury is a common practice in rugby.

6.1.7 The effectiveness of helmets

There is no Australian standard at the present time for soft head protectors in sports other than cycling, horse riding and motor sports.

There are a number of limitations with testing systems:

(a) Acceptance of recognised peak impact and duration of impact loads that result in injury;

(b) Different methodologies in use;

(c) Quality and reliability of testing laboratories;

(d) The use of motor vehicle injury models as a surrogate for sport-related head injury;

(e) Understanding and agreement as to what is an acceptable and safe impact load to the brain. The acceptance that a 400–600 G load may be a 'survivable' head injury does not mean that brain injury will be necessarily reduced since the helmets' impact tolerance may far exceed this;

(f) The extrapolation of laboratory results to the practical situation where other factors including weather, impact speed, surface, number of impacts, helmet fit and helmet deterioration may influence the protective capability of the helmet; and

(g) The requirement of the helmet to withstand multiple repetitive impacts.

6.1.8 Do helmets reduce injury?

The evidence that helmets reduce soft tissue injuries is shown by studies examining the effectiveness of cycling helmets (Dorsh, Woodward & Sommer 1987; Thompson, R., Rivana & Thompson, D 1989; Weiss 1987; Wasserman 1990).

In American football, the National Head and Neck Injury Registry (Torg 1982) prospectively monitors catastrophic injury. When the data are compared both before and after the introduction of NOCSAE-certified helmets, there is a 54 per cent drop in head injury rates. However, this must be interpreted with caution since there were coexistent rule changes related to preventing head injury and it appeared that the incidence of head injury was dropping prior to helmet introduction anyway.

In Australian football and rugby codes, prospective injury surveys (Seward *et al.* 1993) have found too few players wearing helmets for adequate statistical interpretation.

Following a recent death in Rugby union (1994), media reports questioned the role of helmets in football. In this instance, the player's head impacted on hard ground after a legal tackle, causing an acute subdural haematoma. It would appear that injuries in the 17–21 age group are more common than in younger age groups. Head protectors worn by players in the 17–21 age group, therefore, may help to reduce the number of injuries; however, this is scientifically unproved. In addition, there appears to be a general reluctance by players of this age group to wear protective equipment. Psychological acceptance of headgear, if head protectors are found to be appropriate after further studies, would be more easily obtained if it was introduced at an earlier age.

6.1.9 Potential risks of helmet use

Whilst helmets may possibly reduce the incidence of scalp lacerations and other soft tissue injury, there is the risk that helmets may actually increase both the cerebral and non-cerebral injury rates through a number of mechanisms.

(a) Sport-specific helmet design has not been established for Australian football or the rugby codes;

The need to use the correct helmet for a specific activity has been supported by research into helmet performance (Bishop 1984).

(b) The addition of a helmet to the head will increase both the size and mass of the head. This means that blows that would have been glancing become more solid and thus transmit increased rotational forces to the brain. The leverage factor means that any head protectors should be close-fitting;

(c) Because helmets distribute the force from focal impacts across a larger area, this may result in reduced fracture/laceration injuries but may increase diffuse brain injury;

(d) Misplaced faith in an ineffective helmet may create a false sense of security and encourage players to place themselves in dangerous situations and ignore the usual precautionary tactics used in these situations, thereby increasing their injury risk;

(e) It is important to note that the helmet which is designed to protect the head does not and cannot protect the neck. A helmet must not be too heavy. A weight of 60–80 grams for all age groups has been recommended as practical for surface protection without unduly adding weight to the neck (Morrison 1994);

(f) Poorly designed headgear can obscure peripheral vision and increase the risk of collision injury;

(g) A poorly fitting helmet may not adequately dissipate the force of an impact; and

(h) In order for helmets to be effective, they need to be properly cared for and maintained. Failure to do this will reduce the effectiveness of the helmet.

6.1.10 Helmets and litigation

In the US even the addition of warning labels to helmets has not prevented the continuing large awards being made to injured players where helmets are implicated as the cause of injury or where they fail to protect the player from the injury occurring (Patterson 1983; Appenzeller 1982; Schwartz 1988).

6.1.11 Conclusion

There is no available head protection that has been scientifically demonstrated to protect players in Australian football or the rugby codes from concussion or other forms of brain injury. Further research into this area, particularly on-field testing and evaluation of helmets, should be encouraged.

6.2 Mouthguards

It has been shown that the use of correctly fitting mouthguards appears to reduce the rate of concussion, as well as of dental and mandibular injuries (NFL 1988; Hodgson 1975). While not compulsory (it is usually left to the discretion of individual clubs), the majority of Rugby league and Australian football players wear mouthguards. Mouthguards are not compulsory in soccer and few players wear them.

There is a decrease in the intracranial pressure and bone deformation from a blow to the mandible when a mouthguard is worn. This means that mouthguards provide protection of the teeth, jaws and adjacent soft tissues and also protect the brain against concussion following impacts to the mandible.

6.2.1 Rationale for use

The mouthguard should be constructed of a tough resilient plastic closely adapted to the upper teeth, gums and palate.

It aims to:

1. provide direct protection to the teeth;
2. prevent the teeth injuring the lips;

3. act as a shock-absorbing layer between the teeth, reducing both the risk of jaw fracture and the concussive effects of blows applied to the mandible; and
4. reduce the direct transmission of force from the mandible to the skull base as a result of the interposition of material between the teeth moving the mandibular condyle slightly forward within the glynoid fossa.

When properly designed and manufactured, the mouthguard should:

- protect the soft tissues from the teeth;
- protect the teeth from outside influences;
- protect the teeth in both arches;
- protect the temporomandibular joints, through judicial bite opening and bite registration;
- protect the teeth and jaws through shock absorption and transfer of forces to the buttress of the maxilla (so forces are not concentrated in the cranium);
- have measured occlusal coverage so that the condyles are rotated downwards and forwards putting cervical vertebrae in maximum occlusion, minimising concussion and neck damage; and
- have measured occlusal thickness and physical properties of the material base, so that at impact mandibular distortion will be reduced, thereby minimising the possibility of fracture (Dorney 1994).

6.2.2 Types of mouthguards

1. **Stock mouthguard**: this is an unconformed 'gutter' which fits loosely over the teeth. It is easily removed to facilitate breathing and speaking between passages of play. It is less effective as a guard and may be an airway hazard because it is not firmly secured.
2. **Mouth formed (boil and bite)**: these guards are cheap but the fit is less accurate. The guard maybe too thin where it needs to be thick – and vice versa.
3. **Custom fabricated (in a dental laboratory)**: these guards are accurately constructed to provide maximum protection with minimum bulk. The accurate fit and control of the thickness of material used maximises the shock-absorbing effect. Materials permit lamination of mouthguards for greater strength.

There is now a high degree of acceptance amongst players at both the elite level and at schoolboy level of the need to wear mouthguards. An inadequate mouthguard may provide a false sense of security. Although mouthguards reduce the incidence of concussion, some head injuries will still occur. When consciousness is lost, removal of the mouthguard to protect the airway is important. Instances of difficulty in removing the mouthguard have been recorded.

There is a need to develop Australian standards for the manufacture of mouthguards for football and other sports (Hodges 1994).

6.3 Shoulder pads

In Rugby league, shoulder pads may protect the acromio-clavicular joint. They are not used in soccer, Australian football or Rugby union.

Shoulder pads reduce the amount of reach upwards (elevation of the shoulder) that is available. This limits their use in Rugby union (problems in line outs) and Australian football (marking the ball). Soccer does not have the impact problem of the other sports and therefore shoulder pads are unlikely to be useful.

Chest protectors are used by some Rugby league players. They are designed to

protect the sternum and costochondral areas from injury. They may be used to allow harder 'hit ups' which may cause concussion in the player being hit. This form of 'tackle' should be discouraged because of the potential for head and neck injury.

6.4 Summary

In Australia, the various codes of football do not require that participating athletes wear helmets. The paucity of evidence related to the use of helmets in football played in this country makes analysis of the risks and benefits of helmet use difficult. Soft head protectors and scrum caps appear to reduce lacerations and other soft tissue injuries and may lessen intracranial forces on impact. The view has been expressed that such soft helmet equipment should weigh no more than 80 grams. Further research into this area should be encouraged.

Mouthguards provide protection of the teeth, jaws, and adjacent soft tissues. Mouthguards can also reduce the rate of concussion.

Recommendations

Research into the use of soft head protectors or scrum caps to reduce injuries of the scalp, ears and face is supported. Design criteria and manufacturing standards for such head protectors need development.

Research should be undertaken to determine whether standardised soft head protectors reduce brain injury without creating other hazards.

The use of custom-fabricated mouthguards in contact sports, including football (all codes) is strongly recommended.

Australian standards for mouthguards need to be developed.

7 Injury code by code

7.1 Introduction

In a study of football injuries at the elite level in Australia (Sewards *et al.* 1993), data were collected over the 1992 season. All injuries were prospectively recorded from 26 clubs in football competitions which included the Australian football League (AFL), New South Wales Rugby league (NSWRL) and New South Wales Rugby union (NSWRU). Although soccer was not included in this study, the information is timely and provides an indication of the injury profiles of the different codes of football at the elite level. Comparative information is presented in tables 7.1, 7.2 and 7.3.

Table 7.1

Concussion frequency in senior and reserve grade football 1992

AFL	3.6 %
League	8.5 %
Union	5.3 %

Source: Seward *et al.* 1993

Table 7.2

Head and neck injury incidence as percentage of all injuries in senior and reserve grade football 1992

	AFL	League	Union
Head and neck	14.4	28.5	37.3

Source: Seward *et al.* 1993

Table 7.3

Percentage incidence of missed matches caused by each body area 1992

	AFL	League	Union
Head and neck	5.5	8.8	9.6
Upper limb	14.9	22.6	34.7
Trunk	6.5	7.3	3.2
Lower limb:			
Groin/thigh	32.8	10.0	7.3
Knee	19.6	28.2	34.7
Lower leg/foot	18.8	20.3	10.0
Medical illness	1.8	1.7	0.5

Source: Seward *et al.* 1993

General injury surveillance has been conducted in the States and Territories of Australia, coordinating with the National Injury Surveillance Unit. This has provided some useful sports-specific data including descriptions of the mechanism of injury.

The data vary in each State/Territory according to the dominant football code. The use and limitations of such data are illustrated in the following study of football injuries in Victoria (Finch *et al.* 1993).

The Victorian Injury Surveillance System (VISS) maintains a collection of hospital accident and emergency department records from one health region in metropolitan Melbourne and the La Trobe Valley, a regional centre. This surveillance system is designed specifically to collect injury data including that resulting from sporting and recreational activities. Since it only contains injured cases from a limited sample of hospitals in Victoria, its main value is in providing quite detailed information about the nature and causes of sports-related injuries by individual sports. This means that VISS data are able to yield information on the frequency of head and neck injuries in the various football codes but cannot provide meaningful data on injury rates (eg injuries per thousand player hours) across codes.

The limited information available on the incidence of sporting injury in Victoria indicates that sport and recreational activities are a common context for injury. Data from VISS (1989–90) revealed sport-related injuries in children in the 10–14 year age range (both boys and girls) were the single highest cause of attendance at hospital emergency departments as the result of injury (Routley & Ozanne-Smith 1991).

During this period 1989–90, Australian football accounted for more sports injuries than any other sport: 825 injuries (31 per cent of sports injuries) to children aged less than 15 years who attended the four Melbourne participating hospitals (Routley

1991). Soccer, the next most common sporting activity to present at a hospital emergency department, accounted for 15 per cent of all sporting injury presentations to VISS–participating hospitals.

Head injuries of all kinds occurred in 14 per cent of all child presentations to Australian football and soccer. Furthermore, the 1989–90 sports injuries data for children under 15 years showed that 6 per cent of injuries in Australian football were concussions (Routley 1991). These concussions were largely a result of tackling and other forms of body contact and included seven cases of being kicked in the head. Under the VISS coding system, 'head injuries' include fracture of the skull, intracranial injuries and concussions. Less severe head injuries are coded as 'face and scalp' injuries and include other quite severe injuries such as fractures and lacerations. It should also be noted that major injuries occurred even more frequently to other body parts.

The activity being undertaken at the time of the injury was recorded for 79 per cent of Australian football head/neck injuries and 70 per cent of soccer head/neck injuries. Amongst those cases recording the level of play, head/neck injuries also occurred most commonly during organised games (competition or practice) of both football codes (71 per cent for Australian football, 51 per cent for soccer).

All other injuries occurred during informal play. The high proportion of soccer injuries occurring during informal play is of notable concern.

Amongst adults presenting to VISS–participating hospitals with a sports injury, 36 per cent were related to Australian football, 15 per cent to soccer and 2 per cent to both rugby codes (Routley & Valuri 1993). Because Australian football is the preferred football code in Victoria, these presentation frequencies do not necessarily represent those that occur in other States such as NSW. Head and facial injuries accounted for 20 per cent of adult Australian football injuries and 11 per cent of soccer injuries, and 25 per cent of the 1698 Australian football injuries were concussions (corresponding figures for soccer and rugby were 1 per cent and 3 per cent, respectively). The majority of these were caused when a player was struck by, or collided with, another player.

The study made a number of recommendations including:

- strict enforcement of penalties for head-high tackles in Rugby league;
- shortening of the Australian football home-and-away season;
- research into a possible role for protective head gear in reducing head and facial injuries; and
- research into the design of football boots and studs.

7.2 Australian football

7.2.1 Incidence of head and neck injuries

Head and neck injuries comprise 14.4 per cent of all Australian football injuries at AFL level. This compares favourably with the rugby codes (union 37.3 per cent, league 28.5 per cent) (Seward *et al.* 1993).

The incidence of catastrophic neck injuries in Australian football is rare (Taylor & Coolican 1987), and none has occurred at elite level since data were first collected in 1982. Only one quadriplegic injury is recalled at elite level in the last 30 years. This Panel, however, received a submission from a player in a 'suburban grade' of Australian football who had suffered a neck injury and now remains a paraplegic. The incidence of catastrophic brain injury (intracranial haemorrhage or subdural haematoma) is also uncommon and has not occurred in elite levels since data collection commenced in 1982. One case of an intracerebral bleed was brought to the attention of this Panel. This incident occurred in 1992 and the player is still recovering.

Concussion occurs at a frequency of about 4 per cent at AFL/Victorian State Football Level (VSFL) level, which has not altered significantly since the 1983–85 study by Seward & Patrick (1992). Of concern is the higher reported incidence and more lost games due to concussion in the VSFL Under 18 competition (see tables 7.4 and 7.5). This requires substantiation and further research before conclusions can be drawn.

Published research conducted on AFL footballers confirms this finding and most players were found to recover within a few days of injury (Maddocks & Dicker 1988).

Head and facial lacerations occur frequently (41 per 10,000 playing hours) but are rarely severe and it is common to be able to continue playing if this injury occurs alone and is promptly treated. Facial and nasal fractures (10 per 10,000 playing hours) and eye injuries (five per 10,000 playing hours) are uncommon and vary in severity.

