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Rugby Union Injuries to the Cervical Spine and Spinal Cord

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Abstract

Injuries to the cervical spine are among the most serious injuries occurring as a result of participation in rugby. Outcomes of such injuries range from complete recovery to death, depending on the degree of spinal cord damage sustained. Much information has been gained regarding the mechanisms and frequency of such injuries, from case reports and case series studies. The most commonly reported mechanism of injury has been hyperflexion of the cervical spine, resulting in fracture dislocation of C4-C5 or C5-C6. Tracking both the trends of incidence of spinal injuries, and the effectiveness of injury prevention initiatives has proved difficult because of a lack of properly conducted epidemiological studies.

Within the constraints of the research published to date, it appears that hookers and props have been at disproportionate risk of cervical spine injury, predominantly because of injuries sustained during scrummaging. While the scrum was the phase of play most commonly associated with spinal injuries throughout the 1980s in most rugby playing countries, there has been a trend through the 1990s of an increasing proportion of spinal injuries occurring in the tackle situation. The majority of injuries have occurred early in the season, when grounds tend to be harder, and players are lacking both practice and physical conditioning for the physical contact phases of the sport.

A number of injury prevention measures have been launched, including changes to the laws of the game regarding scrummaging, and education programmes aimed at enforcing safe techniques and eliminating illegal play. Calls for case-registers and effective epidemiological studies have been made by researchers and physicians in most countries where rugby is widespread, but it appears to be only recently that definite steps have been made towards this goal. Well-designed epidemiological studies will be able to provide more accurate information about potential risk factors for injury such as age, grade, position, gender and ethnicity. Research into the long-term effects of participation in rugby on the integrity of the spinal column is warranted.

1. Background

Injuries to the spinal cord (along with serious head injuries) are among the most tragic of injuries that can result from participation in Rugby Union football (rugby). While these injuries are rare in terms of number of occurrences per player exposure, they can have devastating consequences for both the individual and their community. Depending on the degree of spinal cord damage sustained, a range of outcomes are possible. Long-term morbidity caused by injuries of the cervical spine varies from no permanent impairment to tetraplegia and, in approximately 5 to 10% of cases, death.[1] The association between participation in rugby and these injuries has been noted for over a century, as evidenced by the report from *The Times* of London from November 1869 shown in figure 1.[2]

Reports from a number of rugby playing countries suggest that the frequency of this type of injury increased during the 1970s and 1980s, and the topic has received greater attention in the medical literature over the past 30 years than was the case prior to that time. To date, most research papers regarding spinal injuries in rugby have been either case reports or case series studies.

A variety of injury prevention measures have been implemented both internationally by the International Rugby Board (IRB) and at the national level by the administrative bodies of the sport in specific countries. These have included:

- Alterations to the laws of the game (such as changes in scrum engagement procedures).
- Education of players, referees and coaches regarding both 'safe techniques' in the contact

phases of the game and guidelines for injury management and first-aid.

The extent to which these injury prevention initiatives have impacted on the incidence of spinal injuries occurring within rugby is debatable. At present, we are unable to determine the extent to which differences in patterns of injury observed over time and across nations reflect true differences in incidence or whether they are more closely associated with variability in data collection. Measuring the incidence of these injuries and evaluating the effectiveness of interventions designed to reduce their incidence has been hampered by many factors, including:

- A lack of systematic recording of the number and severity of spinal injuries occurring in rugby. This includes lack of standardised definitions of both injury and recovery of function with respect to time. In some countries, there is neither central collation of spinal injuries that occur during participation in Rugby Union nor differentiation between spinal injuries sustained in Rugby Union and other football codes.
- Lack of consistent information about the spectrum of severity of spinal injuries associated with potential risk factors (e.g. tackles).

"...in the course of a severe scrimmage a young gentleman named Lomax got down, with his head bent under his chest, and in this position was trampled on by many of the players. He was picked up insensible, and, with the exception of short intervals of consciousness, he has remained so until the present time... If he survives, (which is still doubtful!), it is feared he will be a cripple for life."
The Times, 27 November, 1869.

Fig. 1. A report of a spinal injury in rugby from the 1800s (cited in Dunning and Sheard[2]).