Mechanism of injury has not been assessed in recent research, but in 1983 it was found that 27 per cent of head and neck injuries were attributed to fouls (illegal tackles) in the then VFL competition (Seward & Patrick 1992).

Statistics have been gathered on injuries to players in AFL, VSFL (formerly AFL reserves) and VSFL Under 18 competitions through an AFL Injury Surveillance System. This system was established in 1992, funded by an Australian Sports Injury Research Grant, and is now funded by the AFL and the VSFL. An analysis of these statistics is provided in tables 7.4–7.9.

Table 7.4

Percentage frequencies of most common injuries (Australian football AFL/U18)

	1992		1993	
	AFL	U18	AFL	U18
Hamstring strains/tears	13.4	3.3	13.8	4.6
Head /facial lacerations	6.2	6.6	5.7	6.2
Cork thighs	5.7	5.2	5.0	6.6
Ankle sprain (lateral)	5.3	6.1	4.8	5.6
Groin strains	5.7	4.2	4.8	2.3
Knee medial ligament tear	2.3	1.9	4.4	0.7
Calf strain	2.6		4.3	1.0
Concussion	3.6	6.6	4.1	9.2

Source: Seward *et al.* 1993

Table 7.5

Prevalence of injuries as percentage of time missed (Australian football AFL/U18)

	1992		1993	
	AFL	U18	AFL	U18
Hamstring strains/tears	15.6	2.8	18.0	6.3
Stress fracture	4.9	31.8	6.5	14.1
Knee medial ligament tear	5.9	2.8	5.8	0.8
Ankle sprain (lateral)	4.5	6.5	4.9	6.0
Quad. strain	5.8	0.5	4.4	1.8
Calf strain	2.8		3.5	0.3
Groin strain	6.4	5.6	3.4	1.6
Concussion	2.1	2.8	1.5	6.3

Source: Seward *et al.* 1993

Table 7.6

Location of head/facial lacerations in Australian football league (%)

Forehead/eyebrow/eyelid	43.8
Face (chin/cheek)	23.6
Scalp	22.5
Mouth/lips	6.6
Nose	1.6
Ears	1.6

Source: Seward *et al.* 1993

Table 7.7

Injuries causing most missed matches: prevalence as a percentage of all time missed

	Senior and Reserve Grade		
	A F L	League	Union
Anterior cruciate tears	6.3	7.9	17.4
Hamstring strains	15.7	4.4	5.5
Knee medial ligament tears	3.6	8.4	8.2
Dislocated shoulders	4.4	6.7	13.2
Quadriceps strains	5.6	1.4	0.9
Inguinal canal tears/hernias	2.9	*	*
Groin strains (not hernias)	3.7	2.9	0.5
Stress fractures	5.0	1.8	*
Lower limb fractures (not stress)	4.8	12.6	*
Upper limb fractures	5.0	4.4	11.9
Head and facial fractures	3.3	1.3	5.9
Concussion	1.8	3.7	1.8
Rib fractures/bruising	1.5	2.3	0.9
Posterior cruciate tears	1.6	2.9	2.3
Ankle sprains (lateral)	3.6	4.2	2.7
Calf strains	2.8	0.7	2.3
A/C joint strains	1.8	1.4	4.1
Lower back strains	1.0	2.9	0.5

* *None reported by survey teams.*

Source: Seward *et al.* 1993

Table 7.8

Reported concussions 1992–93 – AFL, VSFL,VSFL Under 18 Competition

AFL 504 Team Games

VSFL 462 Team Games

VSFL U18 270 Team Games

Number of matches missed	AFL (38)	VSFL (34)	U18 (45)
0	53	44	53
1	45	41	40
2	2	6	5
>2	0	9	2

Source: Seward *et al.* 1993

Table 7.9

Other reported head and neck injuries (number) 1992–93

	AFL	VSFL	U18
Facial fractures:			
Zygoma	4	3	-
Maxilla	7	3	-
Mandible	3	2	2
Nose	7	6	4
Lacerations:			
Scalp	16	11	10
Face	61	21	18
All neck injuries (no fractures)	6	7	12
Eye injuries	7	3	3
Dental	1	-	1
Others	4	3	3

Source: Seward *et al.* 1993

Hamstring injuries were the most common injury in 1992 and 1993 and continue to pose the biggest problem in Australian football (table 7.4).

Concussion appears to be more commonly reported at junior level (table 7.4) and represents the most frequent injury. At the senior level there is much greater surveillance of illegal actions through the use of the trial-by-video system. This may have contributed to a reduction in the number of illegal shepherds etc and hence in concussion rates, when compared with the junior competition.

Wood and Seward (1993), who were responsible for conducting the AFL Injury Survey, acknowledge that there is still a problem of accurate record collection, which needs to be done after each training session and each match. With the ever-increasing medical litigation cases, the importance of precise record-keeping for each player cannot be over-emphasised.

Box 7.1:

Case study: An illustration of head and neck injury in a country area.

In July 1992, a player was seriously injured in an Australian rules game whilst playing for Wodonga Football Club at Corowa, NSW.

The player received a knock to his head during the play from a tackle that was no rougher than 100 other tackles that are witnessed during a football season.

Following the accident he was carried by stretcher to the dressing rooms, where he twice stopped breathing. The player may have died then if not for the actions of the honorary club doctor.

The player was taken by ambulance to Corowa Hospital and then to Albury Base Hospital.

An emergency operation was conducted in the Albury Base Hospital to remove the pressure on his brain. At 12 o'clock midnight he was flown by helicopter to Westmead Hospital in Sydney.

He was unconscious for 12 days and stayed in the Westmead Hospital until November 1992, when he was transferred back to Albury Base Hospital where he was discharged on 17 December 1992.

The player sustained serious injuries and at this stage has not returned to work.

The local community, including his football club, raised approximately $50,000 to provide some financial assistance. The player received $300 per week for the first 12 months after the accident from the insurance policy owned by the football club, but this has since ceased. The injured player is also unable to receive Social Security benefits.

Obviously the player has had a great loss in the quality of his life as a result of an injury received whilst playing football. Ironically this person would be the most gentle of our players so it shows this injury can occur to any player.

The incident has had a huge effect on the people involved in our club. Our club has a long and proud history and to see our player receive such a serious injury (in fact he may never fully recover) has affected the many individuals involved in many different ways.

There is no doubt that this sort of injury takes all the fun out of the game and the pastime, even to supporters who love the club and the sport of Australian rules football.

Every endeavour must be made to stop these serious injuries for the sake of the game, the players and the fans of the game.

(Deane 1993)

7.2.2 Prevention

As illegal tackles may account for up to a quarter of head and neck injuries (although it is believed that this has been reduced since this figure was determined 10 years ago), a greater emphasis should be placed on reporting head-high tackles by umpires and video mechanisms. Consideration should be given to an increase in penalties for illegal play. This should be extended to cover the VSFL and Under 18 competitions.

An appraisal of rules that may relate to head and neck injuries (eg kicking dangerously, charging) should also be undertaken, emphasising the role of player protection in the interpretation of rules.

AFL medical officers plan to continue to conduct regular education sessions for their trainers on the management of head and neck injuries. In addition, education programs for coaches, umpires and other officials will be undertaken to improve their understanding of head and neck injury incidence, management and long-term sequelae.

Sports trainers at non-elite levels have regular updating educational programs on the management of head and neck injuries. The ASMF guidelines for head and brain injury in sport provide a useful guide for management. This should be part of a continual education assessment for registration of sports trainers.

Medical officers involved at non-elite levels of football should also receive continuing medical education in the diagnosis, assessment and management of head and neck injuries.

In one submission to this Panel, concerns were expressed about improving safety in games of football through effective rule changes:

'Rule enforcement plays an important role in preventing head and neck injuries. Illegal tackles are the subject of umpire report, tribunal hearings and suspension. Video reporting of players for violence missed by umpires has enhanced the rule enforcement and, although no figures are available yet, the general consensus is a significant reduction in head-high tackles with fist or forearm. As the reported incidence of concussion has not changed, we are concerned that concussion resulting from contact within the rules has increased. Therefore rule changes may provide an opportunity to protect the player more effectively during general play and reduce the incidence of concussion.' (Seward 1993)

The National Australian football Council (NAFC) has undertaken to improve the safety of the game and to reduce the risk of injuries by shortening each quarter by five minutes (reducing player fatigue). Another rule change that the AFL is considering to improve the safety of the game (without substantially changing the nature of the game) is increasing the number of field umpires required for each match from two to three. This was recently trialled in the 1994 AFL pre-season competition.

7.3 Rugby union

7.3.1 Incidence of head and neck injuries

Comprehensive data collection of specific injuries in Rugby union in all games and at all levels is difficult to achieve.

In a study on football injuries at the elite level (Seward *et al.* 1993), the most common injury in Rugby union players was head and facial lacerations (20 per cent). The study also indicated that Rugby union had a significantly lower injury prevalence at the elite club competition level than did Rugby league or Australian football.

Retrospective studies have been undertaken on schoolboy rugby. This information is presented in Chapter 8. Although there are no current prospective studies on the incidence of injuries in Rugby union available for comparisons, various studies have been undertaken to improve the safety of the game in response to serious injuries occurring over the years.

Roux *et al.* (1987) found: (1) that monitoring rugby injuries through correspondence results in underreporting of injuries; (2) that rugby injuries show specific trends with age, team level, playing position, time of the season and phase of play; and (3) that players in the different positions suffer specific injuries in predictable phases of the game.

7.3.2 The issue of safety in rugby union

The safety of players is a high priority of the Australian Rugby Football Union (ARFU Ltd).

Historically, the following incidents heightened the ARFU's awareness of this important issue:

1. Four spinal injuries to Sydney schoolboy players in the late 1970s and early 1980s.
2. Injury to Rugby league schoolboy, Stephen Watson Case, and the subsequent response by the NSW Department of Education in 1987.

The ARFU's response to the first period was to form the inaugural Safety Committee in 1984 to investigate the laws of the game, particularly as they related to schools and junior club rugby.

The ARFU Safety Committee, which still continues today, comprised representatives of the medical, law, administrative, technical, school and junior club aspects of the game.

The key medical personnel included:

Dr John Yeo AO

Professor Tom Taylor

Dr Merv Cross

Dr Geoffrey Vanderfield.

This committee was instrumental in drafting the initial set of Under 19 law variations for the 1985 season.

The cruxes of the Under 19 laws were the controlled, de-powered engagement of the scrum and the outlawing of charging into rucks and mauls.

Since the introduction of the Under 19 laws in 1985 there have been very few permanent neck injuries in school or junior rugby matches.

A serious neck injury was sustained by a 15 year-old player in 1993, which was associated with the tackle. Fortunately this boy is heading towards full recovery. Another cervical spine fracture dislocation occurred in a 17 year-old schoolboy hooker during a scrum collapse. This player is unlikely to return to Rugby union or other contact sport.

To confirm the observations of the committee, the ARFU commissioned Dr Peter Milburn of the Wollongong University to conduct a scientific investigation of scrummaging techniques (Milburn 1990).

It should be noted that the success of the ARFU Under 19 law variations has been acknowledged internationally, with the International Rugby Football Board introducing many of the crucial changes for all levels of the game in 1990. Since this time, the small number of neck injuries at adult club level has substantially declined. The ARFU Safety Committee continues to monitor the game closely and meets regularly to ensure its continued success.

7.3.3 Education of players, coaches and referees

The ARFU has instituted the following programs, resources and procedures to ensure that the correct techniques and laws of the game are adhered to by all participants.

Coaching material:

- Under 19 laws and 'Confidence in contact' video – some 2000 copies of this 50 minute video and accompanying brochure have been distributed to all rugby-playing schools and junior clubs, to referees' associations and at coaching courses throughout Australia. The video demonstrates the laws and techniques associated with scrum, tackling, ruck and maul;
- ARFU coaching manuals – sections are devoted to safety and correct techniques in level 0, I and II coaching manuals;
- Instruction at coach accreditation courses – specific reference is made to safety techniques and associated rugby law in all level 0, I and II coaching courses held nationally;
- Safety in contact field days and seminars – lecture-style seminars are conducted nationally for school and club groups and largely target parents, coaches and referees. Practical, on-field sessions target the front and second row players, as well as team coaches; and
- Modified laws – Australian Junior Rugby Pathway – a three-step modified progression to the full game made for young players aged seven – 12 years. The

Australian Junior Rugby Pathway progressively introduces the skill, laws and contact elements of the game to young participants. In this way, players are able to develop proficiency in the basic concepts and skills of body positioning and scrummaging and preliminary contact techniques before encountering the full contact game.

Safety directives and the laws of the game:

- ARFU handbook – the *Law Book* for the game of rugby incorporates **safety directives** for:

  - referees;

  - coaches; and

  - players.

  The handbook includes guidelines for the management of concussion and suggested guidelines for the management of serious injury and managing injuries at representative level.

- Charts with safety guidelines containing the information described above are circulated annually to all rugby clubs and schools throughout Australia.

Registration, insurance and ARFU Player Welfare Fund:

- AFRU registration form – the ARFU player registration form incorporates the safety directives described in the previous section. Each player is asked to sign the registration form, which is in the form of a release and waiver, to indicate that they have read and understood the safety directives. A tear-off slip enables the players to keep a personal copy of the safety directives; and
- ARFU National Insurance Scheme – in conjunction with the registration process, ARFU provides public liability and permanent disability insurance cover for all players. Adult teams pay an annual premium, while schools and junior rugby players are covered at no cost.

The public liability cover of up to $10,000,000 is extended to all players, coaches, referees and officials associated with the game.

Payment of up to $250,000 is payable for permanent disabilities.

- ARFU Player Welfare Fund – to support those injured and necessitous players, the ARFU has established a player welfare trust fund.

Research programs:

- The biomechanics of rugby scrummaging – this scientific study, conducted by Professor Peter Milburn of Wollongong University in 1990, is highly regarded on the world rugby stage. The findings confirmed many of the developments made by ARFU as Under 19 law in the mid-to-late 1980s, and formed the basis for the introduction of the staged scrum engagement sequence as international law;
- Study of schoolboy rugby injuries – this study, conducted over more than 20 years by Dr Roger Davidson of Newington College, Sydney, is one of the most thorough longitudinal studies available. The study clearly illustrates the very low incidence of injuries.

Other research and gathering of statistics are conducted by the ARFU Technical Advisory Committee as required.

(Bradley 1993).

7.3.4 Law changes to prevent injury

Law changes were introduced for all levels in Australia at various times between 1980 and 1988 with the intention of increasing player safety in several aspects of the game (Vanderfield 1993).

In conjunction with strict enforcement of the modified scrummaging laws, there have been few instances of scrum-related serious cervical spinal injury in Australian Rugby union since the universal adoption of these law changes. The results of this study indicate no reason for the introduction of further changes to the composition of the scrum or to the way in which a scrum is formed. Further improvement in player safety can best be achieved by a commitment to this by those involved in playing and controlling the game.

Despite their introduction, the effectiveness of these law changes still depend on the referee's discretion as to what constitutes charging at engagement and when to terminate the scrum if it collapses, or when a player is 'popped'. A referee may not be aware of a player who is tightly bound in a scrum and who is subsequently at risk of sustaining serious cervical spinal injury. By allowing play to continue, the referee may be subjecting the player at risk to unnecessary trauma. A call for referees not to prolong the scrum has been made by several authors. Scher (1987) and Cohen & Siff (1979) recommended a time limit be imposed on the duration of scrums (along with rucks and mauls) as a safety measure.

They suggested that prolonged scrummaging would increase the risk of a scrum collapse and expose players to flexion injury of the cervical spine. From an understanding of the forces involved in scrummaging and the risks of traumatic injury or chronic degeneration of the spine, a call for a limit on the duration of a scrum is warranted.

Wessels (1980) reported that more than 40 per cent of all injuries surveyed in South Africa were a result of illegal or foul play. The majority of injuries resulting in spinal injury in American football were also a result of a deliberate action ('spearing' or 'head-on tackling'), placing the cervical spine at risk (Torg, Truex & Marshall 1979). Similarly, Scher (1981) alluded to this risk with respect to direct vertex impact injuries during rucking and scrummaging in Rugby union.

Therefore, the safety recommendations already implemented in Australia and those proposed in this report depend to a large extent on a change in attitude as to the way the game should be played at all levels. 'Winning at all costs' is a dangerous and misused term. With this in mind, positive changes could be implemented relatively easily in the present climate of safety awareness without substantially altering the nature and flow of the game (Milburn 1990).

7.4 Rugby league

7.4.1 Incidence of head and neck injuries

The study by Seward *et al.* provides some indication of the injury pattern of Rugby league at the elite level (see 7.1). The following data collected by rugby leage club doctors (Hazard 1993; Gibbs 1993) provide a breakdown of some of these injuries.

Hazard (1993) published injury statistics from three teams in the Rugby league competition over 26 competition rounds. Results included 23 reported injuries to the cervical spine. The majority of these injuries were cervical facet joint irritation. The remainder related to muscular strain and local contusion. None of these injuries were serious.

Other injuries recorded included:

- 99 head injuries;
- 34 concussions;
- 21 lacerations;
- three eye traumas; and
- one fractured jaw, which was the only serious injury, with the player missing six matches.

Gibbs (1993) completed a study on South Sydney Rugby league Football Club over a three-year period covering all three grades. In the study, injury was defined as any injury that required the player to miss at least one subsequent match, and missing training was not counted as an injury for the purposes of the study.

The study found that head injuries accounted for only 6 per cent of the total injuries sustained over a three-year period over the three grades. This 6 per cent of injuries comprised only eight individual injuries, of which five were concussion and three were for a facial bone fracture. With regard to the five episodes of concussion that required a player to miss at least one subsequent game, four of these were a single episode of concussion with no recurrences, whilst one of these was a player who suffered three episodes of concussion in one season. Initially this player missed:

- one game after the first concussion;
- four games after the second concussion; and
- the remainder of the season, which had two games remaining after the third concussion.

Although the five players who suffered concussion were required to miss a subsequent game, and 23 other players were treated on the field and assessed for mild concussion not associated with any loss of consciousness, no player appeared to suffer any complications from these head injuries.

One player in 1992 suffered a minor concussive episode and was removed from the field. Six hours later, he developed cortical blindness as a result of post-traumatic migrainous vasospasm.

In the study, injuries to the spine comprised 9 per cent of all injuries and these included cervical and lumbar spinal injuries. The commonest cervical spine injury was a neck burner (stinger) and there were three individual cases of this injury. One case resulted in a C5 neurapraxia which required the player to miss five games, and full recovery from this injury did occur. The other two episodes of neck injury were diagnosed as a musculoligamentous sprain.

There was no catastrophic head or neck injury over the three years of the study.

Other injuries that occurred during the study included 61 lacerations (55 of these in the head region) requiring suturing. None of these injuries were severe enough to cause a player to miss subsequent games and therefore were not included in the injury statistics of the study.

7.4.2 Prevention of injuries

The medical officer of the Illawarra Steelers, Dr Mark Jones, studied the number of head injuries that occurred during matches in the club in the 1993 season. The study was prompted by the alarmingly high number of head and neck injuries that had been recorded during 1992, of which a large number were seemingly due to foul play.

The results of the study (see table 7.10) showed that the number of head injuries had been significantly reduced since 1992, which may have been due to the NSW rugby league's strict policing of head high-tackles in 1993.

For the purposes of the study, injuries which required medical attention (or injuries for which a player sought attention) were recorded.

Dr Jones notes that:

'the study is not scientifically rigid, but still emphasises that foul play goes undetected by referees. Touch judges need to be more vigilant in helping the referee stamp out illegal play and thus limit one easily remedied cause of head and neck injuries.'

Table 7.10

Head injuries – Illawara Steelers 1993

Injury	Foul	Accid.	Unknown	TOTAL	Action by ref.	Temp. remove from game	Completely remove from game	No. games missed
Fractured facial bone	2	1		3				4
Concussion	6	8	4	18	1	1	3	1
Contusion face	2	1	3	6				2
Laceration	1	15	6	22		1		
Eye		1		1				
TMJ			1	1				
Teeth				-				
Neck		12	2	14				
ENT	2			2				
Total	**13**	**38**	**16**	**67**	**1**	**2**	**3**	**7**

Number of matches 58
Source: Jones 1993

In Rugby league, the incidence of serious head and neck injuries has certainly been helped by the strong stance the administration has taken against head-high and 'spear' tackles. In addition, the Rugby league scrum is no longer very important, as the side putting the ball in the scrum is 'allowed' to feed the ball incorrectly in order to win the scrum. Referees turn a blind eye to this. This has resulted in the forwards on the defending side on most occasions when packing into a scrum not even trying to push or win the ball. Their main emphasis is on breaking from the scrum as quickly as possible in order to defend as soon as the opposition wins the ball, as is expected. This has meant that the pressure exerted in scrums is not nearly as great as it may have been in past years when striking for the ball was more equal between opposing packs of forwards.

Other rule changes to help reduce injuries in Rugby league include the player interchange rule. This allows a player to be taken off the field at any stage of the game and allows the early intervention and diagnosis of potentially serious injuries, including head and neck injury. This rule supersedes the 'head bin'.

7.4.3 Application of rules and laws

The following comments were received in response to requests for submissions to the Panel concerning the safety of Rugby league. Although these comments refer mainly to the application of the rules of Rugby league, they could be applied to all codes of football.

'...Although 'spear tackles' are illegal, at times a combination of the number of tacklers, the angle of contact and the position of the ball-carrier at contact may lead to a 'spear' tackle situation.

Referees need to be constantly and consistently vigilant in this matter [of penalising spear tackles] and apply the letter of the Law ruthlessly, particularly in the upper adolescent years where most risk appears to be present.'

'...[There should be] one only scrum rule introduced into Rugby league with a result or a penalty being the outcome. Referees who repack scrums under the current rule on scrums today may place the hooker in these scrums in danger of spinal injury by repeated repacking of scrums.'

'...An able touch judge can be of inestimable assistance to a referee in the controlling of situations which have a risk potential. While Rugby league has used these officials progressively more and more, perhaps an even greater involvement would be helpful.'

'...The media's influence on playing trends may well be a problem. What may be regarded as spectacular or "good" TV or radio, may not necessarily be safe. The media does tend to over-dramatise the (so-called) spectacular - perhaps to a point where the young and inexperienced may feel they should imitate their "hero's" every move, even when it is beyond them to do so.'

(Corcoran 1993)

'...The only way to deal with this problem (severe injuries), which is exacerbated, I feel, by coaches inciting players to "take opponents out", is to make the non-accidental above-shoulder tackle or the lifting of a forearm/elbow, except in an involuntary, clearly self-protective manner, punishable by immediate expulsion from the playing field, followed by a penalty of such severity that any player would know he needed to adhere scrupulously to the laws and spirit of the game when tackling an opponent.'

(Sheldrick 1993)

'a. Tackles of more than two players, commonly known as gang tackles, on the ball carrier should be stopped;

b. Once the ball carrier's progression and ability to pass the ball has been legally stopped the arrival of the late tackler should not be permitted. This in fact is part of the gang tackle and a further progression of the softening-up process which is usually aimed at the play makers such as the half back and five eighth;

c. All head high tackles, that is above shoulder height, stopped whether reflex or not;

d. The around-the-neck choke hold of the ball carrier and wrenching off balance to the ground should be banned. This is a further method of the softening-up process;

e. *The wearing of heavy padding such as forearm protection should be banned. This padding can be and is known to be used as a further method to injure players about the neck and face; and*

f. *Fighting, apparently encouraged by some media "expert" which is aimed at the head. Ref: Rogers v Bugden.'*

(Gregory 1993)

'The encouragement and/or instructions by coaches and other persons associated with a team to soften up or otherwise slow an opposing player must be stopped.

Some coaches today still believe in the "hit, hurt and hinder" style of tackling, which is dangerous –eg A 6ft forward shoulder charging a player of 5ft 6in. The shoulder hits the head of the ball carrier and can cause serious spinal damage. The shoulder charge should be barred from Rugby league.

Coaches are responsible for their players and style of play, including tackling, and therefore if a particular coach has a number of players sent off during a season all found guilty of dangerous play then that coach and club should be fined an amount of money sufficient to discourage the "hit, hurt and hinder" style of coach.'

(Gomersall 1993)

7.5 Soccer

Over 300,000 males and 24,000 females play soccer in Australia. Given these numbers of participants in Australia, large numbers of head and neck injuries may be expected. Soccer, however, has a significantly low risk of head injuries, in spite of the fact that 'heading the ball' is an essential part of the game.

At senior level, having well developed cervical strap muscles and, at all levels, tightening the muscles in the cervical area during the action of 'heading the ball', may be at least in part responsible for the minimal number of neck injuries in soccer. The ball is generally 'headed' with the frontal area of the skull.

Over the last 15 years, there have been only a handful of head and/or neck injuries in the Under 20 elite level, Olympic (Under 23), and at senior elite level (Socceroos). These include three scalp lacerations, five face lacerations and six senior players were treated for nerve entrapment at the cervical level. There have been few cases of concussion in the elite levels in this time.

Statistics provided by club doctors of two national league soccer teams were as follows:

(a) Heidelberg United Alexander Soccer Club (1992–93 seasons)

- Six significant head or neck injuries:

  Two incidents occurred when players fell on the ground, hitting their heads against the ground and thereby suffering mild concussion. There were no deleterious effects.

Two players clashed heads and each suffered deep lacerations which needed suturing. Each one of these players missed one training session.

One player was elbowed in the mouth and suffered deep lacerations to the lips. This player missed three training sessions.

One player had a significant whiplash injury and subsequently recovered.

(b) Brisbane Strikers and Brisbane United Clubs (1992–93 and 1993–94 seasons)

One fractured nose

Three scalp lacerations

One haematoma

7.5.1 Soccer head injuries

Acute head injuries may occur, as in other contact sport, but are generally considered rare in soccer. Such injuries may result from the head being struck against the ground or the opponent's head, body or boot.

There has recently been speculation that chronic encephalopathy may occur in soccer players. The argument is that neuronal damage is similar to that seen in the chronic traumatic encephalopathy of boxers and, further, it is assumed that this is due to repeated heading of the ball.

When heading correctly, the ball is struck with the frontal bone. Muscle tension keeps the cervical spine rigid, and linear, not rotational, acceleration is imparted to the ball. Of course, this does not apply if the ball is struck incorrectly or if the head receives a glancing blow. There is concern about heading a soccer ball as the modern plastic footballs weigh about 400–450 grams and can reach speeds of 60–120 km per hour (Tysvaer, Storli & Bachen 1989). A ball kicked with half power from a distance of 10 metres travelled 82 km per hour and hit the head with an impact of 116 KP (Kannagara 1994). With full power, the ball could impact at 200 KP. The old leather ball, especially when wet, was heavier than the new plastic one.

Players head the ball on an average of six times in a match and more often during training (Corrigan 1993 pers. comm.). There is a difference among players in their degree of heading skill so that some ('headers') seek to head the ball more often than others ('non-headers').

In the paper written by Taylor and Coolican (1987) it was stated that soccer had five times as many participants as Rugby union, but they only demonstrated one spinal cord injury in a soccer player.

In 15 years experience as a medical officer in soccer (Kannangara 1994), there were three scalp lacerations, five face lacerations and approximately six senior players were treated for nerve entrapment at the cervical level (these were mainly between C5, 6 or 7).

Scalp lacerations were due to contact with another player or contact with shoe against the scalp. In soccer it is extremely difficult for players to wear any protective gear to safeguard against head injuries. Mouthguards are not compulsory and are not worn by players at the elite level.

Deaths due to head injury in soccer:

One death was reported in 1993 in Mudgee, NSW, when the Under 12s played a soccer grand final. The goal-keeper dived on a ball and received a kick in the head which was fatal.

In an incident in 1992 which resulted in the death of the player, a goal-post fell on top of the head of a junior player.

Soccer ball:

Professional and international soccer players use expensive, hand-sewn soccer balls which are designed to meet all levels of competition. FIFA places emphasis on meeting the demands of professional players for correct 'flight' and 'feel'. A good soccer ball is tested for its bounce, flight, damping, air resistance, wear, water absorption and shape retention. With advancing techniques of different sizes and types of soccer balls, FIFA, the international governing body of soccer, has endeavoured to minimise injuries and has tried to obtain value for money.

FIFA continues to minimise injuries through close supervision of the sport. The Australian Soccer Federation (ASF) has had a medical consultant, Dr Brian Corrigan, for the past 26 years and has provided assistance with training programs, overseas trips and international matches.

7.6 American, touch and tag football

Other codes of football including American football (gridiron), touch football and tag football are increasing in popularity in Australia. Touch football currently has approximately 170,000 registered participants in Australia.

Head and neck injury statistics for these codes were unable to be collected for this report.

Statistics on injuries that occur in the US from American football are recorded in the National Football Head and Neck Injury Registry, which has been documenting such injuries since 1971.

7.7 Summary

Available comparative data for the various codes have been presented. From these data, it appears that concussion is more prevalent in the rugby codes and Australian football than in soccer.

Further data concerning the incidence of all types of head and neck injuries in all codes have been included, together with views concerning training and research. Administrative arrangements to minimise injury have also been noted.

8 Football injuries in children and adolescents

8.1 Modified rules – football for primary school children and teenagers

Youth development strategies are a very important part of the football codes' success and significantly contribute to reduction of injury by progressive training in the elements of each game, knowledge of the rules/laws, and initiation into the importance of training and fitness. Modification of field size, ball size, team size, length of the games and rules/laws allows the game to be adapted for players of the various age groups.