- Lack of information regarding the number of participants per year in the various rugby playing countries.
- Lack of information about exposure to rugby by participants at the various levels of the sport (e.g. differences in average number of games played per year by grade).
- Lack of measurement of the changing patterns of activity within the game itself as a consequence of law changes and the continuing evolution of the sport.

Within sports injury epidemiology, these problems are not unique to rugby or to spinal injury. Problems of consistency with respect to injury definition and data collection have been noted across a variety of sports and types of injuries.[3] Calls by researchers from New Zealand,[1] South Africa,[4,5] Australia,[6,7] Canada,[8] and the UK[9,10] for the setting up of proper surveillance methods (including assessment of the population at risk) have been made. Noakes and Jakoet,[11] for example, stated that 'the international community of doctors involved in rugby must convince rugby administrators in all countries to set up epidemiologically valid surveys of injuries. Until they do, there will not be enough accurate data to support change.'

The purposes of this review are:

- To summarise the information regarding risks for spinal injury within rugby that have been presented in the scientific and medical literature.
- To attempt to place this information within an epidemiological framework to facilitate the setting up of data collections systems that will yield information from which to make informed decisions regarding injury prevention strategies.

2. Search Strategies

A variety of search strategies were used in an attempt to source all relevant literature with respect to cervical spinal injuries in rugby. Searches of the Medline, Sport Discus and the CARL Uncover databases were undertaken. In each case the search conditions were:

- inclusion of the words 'rugby' and ('spine' or 'spinal') in the title of the article for Sport Discus, and in the title or the abstract for Medline
- year of publication in the period 1970 to 2001 inclusive
- the language of the article was English.

In addition, articles in which the level of the publication was 'basic' were excluded from the Sport Discus search. The reference lists of all review articles identified by the above searches were examined to determine whether important references may have been missed or were not included in the electronic databases. A database of sports injury literature that has been compiled over the period 1993 to 2000 by the Injury Prevention Research Unit of the University of Otago, New Zealand, was also searched. Internet searches using the metasearch engines 'Metacrawler' and 'Dogpile' were undertaken to allow for the possibility that other relevant literature may have been available, but was not included in the above databases. One book containing information relevant to the topic was located via the web metasearch.[12,13]

The Sport Discus search returned 43 articles that met the search criteria, Medline returned 73, and Carl Uncover returned 21. The search of the Injury Prevention Research Unit database returned 59 references. Once duplicates (107) were identified, the remaining set of articles was checked for relevance against the purposes of the review as outlined in the introduction. Twenty-eight articles were rejected as a result of this check. Two articles could not be obtained, and abstracts only were available for three. Fifteen papers on topics related to risk factors for rugby injury in general were also referred to.

3. Risk Factors for Spinal Injury

Grouping risk factors into those associated primarily with participation in rugby (extrinsic factors), and those associated mainly with the player (intrinsic factors) provides a convenient structure for considering the literature.[3] Figure 2 provides a list of potential risk factors. As will be immediately apparent, many of these are related to each other to some extent (e.g. grade and age). Evaluation of the current state of knowledge regarding a number of these factors is presented in section 4. Many of them have yet to be the subject of research investigations with respect to their association with spinal injury in rugby. While there are likely to be risk factors that are not included in the figure, investigating the relative importance and strength of interactions of the risk factors below would pro-

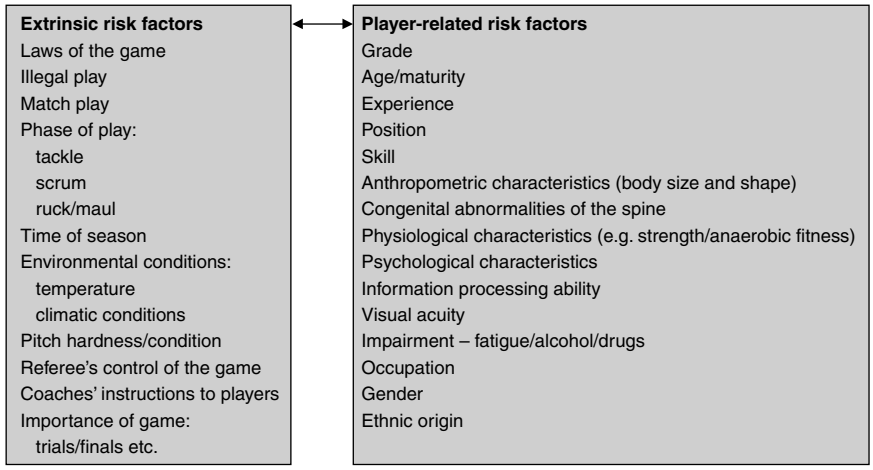

Fig. 2. Potential risk factors for rugby-related spinal injuries.