In Australian football, 'Aussie footy' rules vary for:

- Under seven/Under eight age groups;
- Under nine/10 age groups;
- Under 11/12 age groups; and
- Under 18 competitions.

In Rugby union, there is the Junior Rugby Pathway:

- walla rugby – Under seven–eight years;
- mini rugby – Under nine–10 years;
- midi rugby – Under 11–12 years; and
- Under 19 competitions.

In mini and mod league, which are played in Rugby league, rules also vary for children as well as offering Under 15, Under 17 and Under 19 competitions.

In soccer, roo ball for Under eight and Under 10 uses a modified field and appropriately sized balls.

It appears that, in all the modified versions of football, the objectives are the same – essentially to provide the maximum opportunity for school-age children to participate in the games; to maximise the acquisition and development of basic skills; to provide 'equal opportunity'; and to raise the likelihood of continued involvement because of an emphasis on fun and enjoyment.

8.2 Australian football

McMahon *et al.* (1993) conducted a prospective study of Australian football injuries in 1253 children and adolescents from the Melbourne metropolitan area for the 1992 season. Two skull fractures and 15 concussions were reported (table 8.2). Three (20 per cent) of the concussions resulted in a loss of consciousness. 12 of the 15 concussions (including the three resulting in a loss of consciousness) occurred in the older age group (ie amongst those playing under conventional rules).

Table 8.2

Australian rules football head injuries in children and adolescents (McMahon *et al.* 1993)

Injury	Number of head injuries	% of total injuries
Fractures	2	1
Concussion	15	6
Cuts/lacerations	3	1

A mouthguard was regularly used by 32 per cent of Vickick players (modified game) compared with 69 per cent of players in the Victorian Metropolitan Football League. 8 per cent of younger children wore head protection but it was not stated if any of the protected players received any head injuries.

Nolan (1993), has further reported that a study was conducted between 1 April and 27 September 1992 that ascertained football injuries in a number of Melbourne hospitals providing services to children and adolescents. These hospitals formed the Victorian Injury Surveillance System network. Over this period, a total of 293 injuries from Australian football were treated at these hospitals. The mean age of study subjects was 12.1 years (standard deviation 2.6 years) with a range from three to 16 years. Two-thirds of the injuries occurred during organised football, with the remainder occurring during informal play. Of these 293 injuries, 43 (15 per cent) were head injuries. The head injuries were distributed in the following manner:

fractures	3
haematoma	7
concussion	23
laceration	8
abrasion, and sprain/strain	1

229 cases were subsequently followed up with parental consent on more detailed information to be obtained via a telephone interview over the circumstances of the injuries and the demographic factors. For injuries overall, the most common activity at the time of injury was the taking of a mark (34 per cent), followed by contact (tackling, shepherding or bumping) (20 per cent). If a collision resulted in injury, concussion was more likely to have been the injury sustained.

Seward et al. (1993) recorded injuries in the VSFL Under 18 competition and the NSWRL President's Cup for Under 21 players. Although the overall injury rate for juniors was less than that amongst senior and reserve grade players, junior competition was associated with a greater frequency of concussion and head and face lacerations (table 8.1).

Table 8.1

Frequency of head injuries in junior football competitions (Seward *et al.* 1993)

Injury	VSFL U/18	Rugby league U/21
Head/facial lacerations	9.0%	6.6%
Concussion	10.2%	6.6%

8.3 Rugby union

A survey into injuries occurring in an Australian schools Rugby union season was undertaken in the 1981 season (Sugerman 1983). The aim of the survey was to gather statistical data to ascertain the actual extent, nature and severity of injuries in schoolboy rugby as well as to determine how, when, where, why and to whom the injuries occurred.

The survey covered 33 schools and 3,059 games, giving a base of 45,885 player/games. Those surveyed ranged in age from under nine years to open age schoolboy level.

The results of this survey indicated an injury rate of approximately one injury per 100 player/games – a very low incidence of injury.

The low incidence of injury in schoolboy rugby is also reflected in studies by Davidson (1987, 1993), school medical officer for Newington College in Sydney.

Dr Davidson notes:

'When they enrol their son at school, most parents express a hope that he will become actively involved in lots of school activities, including games, but nowadays quite a few parents express a preference for him not to have to play rugby. Their preference reflects their anxiety about the safety of the game, and not uncommonly they refer to the high degree of publicity that has been given to rugby injuries, most especially to the dangers associated with the front row position.

For some years now, Newington College in Sydney has maintained careful records of the nature and frequency of all injuries which have been sustained by players in all inter-school fixtures played there and which have been attended to by the school's sports clinic.

First of all, it should be noted that the Newington sports clinic has this year [1993] completed its twenty-fifth year of existence and has now overseen more than 100,000 player-

games on the Newington playing fields. A useful pattern of schoolboy rugby injuries over that long period has been obtained and is reflected in the following statistics.

There have now been 122 880 player-games from which 1965 players presented for attention at the clinic. This represents 1.7 per cent of player games, or 184 injuries per 10,000 player-hours [table 8.3]. It should be stressed that this figure relates to all degrees of injury and includes even the most trivial. Of these total injuries, 147 were classified as severe (just over half being fractures of the upper limb), but only two were classified as clinically serious [table 8.4]. One of these was a cervical spine fracture-dislocation that resulted in quadriparesis and required open surgery. The boy concerned, part of a front row that was "popped" in a scrum, made a full recovery. The other serious injury was a depressed fracture of the frontal sinus, caused in a tackle when the boy's head was hit by a knee. He also recovered fully. 22 boys were diagnosed as suffering from concussion. They all recovered within four hours and none of them required admission to hospital.

If all injuries, regardless of degree, are considered, the records indicate that the region that was most affected by severe injury was the head and neck (36.7 per cent of all injuries). There have been 53 attendances for neck injuries; one of these was the fracture-dislocation of the cervical spine; another involved cervical nerve-root irritation without signs of dislocation; the remainder comprised muscular sprains only.

These Newington figures suggest that, as one would probably expect, older players run a greater risk of injury than younger ones. Players who are 16 or more account for nearly 40 per cent of the total number of injuries; those under 14 account for 26 per cent [table 8.5].

Also, over the years, it has been demonstrated consistently that the unskilled players require medical attention less frequently than their peers in the higher grades. Probably because they run harder and play more vigorously, it is the players in the top teams that account for a disproportionate number of injuries [table 8.6].

However, contrary to what is the commonly held belief, forwards do not run a more frequent risk of injury than backs. In each year's tally, the fullbacks top the list for the most frequently injured [table 8.7].

The most important conclusion to be drawn from these records is that the risk of rugby injury is not nearly as great as many people suppose. Rugby injuries should never, of course, be regarded lightly. Nevertheless, they should not be seen out of perspective either. At Newington, over this long period, the incidence of serious cervical spine injury has been 0.11 per 10,000 player-hours. There have been only the two recorded instances of damage to teeth, no lasting eyeball trauma, no fractures that have left any permanent limitation. The risk of injury is small enough, at less than 1.9 per cent of player-games [table 8.8]: the risk of major injury is extremely small (0.1 per cent of player-games); and the risk of injury to young players, particularly those not very adept at the game, is almost non-existent.'

In a survey in Auckland (population for this purpose 850,000), 63 cases of concussion in players under 20 years of age (23 of them under 15) were seen in the first two months of the 1986 football season. There did not seem to be a great deal of understanding of the consequences of concussion among school staff, either of the effects in the first day or two or in the longer term (Wrightson 1994).

25 Rugby seasons – 1969–1993 (Davidson 1993)

Table 8.3

Figures to the 1993 season – sports clinic presentations

Player hours	106,947
Player games	122,880
Clinic presentations	1,965
Injuries/10 000 player hours	184

Table 8.4

Severe injuries

Concussion	**22**
Skull fractures	1
Cervical-spine fractures	2
Nose fractures	23
Maxilla fractures	5
Mandible fractures	1
Upper limb fractures	75
Lower limb fractures	15
Pneumothorax	2
Severe leg lacerations	1
Total:	**147**

13.7 Severe injuries per 10,000 player hours

Table 8.5

Injuries by age-group (1982–1993)

	Player hours	Number of injuries	% of injuries
13 years and under	19,280	245	25.9
14 and 15 years	15,925	315	33.3
16 years and over	16,115	385	40.7

Table 8.6

Injuries according to grade of play (1982–1993)

	Player hours	Number of injuries	% of injuries
A and B teams	19,588	509	53.8
C and D teams	15,677	289	30.6
E, F, G and H teams	12,350	147	15.6

Table 8.7

Player position and percentage injury rate

Fullback	8.6
Hooker	7.2
Lock	7.0
Breakaway	6.8 by 2
Five-eighth	6.8 by 2
Halfback	6.6
Centre	6.5 by 2
Prop-forward	6.1 by 2
Second-row	6.1 by 2
Wing	6.1 by 2

Table 8.8

Periodic pattern of injury

1969–76	1.4% of player-games
1977–78	1.9% of player-games
1979–80	1.7% of player-games
1981–82	1.4% of player-games
1983–84	1.5% of player-games
1985–86	1.8% of player-games
1987–88	1.7% of player-games
1989–90	1.7% of player-games
1991–92	1.9% of player-games
1993	1.7% of player-games

8.4 Rugby league

A prospective study of Rugby league injuries in players of school age is desirable.

8.5 Soccer

The National Development Officer attached to the ASF has developed a program to minimise head and neck injuries in soccer, particularly at the youth and women's soccer level.

Under eights use an A size 3 ball. Under 10s use an A size 4 ball. Not only should these age-groups have smaller and lighter balls, but the balls should be slightly under-inflated to minimise trauma to the head and neck.

Coaches and trainers are encouraged to bring the players straight off the field and immediately to a medical officer in the event of a head injury. In instructions to the juniors, which is referred to as roo ball, there are modified rules to minimise injuries.

8.6 Summary

Modified rules and laws for younger players reduce the risk of injury. Modified rules/laws also provide better training for young players, which in turn may help to reduce the risk when players reach senior grades.

In the management of school-age players, school teachers may need to be taught sports first-aid; in particular first-aid for managing concussion and other head and neck injuries.

There is a similar need in junior non-school competitions, where it is desirable to have a sports first-aid trained attendant (or sports trainer or medical officer).

Copies of modified rules and laws are available from the following organisations:

1. 'Aussie Footy': National Australian football Council;
2. 'Australian Junior Rugby Pathway': Australian Rugby Football Union Ltd;
3. 'Roo Ball': Australian Soccer Federation; and
4. 'Mini and Mod League': Australian Rugby League.

9 Future directions

9.1 Data collection for research

An important approach to the problem of head and neck injuries in football codes is to monitor the incidence of such injuries to obtain data on the nature, severity, mechanisms, associated risk factors and temporal patterns. Epidemiological research, together with research into the biomechanics of football injuries, provide both:

- baseline data to monitor preventive action; and
- the information on which to make sound decisions as to whether alteration of game procedures or rules/laws, modification of equipment, use of protective wear or changing training and preparation practices are likely to be effective in reducing injuries (Taunton *et al.* 1988).

The submission from the Monash University Accident Research Centre and the Centre for Rehabilitation, Exercise and Sports Science, Victoria University of Technology (Finch *et al.* 1993) notes the following general ways in which results from injury surveillance can be used to suggest actions that may minimise injury:

- If head and neck injuries are the result of dangerous practices, a stricter enforcement of existing rules/laws or the introduction of new rules/laws with severe penalties need to be considered;
- If head and neck injuries are the result of accidental collisions, the wearing of protective head gear requires investigation;
- If head and neck injuries result from collisions with the ground, the ground conditions may require monitoring and attention; and
- If fatigue is a contributing factor (with injuries occurring later in the game), player conditioning, duration of the game, number of games or the number of interchange players may require changes.

The National Minimum Data Set (injury surveillance) (NMDS) is currently being developed for use in hospital emergency departments around Australia. Implementation of the NMDS will commence in 1994–95 and will provide some information on sports injury. Development of the NMDS is being coordinated by the National Injury Surveillance Unit.

The NMDS will comprise five core injury data items, of which the most important is a text description of the injury event. The field describing the type of place includes

'sports and recreation area' as a category whereas the field describing the type of activity will include 'sports activity'. Although the NMDS will not be able to identify football injuries specifically, it will allow for the inclusion of such information at a later stage. In some hospitals, a second level of data collection will actually identify specific football codes. There is an urgent need for the development of a stand-alone computer software package based on the NMDS (injury surveillance) for sports injury data collection and analysis in a variety of settings.

Hospital-based data collections identify sports injuries only in an aggregated manner for admissions, and more detailed hospital emergency department data are collected in relatively few hospitals. The hospital admission information is particularly limited because it is based on the existing ICD 9 E-codes, which identify general sports injuries only as either E886.0 (fall on same level from collision, pushing or shoving, by or with other person in sports) or E917.0 (striking against or struck accidentally by objects or persons in sports). This means that injuries due to football cannot be specifically identified. Whilst hospital-based data collections are a very important means of identifying some sources of severe, acute injury, they have obvious limitations for sport-specific injuries.

Australian Bureau of Statistics mortality data also rely on ICD 9 E-coding of the cause of death and therefore are of little use in identifying fatal football injuries.

The updated version of the ICD classification system (ICD 10) allows the recording of environmental events and circumstances as the cause of injury. This means that sports injuries will be able to be identified as occurring 'while engaged in sports activity' and the place of occurrence of injury as "sports and athletics area" (including football field). Different football codes, however, will not be able to be differentiated. It is essential that these limitations are rectified in ICD 10 by the inclusion of nationally agreed additional sports codes. There are also opportunities in the updated version to supplement the NMDS using a heirarchical response.

The Orchard Sports Injury Classification System currently being used by some sporting bodies, including the AFL and the NSWRL, records details of sports injuries (Orchard 1993). Its major limitation from an injury-prevention perspective is that it is a diagnosis-based system and does not include information about the mechanisms of injury. As such, it may be useful for monitoring trends in the numbers over time but its use for injury prevention is likely to be minimal. Coordination of this system with the NMDS (injury surveillance) should be a priority.

9.2 Specific databases

The NSWRL Medical Officers' Association provided the following comment in their submission to this Panel:

'The data base available to the Medical Officers encompasses district representative teams comprising the Matthews, Ball and Flegg (U15, U17 and U19 years), the President's Cup (U21) and Reserve and First Grade teams. As these are representative teams, the games are extremely competitive and may not necessarily reflect the true incidence of injury across the

board. To develop a true picture of the injury incidence it would be highly desirable to have a mechanism of collection of statistics to include teams in local district competitions. Inclusion of children who play Mini and Mod League may also skew the figures. One would suggest that statistics related to the involvement of children should be separately considered.

Compliance with injury data collection is likely to be inversely related to the length of time of data collection. It is suggested that a number of Districts be identified and an attempt made to collect data from all teams within that District for a period of one month, or two at the most. If every team within a specified District can be adequately covered then it is reasonable to extrapolate such data.

The development of a simple but comprehensive injury report form is a major priority. The report form would need to include: date; level or grade of competition; club; player position; mechanism of injury (eg tackling, being tackled, contact with goal posts, etc); provisional diagnosis; emergency management (simple first aid, referral to hospital or LMO, etc) and, if possible, training sessions and games missed.

If these procedures are followed the establishment of a National Head and Neck Injuries Register would be a logical and beneficial progression.'

(Malouf 1993)

The Australian Sports Medicine Federation has identified the following criteria for future statistics on head and neck injury in football:

- Adequate and specific definitions of types of injury;
- The education of all data recorders in the implications of such definitions and tight control over data collection;
- Soft tissue injury such as laceration and contusion to be differentiated from bone injury and the potentially more serious injury to the brain and spinal cord;
- Injuries to nasal structures, eye, ear, teeth and jaw to be separately recorded;
- Particularly in the case of concussion, the standard classification of mild, moderate and severe be reviewed. This classification may be of benefit in hospital practice but has serious limitations on the sporting field;
- Injuries sustained at elite club level or representative level to be differentiated from injuries at district level, and children's participation to also be separately recorded and analysed;
- Samples to be representative of the sport as a whole;
- Available scientific information on the benefits of protective equipment (especially soft head gear) to be comprehensively reviewed prior to any definite recommendations; and
- Tightly controlled data collection of a representative sample, preferably over a short and well defined period of time, to be considered as the method of choice, in preference to broad-based collection which may result in inadequate information being recorded.

9.2.1 General injury data

The following information should be recorded in a general injury data base:

- Age;
- Gender;
- Date of injury (stage of season);
- Code played;
- State/Territory in which injury occurred;
- Match standard/level of play;
- Ball carrier or not;
- State of ground (hard, soft, etc);
- Illegal play in the injury-producing incident, with or without resultant penalty;
- Phase of play;
- Team position (usual or not);
- Specific training to prevent neck injury;
- Stage of match at which injury occurred;
- Description of injury;
- How injury occurred;
- Protective equipment used;
- Treatment received/referred; and
- Time taken to receive treatment after injury.

9.2.2 Head injury

Collection of data should record and note the duration of symptoms in each of the following:

- Diffuse Head Injury;
  - confusion and disorientation;
  - giddiness or unsteadiness;
  - vomiting;
  - loss of memory;
  - double vision;
  - headache; and
  - loss of consciousness.
- Focal Injury;
  - scalp/facial lacerations – soft tissue;
  - skull fractures – position and type;
  - intracranial haemorrhage – extradural, subdural, surarachnoidp;

- cerebral contusion; and
- cerebral haemorrhage.

- Return to Play/Work;
  - period off; and
  - results of psychological evaluation, if performed.

9.2.3 Spinal cord injury

Other information, specific to spinal injuries, should be recorded in a spinal cord injury data base:

- Mechanism of scrum injuries - engagement, collapse, 'popping', etc;
- Mechanism of non-scrum injury;
- Financial settlement (amount);
- Neurological status at follow-up (less than two years) where applicable (Frankel gradings);
- Level of vertebral injury;
- Nature of vertebral injury; and
- Neurological status at first examination.

9.3 Rules and laws

The Panel supports the many and important changes to rules and laws which have been made to reduce head and neck injury.

Recent changes in the various codes include the following:

Australian football

- Reduction of play – each quarter has been reduced by five minutes;
- Introduction of three field umpires (on trial in 1994 pre-season AFL competition);
- A fine for clubs that return a 'concussed' player to the same game; and
- The National Australian football Council has implemented an Order Off Rule at all levels other than AFL – which has extensive video reporting.

Rugby union

- A change to the IRFB laws regarding concussion;
- A change to the laws regarding scrum engagement; and
- Universal adoption in 1993 of a 'Standard Set of Variations of the Laws for Under 19 Rugby', after more than eight years of experimentation.

Rugby league

- A change to the replacement rule – a player may be removed from the game to seek medical attention and may be replaced for the period of time off the field (replaces the 'head bin' rule).

All officials in all games should be able to stop the game if they believe a serious injury has occurred.

9.4 Foul play

Types of foul play in all codes of football that may result in head or neck injury include:

- Kick on head and neck;
- Knee (drop) on head and neck;
- Eye gouging;
- Shoulder charging;
- Head on head;
- High elbow;
- Late tackles;
- 'Spear' tackles (head into ground);
- 'Spear' tackles in American football (driving with the helmet into opponent's body);
- Scrums: fists/wheeling/collapsing/boring in (props onto hooker);
- Wrestling a player to the ground by the neck;
- Above-shoulder tackle;
- Gang tackle;
- Head-high tackle;
- Fighting;
- Headbutting;
- Contacts when player is not prepared (head not in right position);
- Hand on head (of tackling player on tackled player – forced into the ground);
- Tackling from behind (non-ball player in AFL); and
- Deliberately collapsing rucks and mauls in Rugby union.

Illegal play is a major contributor to head and neck injury and should be severely penalised. Elite players in particular have a responsiblity to set an example for younger players and should be heavily punished for breaching the rules.

Video recordings of illegal conduct are used by some administrators for discipline purposes and by the media. Video recordings of play which results in injury in football games may: enable medical personnel to extract additional information about an injury; and provide an opportunity to researchers to gather information.

9.5 Player fatigue and injury

Head and neck injuries may be more likely to occur in fatigued players. Factors contributing to player fatigue include:

- Lack of game/match fitness;
- Length of match;
- Dehydration;
- Glucose/glycogen levels in muscles;
- Electrolyte levels;
- Body temperatures;
- Weather conditions;
- Ground conditions;
- Clothing;
- Recovery since last match; and
- Consecutive games.

Specific education concerning the effects of fatigue is appropriate in all codes. The frequency of hot, dry conditions and hard grounds makes this specific education very important in Australia, particularly when organising pre-season and post-season competitions.

The increased length of playing seasons and the playing of representative games in the middle of the football season may place more pressure on players, particularly when some players may play more than one game in a short period of time (ie not allowing sufficient time for recovery).

9.6 Training and safety programs

Training and safety programs are important to emphasise:

- techniques to reduce the risk of head and neck injury;
- the need to apply protective rules/laws; and
- the importance of elimination of illegal/foul play.

The safety of players in any sport (particularly football) is contributed to by:

(a) referees/umpires;
(b) coach;
(c) the type of game;
(d) the style of game;
(e) ready on-field access to trained personnel to deal with problems;
(f) protective equipment; and
(g) ground conditions.

Personnel trained in sports first-aid are vitally important. The Australian Sports Medicine Federation (ASMF), the Red Cross Society and St John Ambulance Australia all run sports first-aid courses. These courses differ from normal first aid courses as they take into account the restrictions and considerations that are required for sports first-aid coverage.

The National Recreation Industry Training Advisory Board Ltd (NRITAB) is currently developing initiatives to improve the overall standard of training within the recreation industry. These initiatives will, inter alia, have a positive impact on the prevention of injury within sport.

In addition, the Commonwealth, State and Territory Governments responsible for sport are meeting jointly with the peak sporting bodies to devise a national plan to reduce all sport– and recreation-related injuries (information on this program is available from the Commonwealth Department of Human Services and Health).

Training to assist football personnel to recognise the main causes of injuries needs to be encouraged. Such training may assist referees in their adjudication of illegal and dangerous play, and influence administrators in the way they form policy and back up these decisions.

9.6.1 Australian football

As illegal tackles (including a high elbow to the head) may account for up to a quarter of head and neck injuries (this figure may have reduced in the last ten years), a greater emphasis should be placed on reporting head-high tackles by umpires and video mechanisms. Consideration should be given to an increase in penalties for illegal tackles. This should be extended to cover all levels of football (ie State, amateur, club and school levels).

An appraisal of rules/laws that may relate to head and neck injuries (eg kicking dangerously, charging) should be undertaken, emphasising the role of player protection in the interpretation of rules/laws.

AFL medical officers plan to continue to conduct regular education sessions for their trainers on the management of head and neck injuries. Education programs for coaches, umpires and other officials will be undertaken to improve their understanding of head and neck injury incidence, management and long-term sequelae.

Sports trainers of non-elite level players have regular up-dating educational programs on the management of head and neck injuries. The ASMF guidelines for head and brain injury in sport provide a useful guide for the management of these injuries.

Medical officers involved with non-elite levels of football should receive continuing medical education in the diagnosis, assessment and management of head and neck injuries.

9.6.2 Rugby union

Rugby union has instituted the following programs, resources and procedures to ensure that the correct techniques and laws of the game are adhered to by all participants:

Coaching material:

- Under 19 laws and 'Confidence in contact' video; and
- ARFU coaching manuals.

Courses:

- coach accreditation;
- modified laws - Australian Junior Rugby Pathway; and
- Safety in contact field days and seminars.

Safety directives and the laws of the game:

- ARFU handbook; and
- Safety directive charts.

Registration, insurance and ARFU Player Welfare Fund:

- ARFU registration form;
- ARFU National Insurance Schemep; and
- ARFU Player Welfare Fund.

Research programs:

- The biomechanics of rugby scrummaging;
- Study of schoolboy rugby injuries; and
- Other research by the ARFU Technical Advisory Committee, as required.

Monitoring player safety and health in Rugby union:

- ARFU Safety Committee; and
- ARFU Medical Advisory Committee (a newly formed body which will monitor general health aspects of the game and provide direction for specific medical issues (eg policy on AIDS, hepatitis B, etc) as they relate to rugby. Records of serious injury will also be kept by the ARFU Medical Commission).

9.6.3 Rugby league

In Rugby league, it has been recommended that there should be a national (and eventually State) director/coordinator of sports trainers. By this means, the many State, regional and club personnel would have easier access to a greater number of courses and to far more literature, support and direction.

The NSWRL Medical Officers' Association has a close working relationship with the NSWRL and has strongly supported the league in its crackdown on head-high tackles and spear tackling. Over the years the NSWRL has initiated a number of policies and projects which have contributed significantly to the safety of Rugby league players.

These include:

- the Neck Safe Program – this project educated personnel in the management of severe head and neck injuries. A video demonstrating safety immobilisation and movement of injured players was produced and highlighted the use of stiff neck collars, Russell extraction device, Jordan frame and spinal board;
- the promotion of the acceptance of the guidelines for the management of concussion document and the subsequent introduction of the 'head bin';
- the introduction of the 'blood bin'; and
- changes to the rules/laws to allow a player interchange, thus allowing the early intervention and diagnosis of potentially serious injuries, including head and neck injury.

'It is our view that efforts in these areas have been most productive and the incidence of serious head and neck injuries at senior level has been significantly reduced.'

(Malouf, NSWRL Medical Officers Association, 1993).

9.7 Equipment

In sports where high-speed collisions are likely (eg motorcycle racing), hard-shell helmets are of undoubted and proven value (Torg 1991). For sports that have the potential for missile injuries (eg baseball (Torg 1991)) or falls onto hard surfaces (eg gridiron (Bachman 1981) and ice hockey (Fekete 1968)), there is published evidence for the effectiveness of sport-specific helmets in reducing head injuries. These rigid-shell helmets would, however, be inappropriate for football because of the nature of the game.

The use of head protection equipment is a controversial area and no football – specific helmets have yet been shown to be of proven benefit in reducing rates of head injuries on the field. It is likely that scalp and facial lacerations would be reduced by helmets, although this remains to be scientifically tested and proven in the field situation. (For a detailed discussion on the use of head protection in football, see chapter 6).

The following equipment needs should be considered by each football code:

Player equipment:

- Headgear;
- Mouthguards;
- Shoulder pads;
- Boot studs;
- Thigh pads; and
- Clothing.

The football:

- Shape and size of football – especially in relation to age of player;
- Flight;
- Weight;
- Bounce;
- Damping;
- Air resistance;
- Water absorption;
- Shape retention; and
- Lacing.

Football ground:

- Surface of ground;
- Goal post padding;
- Field marking substances and appearance; and
- Padding on boundary fences and other potential obstacles.

Injury management:

- First-aid equipment including:
  - stiff neck collar;
  - Russell extrication device (RED);
  - Guedel airway;
  - Oxyviva (bag and mask);
  - oxygen; and
  - stretcher.
- Telecommunications – mobile phone;
- Educational materials:
  - laws;
  - brochures; and
  - video instructions: 'Neck safe', 'Confidence in contact'.
- Injury reporting system.

Fatigue:

Head and neck injuries may be likely to occur in fatigued players. Factors implicated in fatigue are:

- dehydration;
- glucose/glycogen levels;
- salt levels;
- clothing; and
- heat/cold.

9.8 Evaluation

Evaluation of the effectiveness of injury prevention measures should be an integral part of all measures introduced to reduce injury in sport. Such measures need to be shown to be effective if they are to gain widespread and continuing support.

9.9 Legal implications and insurance

Adequate insurance for serious head and/or neck injuries should be mandatory.

Mechanisms by which this may be achieved is beyond this Panel's terms of reference.

Litigation and legal issues need to be considered in all changes (and non-changes) to rules/laws and the application of rules/laws in all codes of football.

Insurance claims experience provides an important, though incomplete, source of information on injury occurrence.

It is noted that sports first aiders and sports trainers accredited under the National Sports Trainers Scheme have insurance cover within the guidelines of that scheme.

9.10 Responsibility of the media

Efforts to prevent head and neck injuries may be undermined by the approach taken by the television medium to promote football. In television advertisements matches are often referred to as 'clashes' (Millar 1994). Vision and sound effects are used to heighten the body contact aspect of tackles. To reduce the incidence of illegal play that can cause head and neck injury, there needs to be less emphasis on the violent aspects of football and more focus on the skills involved (Wallner 1994).

9.11 Summary

The collection of data on the incidence and management of head and neck injuries is essential for further research in this area. Specific databases for head and neck injuries are listed in this chapter.

Research and education regarding applications of rules and laws, types of foul play, player fatigue and equipment remain important.

Illegal play is a major contributor to head and neck injury and should be severely penalised. Elite players, in particular, have a responsibility to set an example for younger players and should be heavily punished for breaching the rules/laws.

Recommendations

The official in-charge of a football game should have the power to stop the game if a serious injury has occurred. Training to a sports-first-aid-standard certificate is desirable for all referees and umpires to enable them to conduct their administrative responsibilities.

Training and safety programs to reduce both illegal play and the effects of accidental injury should be continually promoted. Illegal play, especially above the line of the shoulder, is a major contributor to head and neck injury and should be severely punished.

Player interchange which allows early intervention to assess injury should be considered by codes where this is not currently allowed.

Possible obstacles to players such as goal posts, boundary fences and television cameras should be covered with soft material to reduce the possiblity of serious injury should a player collide with any of these.

Appropriate first-aid equipment designed to cope with head and neck injuries should be on-site wherever a football match is being played.

Video recordings of illegal conduct and play which results in injury in football games should be made readily available for research purposes.