vide a good start to gaining enough knowledge with which to make sound recommendations about how to reduce the risk of spinal injury faced by players.

4. Player-Related (Intrinsic) Risk Factors

4.1 Age, Grade and Experience

As might be expected from studies that have used varying data collection methods and definitions of injury, there are conflicting opinions as to the relative importance of age, grade and experience on the risk of spinal injuries. Early reports of spinal injuries suggested that schoolboys were at greater risk of sustaining spinal injuries than players at senior level.[14-17] A number of these reports[16-23] were either small-scale case series reports or letters to the editors of scientific journals by those working in spinal units expressing concern about apparent increases in the number of schoolboys that had sustained spinal injuries.[9,14,24,25] An explanation posited for why this might be the case included lack of maturity of the skeletal and ligamentous systems, leading to greater ease of fracture and dislocation injuries than was the case as players matured.[14] Bottini et al.[26] found that in Argentina, young players were at higher risk of sustaining muscular or ligament injuries to the cervical column than were senior players. While noting that this was 'worrisome', the authors did not suggest what factors might have contributed to this finding. Milburn[27] also suggested that older and more experienced players were better able to both cope with the forces generated in the scrum and maintain their body positions during engagement, thereby preserving the integrity of the scrum. Other points of concern included the fact that schoolboys were often not at liberty to choose whether they participated in the sport, and a lack of insurance against injury for schoolboys.[28]

While some larger scale studies still reported that young players make up a large proportion of all spinally injured players,[29] most have reported that the incidence of injuries tends to be higher among adults, and especially those at higher grades. This pattern has been observed for other types of injury.[26,30-32] Kew et al.[4] found that adults sustained 69% of spinal injuries in a South African survey. They suggested that the ratio of schoolboy players to adults in the area from which their injured players were drawn was likely to be between 5 : 1 and 10 : 1. From these ratios, they calculated that adult players faced a risk that was 10 to 12 times higher than that of schoolboys. Reasons suggested for this included greater size and physical strength of players (thus making them capable of generating greater forces during impacts) and greater aggression. Hence, Kew et al.[4] suggested that high levels of skill and fitness, far from protecting against these injuries, might actually make injury more likely. Armour et al.[1] concurred that in New Zealand, when taking into consideration the number of players at risk, senior club games produced the highest concentration of injuries. Similar sentiments have recently been expressed by Silver,[33] who has worked with spinal injuries among rugby players in England since the 1950s. Both Armour et al.,[1] and Silver and Stewart[34] referred to the fiercely competitive nature of the game at this level as being a factor that potentially places players at higher risk.

A number of these studies, while reporting the proportion of schoolboy and adult players injured, provided insufficient information from which to determine the average age of the players in their sample. The average age of 273 injured players over a number of case series studies was 22.8 years.[1,6,16,29,35-37] As with the proportion of players injured at various ages, the findings regarding the relationship between age and severity of injury, or prognosis for recovery are varied. An Australian study found no relationship between age and the degree of subsequent recovery.[6] In New Zealand,[1] the proportion of players who were confined to wheelchairs was greater among the youngest 32 players (41%) than in the oldest 32 (25%). This difference was not statistically significant. In contrast to this, in South Africa, between 1990 and 1997,[38] 61% of schoolboys made total or near

complete recovery from injury, compared with 28% among adult players.

A 20-year review of spinal injuries among players in Wales revealed that there appeared to be a relationship between the level of injury (i.e. the cervical vertebrae at which the lesion occurred) and the player's age.[35] The evidence presented suggests that as players age, the lower part of the neck becomes more prone to damage. A similar proportion of young players sustained serious spinal cord injury (75%) to the total group (70%). While their injuries appeared to be of the same type as those of the older players, they tended to be higher up the neck. Whether this pattern of level of injury relating to age is in any way related to the degenerative changes observed in the spine of older players presented in samples of players from New Zealand,[39] South Africa[40] and France[41] is unknown.