A central fund for specific research into the prevention and management of head and neck injuries in football should be established. In addition, administrators of each code should be encouraged to direct additional funds towards safety measures and the care of injured players.

There should be a national registry of deaths, brain injury with permanent functional disability, and cervical spine injury (spinal injury with or without cord involvement) established, to commence data collection at the beginning of the 1995 football season.

Appendix A

Head and neck injuries in football – Guidelines for prevention and management

Australian football

Rugby union

Rugby league

Soccer

Contents

Overview of National Health and Medical Research Council Report – 'Football injuries of the neck and head'

This appendix is based on the report of the National Health and Medical Research Council Panel on Head and Neck Injuries in Football. It includes key guidelines to be followed in the management of these injuries and the Recommendations made by the Panel. A summary of the Panel's main findings and activities is given below.

Injuries to the head and neck can be sustained in most sports, but this is more likely in the body contact/collision sports. Given the high participation rate in football in Australia, the risk of injury from football is nevertheless not as great as many would believe.

When discussing head injuries sustained in collision sports, a distinction needs to be made between the terms 'mild' or 'minor head injury' and 'mild concussion'. Similarly, concussion means different things to different people. Definitions with qualifications of these differences have been outlined in the report.

Most head injuries in football are minor. On the other hand, any head injury can be followed by complications. These injuries are more likely to occur after direct impact injury.

Head injury where consciousness is lost for a few minutes may be sufficient to cause measurable impairment of brain function for a variable period following injury.

Diagnosis on the field and management of brain injury is not simple for non-medical personnel. Players should not continue to play after they have been concussed. A defined procedure for referees, umpires and sports first-aid attendants has been recommended in the text.

The timing of returning to training and to play is also difficult to determine. The Concussion Guidelines provided should be of benefit for all codes of football.

Courses in early management of severe trauma have been promoted within Australia for medical officers likely to have to deal with trauma in an isolated setting. Similarly, guidelines for the care of head and spinal injuries have been produced by the Neurosurgical Society of Australasia and the Royal Australasian College of Surgeons and have been adapted to form the basis of the guidelines for the Management of Severe Head Injury and Neck Injury.

Apart from a prospective study on school rugby union, there is an absence of good overall data on injuries in football. Although useful for elite grades of football, injury studies on elite footballers cannot give a true representation of the risk of injury across the board. As a result, there is a need for uniform data collection and a national injury register in Australia. To this end, the information to be recorded in a Data Base for Surveillance of Head and Neck Injuries in Football has been specified.

Lacerations and contusions of the face are common in football. They appear to occur with greater frequency in elite and senior football. The risk of transfer of infectious

diseases via bleeding wounds requires special precautions. Eye injuries include bruising and laceration around the eye socket, bleeding in the chambers of the eye and damage to the retina.

Fractures of the nose are common. Fractures of the jawbones and around the eye also occur. The high elbow in tackles is a common mechanism leading to such injuries.

The use of custom-fitted mouthguards and avoidance of high tackles are important factors in prevention. Mouthguards provide protection of the teeth, jaws and adjacent soft tissues. Mouthguards can also reduce the rate of concussion.

Neck injuries that may occur in football include soft tissue musculoskeletal injury, brachial plexus injury (shoulder and arm nerve injury), cervical spine injury and spinal cord injury. These result in a variety of injuries from the minor to the catastrophic – from simple sprains, 'stingers' and 'burns' to disc injury, fractures, dislocations, paraplegia, quadriplegia and death.

Scrum injury, tackling injury, ruck and maul injury and open play accidents are all areas that require further attention. Substantial progress has been made towards prevention of these injuries by rule/law change, compliance, player selection and training, and general public awareness.

In Australia, the various codes of football do not require that participating athletes wear helmets. The paucity of evidence related to the use of helmets in football played in this country makes analysis of the risks and benefits of helmet use difficult. Soft head protectors and scrum caps appear to reduce lacerations and other soft tissue injuries and may lessen intracranial forces on impact. The view has been expressed that such soft helmet equipment should weigh no more than 80 grams. Further research into this area should be encouraged.

Available comparative concussion data for the various codes were studied by the Panel. From these data, it appears that concussion is more prevalent in the rugby codes and Australian football than in soccer. Further data concerning the incidence of all types of head and neck injuries in all codes, views concerning training and research, and administrative arrangements to minimise injury were also considered by the Panel.

Modified rules and laws for younger players reduce the risk of injury. Modified rules/laws also provide better training for young players, which in turn may help to reduce the risk when players reach senior grades.

In the management of school-age players, school teachers may need to be taught sports first-aid, in particular for managing concussion and other head and neck injuries. There is a similar need in junior non-school competitions, where it is desirable to have a sports first-aid trained attendant (or sports trainer or medical officer).

Research and education remain important regarding applications of rules and laws, types of foul play, player fatigue and equipment.

Illegal play is a major contributor to head and neck injuries and should be severely penalised. Elite players in particular, have a responsibility to set an example for younger players and should be heavily punished for breaching the rules/laws.

Recommendations

1. Management and Administrative Arrangements

(a) The official in charge of a football game should have the power to stop the game if a serious injury has occurred. Training to a sports-first-aid-standard certificate is desirable for all referees and umpires to enable them to conduct their administrative responsibilities. They are not required to manage the injury but only to ensure that the injury is managed.

(b) At every football venue, at every level, in every age group, the aim should be to have trained personnel, ie a person qualified in sports first-aid, and appropriate first-aid equipment for head/neck injuries.

(c) The frequency, duration and resetting of rugby union scrums, including a limitation on the number of times a scrum is reset, should be reviewed.

(d) Training and safety programs to reduce both illegal play and the effects of accidental injury should be continually promoted. Illegal play, especially above the line of the shoulder, is a major contributor to head and neck injury and should be severely punished.

(e) Player interchange which allows early intervention to assess injury should be considered by codes where this is not currently allowed.

(f) Appropriate practices and education to reduce the risk of blood contamination in contact/collision sports should be adopted in all football codes. Immunisation against hepatitis B is strongly recommended.

(g) Guidelines for the recognition of concussion and spinal injury should be promulgated to referees and umpires to enable them to conduct their administrative responsibilities.

(h) The guidelines should be widely distributed to all clubs, coaches, medical practitioners and hospitals and reinforced with an education campaign.

(i) Common guidelines for concussion should be adopted by all codes. Retrospective grading of concussion, if utilised, should also be by a system agreed to by all codes.

2. Data Collection

(a) There should be a national registry of deaths, brain injury with permanent functional disability, and cervical spine injury (spinal injury with or without cord involvement) established, to commence data collection at the beginning of the 1995 season.

(b) Such reporting or notification of injury should be the responsibility of each individual code of football. Initial reporting should occur at the completion of each game.

(c) Since concussion is so important, it is recommended that this be targeted for prospective research using uniform data coding. Guidelines for the management of concussion are recommended for adoption by all codes. Certification of recovery should be by a medical practitioner.

3. Equipment

(a) The use of custom-made mouthguards in contact sports, including football (all codes) is strongly recommended.

(b) Australian standards for mouthguards need to be developed.

(c) Possible obstacles to players such as goal posts, boundary fences and television cameras should be covered with soft material to reduce the possibility of serious injury should a player collide with any of these.

(d) Appropriate first-aid equipment designed to cope with head and neck injuries should be on-site wherever a football match is being played.

4. Research and Education

(a) Qualified sports trainers should have additional training in sports injury prevention and management. All football code administrators should encourage training and education as offered by the National Sports Trainers Scheme.

(b) Programs of prevention of head and neck injuries should include:

(i) research into the selection of a player for a position according to body type;

(ii) education of players, coaches, administrators and sports trainers; and

(iii) research into specific aspects of fitness training, including neck muscle strengthening.

(c) Research into the use of soft head protectors or scrum caps to reduce injuries of the scalp, ears and face should be developed. Design criteria and manufacturing standards for such head protectors need development.

(d) Research should be undertaken to determine whether standardised soft head protectors reduce brain injury without creating other hazards.

(e) Video recordings of illegal conduct and play which results in injury in football games should be made readily available for research purposes.

(f) A central fund for specific research into the prevention and management of head and neck injuries in football should be established. In addition, administrations of each code should be encouraged to direct additional funds towards safety measures and the care of injured players.

The following guidelines on concussion are adapted from those of the International Rugby Football Board (IRFB). In particular, changes have been made to the IRFB guidelines for return to competition. This Panel recommends that the following guidelines be adopted by all codes.

Concussion guidelines

CONCUSSION occurs when, after a blow to the head, there is brain injury with some immediate disturbance of brain function. Signs and symptoms of this may include:

- confusion and disorientation;
- loss of consciousness;
- loss of memory;
- double vision;
- giddiness or unsteadiness;
- vomiting; and
- headache.

A player showing any of these signs or symptoms should be removed from the field and referred to a medical practitioner and should not be allowed to engage in further play until fully recovered.

Immediate medical attention is essential where there is loss of consciousness.

Loss of consciousness for a period exceeding 4 or 5 minutes as a result of a blow to the head would be indicative of a more severe injury, therefore, the player should be immediately referred to a hospital for further attention.

Post-concussive symptoms include:

- headache (with or without exertion);
- lethargy;
- fatigue;
- irritability;
- poor concentration;
- giddiness;
- nausea and vomiting especially in children; and
- post-traumatic amnesia (PTA) (gap in memory – memory loss after injury).

Whether a player is in PTA or not can be readily tested by a simple daily assessment. The gap in time between injury and continuous memory afterwards is important. Some questions which are useful are:

- How old are you?;
- What is your date of birth?;

- What month are we in?;
- What time of day is it? (morning, afternoon or night);
- What day of the week is it?;
- What year are we in?; and
- What is the name of this place?

Return to competition

Players who have suffered concussion with or without loss of consciousness:

- should not participate in any match or training session until they are fully recovered* and no longer have post-concussive symptoms, and have been cleared by a thorough medical examination (including examination of the central nervous system). During this period off, alcohol must be avoided;
- should undertake a non-contact exertional training session, when asymptomatic. This is to ensure that such exertion does not provoke a recurrence of symptoms; and
- should not be given a medical clearance until after this training session.

Warning

Complications, potentially serious, may occur in the 24 hours after a seemingly slight head injury. Accordingly, deterioration of consciousness after apparent recovery or the onset of symptoms such as headaches, increasing drowsiness, blurred vision and vomiting require immediate medical assessment.

*Some football codes have chosen a mandatory exclusion time for players with concussion and this has been found to be administratively acceptable.

Management of severe head injury

At every football venue, at every level, in every age group, the aim should be to have trained personnel, ie a person qualified in sports first-aid, and appropriate first-aid equipment for head/neck injuries.

Prehospital care of severe head injury

The following factors require attention: airway, breathing, control of haemorrhage, prevention and treatment of shock, avoidance of factors which can either precipitate or aggravate raised pressure within the skull (the head-down position, low oxygenation of the blood, high carbon dioxide retention and vomiting), recognition of serious associated injuries especially spinal injury, effective communications and transport. It is essential to obtain and maintain adequate brain oxygenation and blood supply. All of these measures serve to reduce deterioration in brain and spinal cord function after injury.

Position of the unconscious patient

The LATERAL position is indicated for airway control. This does not apply in a patient with a suspected spinal injury, where the supine position is usually the position of choice, with the airway controlled and manual inline immobilisation is maintained by an attendant. The lateral position is described as a position in which an unconscious victim lies on one side with the weight supported by the under shoulder, hip and the upper knee, which is at right angles to the hip. The face is turned slightly downwards to allow the tongue to fall forwards so that saliva or vomit will drain away.

On the field and in a stretcher–carry off the field, the trained attendant (fifth person) MUST walk at the player's head maintaining the airway and maintaining manual inline support of the head and neck.

Tracheal intubation

In certain circumstances, tracheal intubation (special tubes placed through the mouth to the windpipe) may be needed if the airway is inadequate. Tracheal intubation should be performed only by a competent medical practitioner or by an ambulance officer specially trained and certified in this potentially dangerous procedure.

Management of neck injury

Spinal injury

It is important to emphasise that, in a patient with suspected cervical spine injury with an obstructed airway, the immediate risk of hypoxia (low oxygen in the blood stream) takes priority over the potential risk of spinal instability. If the person is unconscious, the tongue may passively fall backward, blocking the airways. A good airway can be restored by either the modified jaw thrust manoeuvre or by pulling the mandible forward (without inadvertently extending the neck) and then inserting an oropharyngeal airway (special tube designed to pass through the mouth to the throat over the tongue), whilst an assistant maintains the head in the neutral or inline position.

In line with regular guidelines for Early Management of Severe Trauma (EMST), the mnemonic 'ABC' – **(a) airway with cervical spine control; (b) breathing; (c) circulation** – should be adhered to.

A semi-rigid cervical collar such as the 'Stifneck' collar should be applied as soon as practical after cervical injury is suspected.

Management on the field

Whenever cervical spine injury is suspected: after protecting the airway (in line with regular guidelines for EMST), the head should be immobilised with the attendant's hands and maintained in the 'neutral position', ie aligned with the spine.

Inadvertent movements of the neck must be prevented. It is particularly important not to flex the neck. For a stretcher–carry off the field, a minimum of five (5) people is recommended, one at each corner and one holding the patient's head and neck. The direction of travel for the injured player is feet first.

The preferred means of rapidly and safely immobilising the neck from flexion and extension is to apply a semi-rigid cervical collar, such as 'the Stifneck'. Lateral cervical immobilisation also needs to be maintained. This can be accomplished using blanket rolls, blanket halo, Russell Extrication Device (RED) or other types of immobilisation boards.

Transfer after removal from field

Neurological deterioration may occur during transport. Wherever possible, patients with major spinal cord injury should go direct to Spinal Units from the field. Other patients with neck injury need to be assessed in the nearest appropriate medical facility with access to radiological equipment.

In many instances, initial care in a general hospital will also be indicated before transfer to a Spinal Unit is practical for patients that have suspected spinal cord injury.

Before transportation to hospital, the following important matters should be confirmed:

1. The airway is clear and 'guaranteed'.
2. Breathing (either spontaneous or assisted) is satisfactory. Supplemental oxygen is being administered. Airway tubes and other tubes are securely attached to the patient.
3. Neurologic assessment is completed and documented.
4. The entire spine has been immobilised securely for transport in devices such as the Russell Extrication Device and Stifneck collar.

Before transport between hospitals (to a Spinal Unit) the following important matters should be confirmed:

1. The airway is clear and 'guaranteed'.
2. Ventilation (either spontaneous or assisted) is satisfactory. Supplemental oxygen is being administered. Endotracheal and other tubes are securely attached to the patient.
3. Neurologic assessment is completed and documented.
4. Chest X-ray is completed, examined and preferably reported by a radiologist.
5. Blood pressure is stable and intravenous lifelines are established.
6. The stomach has been decompressed with a naso-gastric tube.
7. Urinary bladder drainage has been established.
8. The entire spine has been immobilised securely for transport in devices such as the Russell Extrication Device and Stifneck collar.

9. Pressure on the skin over bony prominences has been relieved.
10. The Spinal Unit has accepted the patient and the Retrieval Team notified.
11. When removing clothes they should be cut off in order to avoid unnecessary spinal movement.

The Russell Extrication Device is made in Australia and has been shown to be highly effective in the immobilisation and transport of patients with spinal injury.

The Jordon frame is also an Australian device which allows lifting, without 'moving' the patient, but is not an immobilisation device.

The 'scoop-stretcher' is a lifting device that is beginning to be used widely in elite football.

Equipment

The following equipment needs should be considered by each football code:

Player Equipment:

- Headgear;
- Mouthguards;
- Shoulder pads;
- Boot studs;
- Thigh pads; and
- Clothing.

The Football:

- Shape and size of football – especially in relation to age of player;
- Flight;
- Weight;
- Bounce;
- Damping;
- Air resistance;
- Water absorption;
- Shape retention; and
- Lacing.

Football Ground:

- Surface of ground;
- Goal post padding;
- Field marking substances and appearance; and
- Padding on boundary fences and other potential obstacles.

Injury Management:

- First-aid equipment including:
  - stiff neck collar;
  - Russell extrication device (RED);
  - Guedel airway;
  - Oxyviva (bag and mask);
  - oxygen; and
  - stretcher.
- Telecommunications – mobile phone
- Educational materials:
  - laws;
  - brochures; and
  - video instructions: 'Neck safe', 'Confidence in contact'.
- Injury reporting system

Fatigue:

Head and neck injuries may be likely to occur in fatigued players. Factors implicated in fatigue are:

- dehydration;
- glucose/glycogen levels;
- salt levels;
- clothing; and
- heat/cold.

Guidelines for future studies of head and neck injury in football

Future criteria for the collection of data concerning head and neck injuries in football may include:

- adequate and specific definitions of types of injury;
- the education of all data recorders in the implications of such definitions and tight control over data collection;
- definitions of soft tissue injury such as laceration and contusion being differentiated from bone injury and the potentially more serious injury to the brain and spinal cord;
- injuries to nasal structures, eye, ear, teeth and jaw being separately recorded;

- in the case of concussion, the standard classification of mild, moderate and severe being reviewed. This classification may be of benefit in hospital practice but has serious limitations on the sporting field;
- injuries sustained at elite club level or representative level being differentiated from injuries at district level, and children's participation also being separately recorded and analysed;
- samples being representative of the sport as a whole; and
- available scientific information on the benefits of protective equipment (especially soft headgear) being comprehensively reviewed prior to any definite recommendations.

Data base for surveillance of head and neck injuries in football

General injury data

The following information should be recorded in a general injury data base:

- Age;
- Gender;
- Date of injury (stage of season);
- Code played;
- State/Territory in which injury occurred;
- Match standard/level of play;
- Ball carrier or not;
- State of ground (hard, soft, etc);
- Illegal play in the injury-producing incident, with or without resultant penalty;
- Phase of play;
- Team position (usual or not);
- Specific training to prevent neck injury;
- Stage of match at which injury occurred;
- Description of injury;
- How injury occurred;
- Protective equipment used;
- Treatment received/referred; and
- Time taken to receive treatment after injury.

Head injury

Collection of data should record and note the duration of symptoms in each of the following:

- Diffuse Head Injury;
  - Confusion and disorientation;
  - Giddiness or unsteadiness;
  - Vomiting;
  - Loss of memory;
  - Double vision;
  - Headache; and
  - Loss of consciousness.
- Focal Injury;
  - Scalp/facial lacerations – soft tissue;
  - Skull fractures – position and type;
  - Intracranial haemorrhage – extradural, subdural, surarachnoid;
  - Cerebral contusion; and
  - Cerebral haemorrhage.
- Return to Play/Work
  - Period off; and
  - Results of psychological evaluation, if performed.

Spinal cord injury

Other information, specific to spinal injuries, should be recorded in a spinal cord injury data base:

- Mechanism of scrum injuries - engagement, collapse, 'popping', etc;
- Mechanism of non-scrum injury;
- Financial settlement (amount);
- Neurological status at follow-up (less than two years) where applicable (Frankel gradings);
- Level of vertebral injury;
- Nature of vertebral injury; and
- Neurological status at first examination.

Concussion

Notes for referees, umpires and coaches

There has been concussion if:

- The player is seen to have been unconscious for even the shortest time;
- The player was unresponsive for even the shortest time - ie did not open his eyes, speak or get up at once;
- The player was confused for even the shortest time - didn't know what to do, which way to play, where he was;
- The player was unsteady on his feet, reeling or unable to hold the ball;
- The player showed spasms or convulsions; and
- The player has giddiness, double vision or vomiting.

The player must be able:

- to tell you:

  the time, the day, the month, the year, the name of the other team, the score and how long the game has been going.

- to walk steadily heel to toe.

Concussion often destroys judgment.
Do not allow a player to influence you.
The player's health – and the reputation of the game – is at stake.

Off the field:

As a part of team discipline, players must accept that, after being concussed, they must be seen by a doctor immediately – either at the site of the match or by being taken to the surgery or hospital by a responsible person. After this has been arranged, whatever local arrangements there are for the management of mild head injury should be followed and the immediate responsibility of the game administrator ceases.

Spinal injury

Notes for referees, umpires and coaches

There has been a spinal injury (until proven otherwise) if:

- the player is unconscious;
- the player has prominent neck pain;
- the player has no sensation, or has pins and needles, in any limb; and
- the player is weak or cannot move the limbs below the site of the injury.

Note: If the player has received a prominent impact above the collar bone, the possibility of a spinal injury needs to be considered.

The following record is to be completed by the team manager, sports trainer or medical officer

Sample injury record
Head and neck injuries

Name: **Date of birth:**

Date: Match: Code: Rugby league
Rugby union
Soccer
Australian football
Other:

Players description of incidence:

Attendant/Onlooker's description of incident:

Referee/Umpire ruling:
(if applicable)

Ground conditions (circle): Hard Wet/Muddy Good Excellent

Management of injury

On field:

After match:

Hospital (circle): Yes No

If Yes, which hospital?:

Return to play:

This is a general record for different types of head and neck injuries. The record would need to be adapted for the particular kind of study being undertaken. For example, for surveillance of severe head and neck injuries only, the following criteria might be included in the record:

- Head injury needing surgery or leading to neurological impairment; or
- Spinal injury needing surgery or leading to neurological impairment.

Appendix B

Submissions to the inquiry

1. Mr Russell Trotter, National Referee Development Officer, Australian Rugby Football Union Ltd
2. Dr Geoffrey M Boyce, Consultant Neurologist, Far North Queensland Neurology
3. Mr John Sheldrick, Metro Chiropractic Clinics
4. Mr Gary Allsop
5. Dr Hugh Hazard, Medical Officer, Canterbury Bankstown NSWRL
6. Dr Nathan Gibbs, Medical Officer, South Sydney NSWRL
7. Dr P F Berry
8. Ms Mary Albon
9. Mr Tony Henson, Managing Director, Albion Hat and Cap Company Pty Ltd
10. Mr E B Watkins, JP
11. Mr Rob Bradley, National Development Co-Ordinator, Australian Rugby Football Union Ltd
12. Mr Warwick L Spinks, Senior Lecturer, Human Movement Studies, School of Leisure and Tourism Studies, University of Technology, Sydney
13. Mr Peter D Corcoran, National Director of Coaching, Australian Rugby League
14. Associate Professor H Sharpe, School of Physiotherapy, University of South Australia
15. Mrs Ursula Carland
16. Dr Peter Malouf, Cronulla Sutherland DRLFC Medical Officer, Secretary NSWRL Medical Officers Association
17. Mr Neil Sachse
18. Mr Terry Sanders, National Executive Director, Australian Sports Medicine Federation Ltd
19. Dr Laurie Pincott, Executive Director, New South Wales Branch, the Australian Medical Association
20. Mr Tom Duffy
21 Dr Hugh Seward, President, AFL Medical Officers Association

22. Dr M R J Coolican & Professor T K F Taylor, Spine Society of Australia
23. Dr R F Gorman
24. Ms Caroline Finch, Dr Joan Ozanne-Smith, Accident Research Centre, Monash University and Prof. Bill Morrison, Mr Con Hrysomalis, Centre for Rehabilitation, Exercise and Sports Science, Victorian University of Technology.
25. Dr Eric Milne
26. Ms Fae Horridge
27. Mr Lloyd Deane
28 Mr Winston Gregory
29. Mr Barry Gomersall
30. Dr Philip Wrightson
31. Dr John Yeo, Spinal Injury Rehabilitation
32. Dr Mark Jones, Medical Officer, Illawarra Steelers NSWRL
33. Dr D J Lugg
34. Professor Terry Nolan, Clinical Epidemiology and Biostatistics Unit, Royal Children's Hospital
35. Dr Adrian Cohen, Medical Director, Doctor's Television Network Pty Ltd
36. Professor Tim Noakes, Bioenergetics of Exercise Research Unit, Medical Research Council & the University of Cape Town
37. Dr Geoffrey Vanderfield, Neurosurgeon, Medical Officer, Australian Rugby Football Union
38. Dr Siri Kannangara, Senior Visiting Medical Officer, Concord Hospital, and Chief Medical Commissioner to the Australian Soccer Federation
39. Dr John Orchard, Sports Medicine, Australian Sports Commission, Medical Officer, Sydney Swans, AFL
40. Dr David Hughes & Dr Peter Fricker, Sports Medicine, Australian Sports Commission
41. Jan Van Duser, Director of Game Operations, National Football League, USA
42. Dr Paul McCrory, Sports Physician, Medical Officer Australian Football League
43. Dr Brian North, Director of Neurosurgery, Royal Adelaide Hospital
44. Professor Gina Geffen, Director, Cognitive Psychophysiology Laboratory, University of Queensland
45. Dr John Crompton, Neuro-ophthalmologist
46. Dr Paul Curtin, Plastic & Reconstructive Surgeon
47. Dr Joan Ozanne-Smith & Ms Caroline Finch, Accident Research Centre, Monash University
48. Dr Peter Blum, Randwick Medical Centre49.Ms Amanda King, Neuropsychologist
50. Professor Bill Morrison, Executive Director,Centre for Rehabilitation, Exercise & Sports Science, Victorian University of Technology

51. Dr Peter Milburn, Department of Biomedical Science, University of Wollongong
52. Royal Australasian College of Surgeons and Neurosurgical Society of Australasia
53. Associate Prof. Margaret Sharpe, School of Physiotherapy, University of South Australia
54. Mr Alan Knox, Project Officer, Sports Injury Prevention Project, North Sydney Area Health Service
55. Dr Brett Dorney, Sports Dentist
56. Mr Julian Hodges, Hodges Health Care Products
57. Mr Don Jordon and Associates, Victoria

Appendix C

Submissions received commenting on draft report

1. Dr Hugh Hazard, Australian NSW Sydney Rugby League
2. Mr Frank Wallner, National Development Manager, Australian Sports Medicine Federation
3. Dr Paul McCrory
4. Dr Vernon Hill, Director, Princess Alexandra Hospital
5. Dr Brett Dorney, Sports Dentist
6. Dr Eric Milne
7. Dr Tim Noakes, Bioenergetics of Exercise Research Unit, Medical Research Council and the University of Capetown, South Africa
8. Dr Philip Wrightson
9. Dr Brad McCall, West Moreton Population Health Unit, and the QLD Injury Coalition
10. Ms Sonya Hender, University of South Australia
11. Mr Ed Biggs, General Manager, National Australian Football Council
12. Mr Michael Darby
13. Mr Gary Allsop
14. Dr Adrian Cohen, Medical Director, Doctor's Television Network
15. Dr Hugh Hazard, Australian College of Sports Physicians
16. Mr Terry L Sanders, National Executive Director, Australian Sports Medicine Federation
17. Mr Anthony P Millar, Lewisham Institute of Sports Medicine
18. Prof. Gina Geffen and Dr Sue Cremona-Meteyard, Psychology Department, University of Queensland
19. Ms Elizabeth C Percival, Executive Director, Royal College of Nursing Australia
20. Dr R F Gorman
21. Dr David Chalmers, Deputy Director, Injury Prevention Research Unit, University of Otago, New Zealand

22. Royal Australian College of Surgeons
23. Dr John Vinen, Chair, Scientific Committe, Australasian College for Emergency Medicine, Royal North Shore Hospital and Community Health Service
24. Mr Julian Hodges, Hodges Health Care Products

References

Alexander, D., Kennedy, M. & Kennedy, J. 1979, 'Injuries in rugby league football', *The Medical Journal of Australia,* vol. 2, pp. 341–342.

Appenzeller, H. 1982, 'Footballer's dilemma', *Phys Ed and Sports Law Quart,* vol. 3, pp. 1–3.

Australian Sports Medicine Federation 1992, Policy on infectious diseases.

Bachman, D. 1981, Head and neck injuries and helmetry, New York, Riddell.

Bishop, P. 1984, 'Impact performance of bicycle helmets', *Can J Appl Sports Sci,* no. 9, pp. 94–101.

Bradley, R., 1993, Australian Rugby Football Union, Submission to Inquiry.

Broughton, H. 1993, 'Premature degeneration of the cervical spine in a rugby union player', *New Zealand Sports Medicine,* vol. 213, pp. 48-9.

Chalmers, D. 1994, Submission to Inquiry.

Cohen, A.J., Bothard, R.G. & Yeo, J.D.1990, 'A new device for the care of acute spinal injuries: The Russell Extrication Device (RED)', *International Medical Society of Paraplegia,* pp. 151–157.

Cohen, I. & Siff, M.C. 1979, 'Increased safety in the rugby scrum', *South African Medical Journal,* no. 56, pp. 625.

Committee on Head Injury Nomenclature of the Congress of Neurological Surgeons, *Clin Neurosurg 1966,* 12, pp. 386–394.

Coolican, M.R. & Taylor, T.K. 1993, Submission to Inquiry.

Corcoran, P.D. 1993, Submission to Inquiry.

Cremona-Meteyard, S.L. & Geffen, G.M. 1994, 'Event-related potential indices of visual attention following moderate to severe closed head injury', *Neuropsychologia* (in press).

Crompton, J.L. & Hammerton, M.E. 1994, Ophthalmic injuries, in cranio-facial maxillo trauma, eds David D,J., Simpson, D.A.S., Churchill, Livingstone, Edinburgh (in press).

Davidson, R.M. 1987, 'Schoolboy rugby injuries, 1969–1986', *The Medical Journal of Australia,* vol. 147, pp. 119–120.

Davidson, R.M. 1993, Submission to Inquiry.

Deane, L. 1993, Submission to Inquiry.