A finding that has been reported somewhat more consistently is that of the increased risk faced by players when a 'mismatch' between skill, experience and/or strength occurs among players within the scrum – especially those in the front row. Silver,[14] in a letter commenting on this phenomenon, suggested that mismatches between schoolboys and adults were particularly risky, and that it was not always the players in the weaker team that were injured. A submission made by Silver[42] regarding prevention methods included advice that schoolboys should not be permitted to play for, or against adult teams. This recommendation was among several adopted, and Silver and Stewart[34] reported several years later that injuries occurring because of 'mismatches' had ceased within the area over which they were collecting information. Similar concerns have been voiced regarding variations in maturational level of adolescents of the same chronological age, and the increased risk that may be faced by players who are less physically mature.[43] In Australia, Taylor and Coolican[6] reported that 'a discrepancy in strength between opposing front rows may contribute to scrum instability. However, in the players' judgement of the relative strength of the front rows, injuries occurred with almost equal frequency to players in both the adjudged stronger or weaker front rows.'

Wetzler and coworkers[36] stated that 15% of spinal injuries recorded in the US 'involved a documented mismatch in experience and size between collegiate and men's clubs'. This proportion rose to 25% when the scrum was the only phase of play considered.[44] Wetzler et al.[44] clearly outlined the relative shortage of practice facilities for scrummaging in the US and that players were often learning to scrummage during games. Lack of coaching and practice facilities were postulated to contribute to a lack of coordination among the players within the scrum, lessening the ability of the scrum to coordinate the engagement and maintain control during game situations. They felt that forwards in America were generally bigger and had greater strength than those in other nations. The higher incidence of scrum injuries seen in the US was attributed to these factors, in conjunction with relatively inexperience players. It was not known how many 'experienced' players were injured due to the inclusion of inexperienced players in the front row positions.[36,44]

4.2 Gender

As with grade, there is little evidence about the extent to which gender is a risk factor for spinal injuries in rugby. Case reports of female rugby players sustaining spinal injuries have appeared in the literature,[1,36] but in the absence of any reliable estimates of numbers of women players in the game, relative risks by gender are unable to be assessed.

4.3 Ethnicity

Little attention has been given to whether ethnicity is a risk factor for spinal injury among rugby players. Compared with other countries, a high rate of spinal cord injuries among Fijian players has been reported from within the Fiji Islands.[45] At present, the lack of epidemiological evidence precludes conclusions from being drawn about whether the higher rate is primarily related to the style of the game (e.g. extrinsic factors), or

whether there are any intrinsic differences in risk among ethnic groups. Within New Zealand, the Maori population were found to have a higher rate of spinal cord injury from all causes than New Zealand Europeans.[46] Whether this pattern is also found within contact sports such as rugby is worthy of further examination.

4.4 Position

A consistent finding from case series analyses has been the high proportion of injuries sustained by players in the front row (table I). Approximately 30% of the spinal injuries reported were sustained by hookers (who represent 6% of all players by number). This over-representation was due almost entirely to increased risk during the set scrum. Props were the second most frequently injured position, sustaining about 17% of rugby-related spinal injuries.

Few reports identified which positions in the backline were most frequently injured. The highest proportion of spinal injuries to backs has been reported in South Africa.[4] Of 34 spinal injuries to backs, 41% were sustained by the midfield backs – the second five-eighths and centre positions, 26% by the inside backs (half back and first five-eighths), 23% by the two wings, and 9% by the fullback. The tackle situation was the phase of play in which backs sustained the majority of their spinal injuries (84%), with the remainder from the ruck/maul.

Williams and McKibbin[35] similarly found that of seven spinal injuries to backs, centres were the most frequently injured (57%), with the remainder sustained by inside backs (43%). Williams and McKibbin[35] reported no injuries to wings or fullbacks. In New Zealand, the position of 21 backs injured from 1976 to 2000 was obtained by combining the reports of Armour et al.,[1] and Palairet and Xiong.[37] Seven injuries (33%) were sustained by both midfield and inside backs, six (28%) by wings and one (4%) by a fullback. As was the case in South Africa, the majority of injuries to backs occurred in the tackle situation, and from 1996 onward, all of the injuries to backs reported by Palairet and Xiong[37] were sustained during tackles. Percentages are not corrected for number of players within each position in the team.

4.4.1 Laws of the Game Relating to Training and Experience of Front-Row Players

The importance of having experienced players in the front row of the scrum has been incorporated within the laws of the game.[47] Law 3.5, which deals with this matter states: *Suitably trained and experienced players in the front row:*

- [table II*] indicates the numbers of suitably trained and experienced players for the front row when nominating different numbers of players.*
- Each player in the front row and the potential replacement must be suitably trained and experienced.
- The replacement of a front row forward may come from suitably trained and experienced players who started the match or from the nominated replacements.

Table I. Distribution of cervical spinal injuries in rugby by position

Study	Country	Period of study	Hooker		Prop		Other forward		Back		Unknown		Total
			n	%	n	%	n	%	n	%	n	%	n
Secin et al.[29]	Argentina	1977-1997	9	50.0	1	5.6	4	22.2	4	22.2	0	0.0	18
Taylor and Coolican[6]	Australia	1960-1985	16	43.2	14	37.8	4	10.8	3	8.1	0	0.0	37
Armour et al.[1]	New Zealand	1976-1995	33	27.7	20	16.8	24	20.2	13	10.9	29	24.4	119
Palairet and Xiong[37]	New Zealand	1996-2000	10	28.6	3	8.6	13	37.1	8	22.9	1	2.9	35
Kew et al.[4]	South Africa	1963-1989	14	18.4	7	9.2	21	27.6	34	44.7	0	0.0	76
Wetzler et al.[36]	USA	1970-1994	28	47.5	7	11.9	10	16.9	12	20.3	2	3.4	59
Williams and McKibbin[35]	Wales	1964-1984	3	10.0	10	33.3	9	30.0	7	23.3	1	3.3	30
Total			**113**	**30.2**	**62**	**16.6**	**85**	**22.7**	**81**	**21.7**	**33**	**8.8**	**374**

Table II. Numbers of suitably trained and experienced players for the front row when nominating different numbers of players (adapted from International Rugby Board,[47] with permission)

Number of players	Number of suitably trained and experienced players
15 or less	3 players who can play in the front row
16, 17 or 18	4 players who can play in the front row
19, 20, 21 or 22	5 players who can play in the front row

While this is laudable, it begs the question of what 'suitably trained and experienced' is defined to be. Unless standards are developed by the IRB (or its member nations) for players at various ages/grades, it is likely that what constitutes 'suitable training and experience' will be decided by a court of law.

4.5 Anthropometric and Physiological Characteristics

As with age and experience, a range of views as to the importance of anthropometric characteristics of players with respect to risk of injury have been expressed in the scientific literature. On one extreme, Calcinai[48] stated that 'probably the most important single factor in preventing scrummage injuries is to ensure that player (sic) have an appropriate body-type for the position. Front-row players must have short squat necks and it is a recipe for disaster to ask a player who has a long thin neck to play in the front row.'

By contrast, Armour et al.[1] proposed that in the 'mismanaged' scrum, all builds are equally at risk. They pointed to a number of high-profile New Zealand tight forwards who had recently been forced out of the game through injury, and to one case in particular where an All Black prop sustained a serious neck injury (subluxation of the atlas on the axis). The unanswerable question is whether an injury of this type would have happened much sooner had an individual of less imposing physical characteristics been in the same position and subjected to the same loads. Quarrie et al.[49] found that when position and grade were controlled for, the thinnest 20% of club players (as measured by body mass index) missed a greater amount of playing time during the season (caused by all injuries reported, not just spinal injuries) than their more robust counterparts. A number of studies have identified that the anthropometric characteristics of players vary substantially by position.[50-54] Presumably, players gravitate towards positions in which their particular anthropometric characteristics provide them with a competitive advantage (or at least, do not unduly disadvantage them). While the scientific evidence is sparse, a court case in Australia in 1987[55] resulted in a prosecution against a school for allowing a schoolboy player of 'inappropriate' build to be placed in the front row of a rugby league scrum. Until more information is collected about the effect of physique on risk, it is safer to err on the side of caution and continue to recommend that thin players (or players with long/thin necks) do not take up positions in the front row. The development of prospective studies should help to provide answers to these questions.