Dicker, G., Maddocks, D. & Saling, M. 1992, 'The assessment of orientation following concussion in Australian rules football', Abstract, Annual Scientific Conference in Sports Medicine, Melbourne, Australia.

Dorney, B. 1994, Submission to Inquiry.

Dorsh, M., Woodward, A. & Somer, R. 1987, ' Do bicycle helmets reduce the severity of head injury in real crashes?' *Accid Anal Prev,* vol. 19, pp. 183–190.

Editorial 1977, 'Rugby injuries to the cervical cord', *British Medical Journal,* no. 1, pp. 1556–1557.

Ewing, R., McCarthy D., Gronwall, D., Wrightson P. 1980, 'Persisting effects of minor head injury observable during hypoxic stress', *Journal of Clinical Neuropsychology,* no. 2, pp. 147–155.

Fekete, J.F. 1968, 'Severe brain injury and death following minor hockey accidents: the effectiveness of the 'safety helmets' of amateur hockey players', *Can Med Assoc J,* no. 99, pp. 1234–1239.

Finch, C., Ozanne-Smith, J., Morrison, B., Hrysomalis, C. 1993, Submission to Inquiry.

Geffen, G. & Cremona-Meteyard, S. 1994, Submission to Inquiry.

Gennarelli, T.A. 1983, 'Head injury in man and experimental animals. Clinical aspects', *Acta Neurochirurg Suppl,* vol. 32, pp. 1–13.

Gennarelli, T.A. 1986, 'Mechanisms and pathophysiology of cerebral concussion', *J Head Trauma Rehab,* vol. 1, pp. 23–29.

Gennarelli, T.A. & Thibault, L. 1982, 'Biomechanics of acute sub-dural haematoma', *J Trauma,* vol 22, pp. 680–686.

Gibbs 1993, 'Injuries in professional rugby league. A three year prospective study of the South Sydney Rugby League Football Club (1989–91), *Am J Sports Med,* vol 21, no. 5, pp. 696–110.

Gomersall, B. 1993, Submission to Inquiry.

Gregory, W. 1993, Submission to Inquiry.

Gronwall, D. & Wrightson, P. 1974, 'Delayed recovery of intellectual function after minor head injury', *The Lancet,* pp. 605–609.

Gronwall, D. & Wrightson, P. 1975, 'Cumulative effect of concussion', *The Lancet,* no. 2, pp. 995–997.

Hazard 1993, Submision to Inquiry

Herzog, R.J., Wiens, J.J., Dillingham, M.F., Sontag, M.J. 1991, 'Normal cervical spine morphometry and cervical spinal stenosis in asymptomatic professional football players: plain film radiography, multiplanar computed tomography, and magnetic resonance imaging', *Spine,* no. 16 (6) supplement, pp. S178–186

Hill, C.M., Crosher, R.F. & Mason, D.A. 1985, 'Dental and facial injuries following sports accidents: a study of 130 patients', *Br J Oral Maxillofac Surg*, Aug, no. 23 (4), pp. 268-274

Hodges, J. 1994, Submission to Inquiry.

Hodgson, V. 1975, 'NOCSAE [National Operations Committee for Standards for Athletic Equipment] football helmet certification program', *Med Sci Sports*, vol. 7, pp. 225–232.

Holburn, A. 1943, 'Mechanisms of head injury', *The Lancet*, vol. 2, pp. 438–444.

Holburn, A. 1945, 'The mechanics of brain injury', *Brit Med Bull*, vol 3, pp. 147–9.

Hughes, D.C. & Fricker, P.A. 1994, 'A prospective survey of injuries to first-grade rugby union players' (in press).

Hume, P.A. & Marshall, S.W. 1994, ' Sports Injuries in New Zealand: Exploratory Analyses', *New Zealand Journal of Sports Medicine*, vol. 22, no. 2, pp. 18–22.

Jones, M. 1993, Submission to Inquiry.

Kannagara, S. 1994, Submission to Inquiry.

Kay, E.J., Kalarla, P., MacLeod, D.A. *et al.* 1990, 'Orofacial and dental injuries in club rugby union players', *British Journal of Sports Medicine*, vol. 24, no. 4, pp. 271–3.

Kelly, F.P., Nichols, J.S., Filley, C.M. *et al.* 1991, 'Concussion in sports: guidelines for the prevention of catastrophic outcome', *JAMA*, vol. 266, no. 20, pp. 2867–2869.

Kew, T., Noakes, T.D., Roux, C., Kettles, A.N., Goedeke, R.E., Newton, D.A., Scher, A.T. 1991, 'A retrospective study of spinal cord injuries in Cape Province rugby players: 1963–1989', *South African Medical Journal*, no. 80, pp. 127–133.

Lim, L.H., Moore, M.H., Trott, J.A. *et al.* 1993, 'Sports-related facial fractures: a review of 137 patients', *Australian New Zealand Journal of Surgery*, vol. 63, pp. 784–89.

Lindsay, K., McLatchie, G. & Jennet, B. 1980, 'Serious head injury in sport', *British Medical Journal*, no. 291, pp. 789–791.

Maddocks, D. & Dicker, G. 1988, 'An objective measure of recovery from concussion in Australian rules footballers', Proceedings Australian Sports Medicine Federation Annual Scientific Conference, Sydney, Australia.

Maddocks, D., Dicker, G. & McCrory, P. 1993, 'Does concussion in sport result in cumulative effects? Abstract from National Annual Scientific Conference in Sports Medicine, Australia, 1993.

Maddocks, D. & Saling, M. 1991, 'Neuropsychological sequelae following concussion in Australian rules footballers', Paper presented at the International Neuropsychological Society Conference, Queensland, Australia.

Malouf, P., NSWRL Medical Officers Association 1993, Submission to Inquiry.

McCall, B. 1994, Submission to Inquiry.

McCrory, P. 1994, Submission to Inquiry.

McMahon, K.A., Nolan, T., Bennett, C.M. *et al.* 1993, 'Australian rules football injuries in children and adolescents', *The Medical Journal of Australia,* no. 159, pp. 301–306.

McQuillen, J., McQuillen, E., & Morrow, P. 1988, 'Trauma, sport and malignant cerebral oedema', *Forensic Med Pathol,* no. 9, pp. 12–15.

Milburn, P.D. 1990, 'The kinetics of rugby union scrummaging', *Journal of Sports Sciences,* vol 8, pp. 47-60.

Milburn, P.D. 1993, 'Biomechanics of rugby union scrummaging', *Sports Medicine,* no. 163, pp. 168-179.

Milburn, P.D. 1994, 'The rugby tackle – a time for review', *The New Zealand Journal of Health, Physical Education and Recreation* (in press).

Millar, A.P. 1994, Submission to Inquiry.

Mills, N.J. 1990, 'Protective capabilities of bicycle helmets', *Br J Sports Med,* No. 24, pp. 55–60.

Morrison, W. 1994, Personal communication.

Morrison, W. & Morrison, K. 1994, 'Investigations into the impact attenuation characteristics of softshell head protectors for sport', Technical Report, pp. 411–94, Victoria University of Technology.

Morrison, W. & Young, D. 1993, 'Development of a head protector for contact sports (Australian rules and rugby)', National Annual Scientific Conference in Sports Medicine, Sports Medicine in Oceania, Melbourne, Australia.

Myres, P.T. 1980, 'Injuries presenting from rugby union football', *The Medical Journal of Australia,* vol. 2, pp. 17–20

National Football League, National Coaching Committee. 1988, Position statement on protective headgear in Australian rules football, National Football League, Melbourne, Hodgson, 1975.

National Health and Medical Research Council 1994, *Boxing injuries,* AGPS, Canberra.

Neurosurgical Society of Australasia and the Royal Australasian College of Surgeons 1992, 'The management of acute neurotrauma in rural and remote locations'.

Nolan, T. 1993, Submission to Inquiry.

North, B. 1994, Submission to Inquiry, Information from database records of the Neurosurgical Unit, Royal Adelaide Hospital, 1984–1994.

Orchard, J. 1993, 'The Orchard sports injury classification system (OSICS)', Abstract, Annual Scientific Conference in Sports Medicine, Melbourne, Australia.

Patterson, D. 1983, 'Product liability crisis', *Texas Coach,* no. 26, pp. 20–22.

Reid, D. 1975, 'Head protection in football', *J Sportsmed*, no. 2, pp. 86–92.

Routley, V. 1991, 'Sports injuries in children – the five most commonly presented sports', *Hazard*, no. 9. Victorian Injury Surveillance System.

Routley, V. & Ozanne-Smith, J. 1991, Sport-related injuries – an overview. *Hazard.* no. 8. Victorian Injury Surveillance System.

Routley, V. & Valuri, J. 1993, 'Adult sports injury'. *Hazard.* no. 15. Victorian Injury Surveillance System.

Roux C.E. *et al.* 1987, 'The epidemiology of schoolboy rugby injuries', *South Australian Medical Journal*, vol. 71, pp. 307–313.

Ryan, A.J. 1991, 'Protecting the sportsman's brain', *Br J Sports Med*, no. 25, pp. 81–86.

Sane, J. & Ylipaavalniemi, P. 1987, 'Maxillofacial and dental soccer injuries in Finland', *British Journal of Oral and Maxillofacial Surgery*, vol. 25, no. 5, pp. 383–90.

Saunders, R. & Marburgh, R. 1984, 'The second impact in catastrophic contact sport head trauma', *J Am Med Assoc*, no. 252, pp. 538–539.

Scher, A.T. 1977, 'Rugby injuries to the cervical spinal cord', *South African Medical Journal*, no. 51, pp. 473–475.

Scher, A.T. 1981, 'Vertex impact and cervical dislocation in rugby players', *South African Medical Journal*, no. 59, pp. 227–228.

Scher, A.T. 1987, 'Rugby injuries of the spine and spinal cord', In Torg, J.S. ed.,

Clinics in Sports Medicine, no. 61, pp. 87–99.

Scher, A.T. 1990, 'Premature onset of degenerative disease of the cervical spine in rugby players', *South African Medical Journal*, no. 77, pp. 557-58.

Schwartz, J. 1988, 'Helmet labels warn of head and neck injuries', *Phys Sportsmed*, vol. 11, pp. 33.

Seward, H. 1993, Submission to Inquiry.

Seward, H., Orchard, J., Hazard, H. *et al.* 1993, 'Football injuries in Australia at the elite level', *The Medical Journal of Australia.* vol. 159, pp. 298–306.

Seward, H. & Patrick, J. 1992, 'A three year survey of Victorian football league injuries', *The Australian Journal of Science and Medicine in Sport*, vol. 24, pp. 51–54.

Sheldrick, J. 1993, Submission to Inquiry.

Shores, E.A., Marosszeky, J.E., Sandanam, J. *et al.* 1986, 'Preliminary validation of a clinical scale for measuring the duration of post-traumatic amnesia', *The Medical Journal of Australia*, vol. 144, pp. 569–572.

Stock J.G. & Cornell, F.M. 1991, 'Prevention of sports-related eye injury', *Am Fam Physician*, Aug 44, no. 2, pp. 515-20.

Sugerman, S. 1983, 'Injuries in an Australian schools rugby union season,' *Aust J Sports Med Ex Sci*, vol. 15, pp. 5–14.

Taunton, J.E., McKenzie, D.C. & Clement, D.B. 1988, 'The role of biomechanics in the epidemiology of injuries', *Sports Medicine*, no. 6, pp. 82–99.

Taylor, T.K. & Coolican, M.R. 1987, 'Spinal cord injuries in Australian footballers, 1960–1985', *The Medical Journal of Australia*, vol. 147, Aug, pp. 112–118.

Taylor, T.K. & Coolican, M.R. 1988, 'Rugby must be safer', *Medical Journal of Australia*, vol. 194, pp. 244.

Thompson, R., Rivana, F. & Thompson, D. 1989, ' A case-control study of the effectiveness of bicycle safety helmets', *New Eng J Med*, vol. 320, pp. 1361–1367.

Torg, J.S. *et al.* 1979, 'The national football head and neck injury registry, report and conclusions 1978', *Journal of the American Medical Association*, vol 241, no.14, pp. 1479.

Torg, J.S. 1982, Athletic injuries to the head, neck and face. Lea and Febiger, Philadelphia.

Torg, J.S. (ed) 1991, Athletic injuries to the head, neck and face, 2nd ed, Mosby Year Book Co. St Louis.

Torg, J.S. *et al.* 1991(a), 'Axial loading injuries to the middle cervical spine segment', *American Journal of Sports Medicine*, vol 19, no. 1.

Torg, J.S. *et al.* 1991(b), 'The axial load teardrop fracture', *American Jounal of Sports Medicine*, vol 19, no. 4.

Torg, J.S., Truex, R.C. & Marshall, J. 1977, 'Spinal injury at the level of the third and fourth cervical vertebrae from football', *Journal Bone and Joint Surgery*, 59A, pp. 1015–1019.

Toscano, J. 1988, 'Prevention of neurological deterioration before admission to a spinal cord injury unit', *Paraplegia*, vol. 26, pp. 143–150.

Tysvaer, A.T. & Lochen, E.A. 1991, 'Soccer injuries to the brain: a neuropsychologic study of former soccer players', *The American Journal of Sports Medicine*, vol. 19, pp. 1119–1121.

Tysvaer, A.T., Storli, O., Bachen, N. 1989, 'Soccer injuries to the brain: a neurologic and EEG study of former players', *Acta Neurol Scand*, no. 80, pp. 151–156.

Vanderfield, I.R. 1993, 'Injury prevention and the laws of rugby football in intermittent high intensity exercise', eds D.A.D. Macleod et al, E & F Spon, London, pp. 443–447.

Wallner, F. 1994, Submission to Inquiry.

Wasserman, R. 1990, 'Helmet protection from head injury among recreational cyclists', *Am J Sports Med*, vol. 18, pp. 96–97.

Wechsler, D. 1981, Weschsler Adult Intelligence Score Revised Manual. New York. The Psychological Corporation, New York.

Weiss, B. 1987, 'Childhood bicycle injuries,' *Am J Dis Child*, vol. 141, pp. 35–136.

Wessels, L.G.D. 1980, 'Rugby injuries in South Africa', *South African Sports Medicine Journal*, vol 8, pp. 14–18.

Wood, T. & Seward, H. 1993, 'AFL injury survey 1993: a comparison with 1992 with particular reference to junior football'.

Wrightson, P. 1993, Submission to Inquiry.

Wrightson, P. 1994, Submission to Inquiry.

Wrightson, P. & Gronwall, D. 1981, 'Attitudes to concussion in young New Zealand men', *NZ Medical Journal*, vol. 92, pp. 359–361.

Wrightson, P. & Gronwall, D. 1981, 'Time off work and symptoms after minor head injury', *Injury*, vol. 12, pp. 445–454.

Yeo, J.D. 1979, 'Five-year review of spinal cord injuries in motorcyclists'. *Med J Australia*, no. 2, pp. 381.

Yeo, J.D. 1986, 'Survey of football injuries between 1968 and 1985'.