4.5.1 Congenital Abnormalities of the Spine

Case reports of players with congenital abnormalities sustaining serious spinal injuries have appeared in both South Africa and New Zealand. Scher[23] initially called for screening of all players over a certain age (30 years), because of the fact that repeated trauma may have caused degenerative changes to their spine, and hence be placing them at greater risk. He subsequently suggested[56] that those with congenital fusion of the spine were particularly at risk of hyperextension injuries of the spine, and that all regular rugby players should undergo a screening x-ray at least once in their careers. It may be worth noting that while hyperextension injuries to the spine occurring in rugby have been reported, they appear to be much less common than either impacts to the top of the head or injuries occurring via hyperflexion and rotation.

The same suggestion for the screening of rugby players has recently been made in New Zealand by Hughes.[57] To summarise the information outlined by Hughes,[57] of 100 cases of rugby-related cervical spine injuries treated at the Burwood Spinal Unit in Christchurch, New Zealand, between 1979 and 1999, 85 had complete records. Examination

of the x-rays of these 85 cases revealed that seven players had congenital cervical fusion. This rate (7/85) is much higher than has been reported for congenital fusions in other populations (an average of around 7/1000 from three studies of cadavers). Among the 85 cases, 28 remained tetraplegic. Three of the players who became tetraplegic as a result of their injuries had congenital fusions. Further research regarding the extent to which these conditions predispose rugby players to catastrophic injuries should be conducted. It would be prudent, however, to advise any player who sustains a neck injury beyond a simple muscle strain to obtain a clearance to play from a spinal or orthopaedic specialist prior to recommencing participation in rugby.

Congenital abnormalities of the spine have been extensively researched in American Football, and a series of recommendations regarding the advisability of playing contact sports given a range of conditions exists.[58] The condition for which screening has been recommended in New Zealand rugby (a type II Klippel-Feil fusion – a single level fusion of two vertebrae in the cervical spine) at C3 or below with no neurological symptoms or restricted movement was considered by Torg and Ramsey-Emrhein[58] to present no contraindication to participation in contact or collision sports.

4.5.2 Chronic Conditions/Degenerative Changes of the Spine

Studies showing accelerated degeneration of the cervical spine among front-row forwards have appeared in the medical literature.[39-41] Berge et al.[41] examined the spines of 47 rugby players and 40 age-matched controls by using magnetic resonance imaging (MRI). Of 35 senior and veteran front-row players, a significantly greater proportion (71%) exhibited narrowing of the intervertebral disks than did age-matched controls (17%). A significantly greater proportion of senior and veteran front-row players also had herniated disks (31%) than did controls (3%). Among front-row players, there was an almost total loss of bone marrow in the cervical spine, which was replaced by fibrosis and sclerosis. Among American football players, stenosis of the cervical spine defined as loss of CSF around the cord or in more severe cases as deformation of the spinal cord has been identified as a risk factor for spinal cord injury.[59] This definition of cervical spinal stenosis ('functional' spinal stenosis) cannot be made by bone measurements or ratios, a technique Herzog and associates[60] found had a positive predictive value of only 12%, but requires imaging by MRI, contrast enhanced computed tomography or myelography.

In the data from the National Center for Catastrophic Sports Injury Research between the years 1987 and 2000,[61] no patients with quadriplegia with cervical spine fracture dislocation and functional spinal stenosis recovered completely. This is to be compared with nearly 20% of patients with initial quadriplegia with fracture dislocation who had normal-sized spinal canals who went on to a complete neurologic recovery. During this same time period there were cases of quadriplegia that occurred without fracture dislocation, and in every instance, severe functional spinal stenosis was present. Thus, in the experience of the National Center for Catastrophic Sports Injury Research, cervical spinal stenosis as defined above predisposes the athlete to a worse neurologic outcome when spinal cord injury occurs. The same might be anticipated in rugby, but data examining the relationship between spinal stenosis as measured by MRI and the relationship with injury is lacking.

Berge et al.[41] found that the canal diameter, and the canal-cord ratio of rugby players was lower than that of age-matched controls, and that the condition appeared to worsen with age. Similar differences were found in other measures of degenerative changes, and the extent of the degeneration correlated with age.

The majority of lesions were located in the lower cervical spine, which is the region that Williams and McKibbin[35] found was more commonly injured in older players. The changes were attributed to the repetitive cervical trauma that players experienced throughout their careers. Scher[40] suggested that the risk of spinal cord injury to players would be increased by this type of

degeneration, but as yet there is a lack of evidence to substantiate this claim. Presumably, the increased rate of degeneration[39-41] is related to the demands of scrummaging, in which players attempt to twist and buckle their opponents in an attempt to gain an advantage.

A report examining changes to the patterns of the game suggests that primarily because of law changes introduced in 1963, the time spent practising scrummaging, and the use of scrum machines is much greater than was usual before that time. These changes mean that front-row players are subjected to physical pressure and stress for much longer periods than was previously the case.[62]

4.6 Summary of Intrinsic Risk Factors for Spinal Injuries in Rugby

- Research into the relationship between age and both incidence and severity of spinal injuries has produced equivocal findings.
- Players at higher grades may be at relatively higher risk of injury because of the greater size and power of players, and the aggression with which the game is played.
- Mismatches in skill and experience are a major risk for injuries within the scrum.
- Unless rugby unions define what 'suitably trained and experienced' means within the context of front-row play for the various levels of the sport, a definition is likely to be decided upon in a court of law.
- Players occupying different positions face varying levels of risk of spinal injury. Hookers especially, and to a lesser extent props, are most frequently injured during scrums. Injuries occur both as a result of mistimed impacts (vertex and hyperflexion/rotation injuries) and scrum collapse (hyperflexion and rotation).
- Research into performance-related factors for rugby players suggests that rugby players of particular positions possess stereotypical physical attributes, which presumably confer an advantage in meeting the demands of the given position. Props and hookers have been demonstrated to be shorter, more endomorphic and less ectomorphic than other forwards are. Unless strong evidence emerges to the contrary, it is safer to err on the side of caution and continue to recommend that thin players, especially those with long thin necks, not be placed in the front-row positions.
- Backs sustain spinal injuries most often during tackles. Both the ball carrier and the tackler are at risk. The midfield backs (second five-eighths and centres) appear to be the backs that are injured most often. This may be caused by their role of 'crashing' into the opposition to set up second (or subsequent) phase ball for their team.
- Further work to examine the risks faced by rugby players with various congenital, developmental and post-injury conditions of the spinal column is warranted.
- The long-term impact of playing rugby on the health of the spines of participants should be examined, given that research has identified accelerated degenerative changes in the spines of players in the front-row positions. The extent to which acquired stenosis places players at risk of spinal injury should be examined with prospective studies.

5. Game-Related (Extrinsic) Risk Factors

5.1 Laws of the Game

The laws of the game set the structure within which the patterns of activity of rugby occur.[47] A report on developments in the scrum by the Injury Prevention sub-committee of the Rugby Foundation of New Zealand[62] suggests that law changes implemented in 1963 resulted in the desirability of slower ball emerging from the scrum, with resulting longer scrum times and greater pushing from flankers than had previously been the norm. This is thought to have lead to the development of power scrummaging through the 1970s, with the associated increased incidence of serious scrum injuries.[62] Over the past 20 years, there have been a number of law changes introduced to the game with the intention of decreasing the risk of serious injury. Law changes have been implemented both

throughout the game, by the IRB, and via local 'experimental variations' within particular countries. These law changes have included alterations to the binding permitted in the scrum, changes to the replacement laws (as outlined in section 4.4.1) which mandate that a trained front-row player be available if a front-row player leaves the field, procedures for scrum engagement, and the ability of the touch judges to notify the referee of dangerous play. Changes to regulations and policies which impact on the way the laws of the game are applied can also alter patterns of player behaviour, without necessarily altering the 'letter of the law'. Thus, the degree to which changes in the law have impacted on spinal injuries within rugby is difficult to assess. Any law change is likely to result in changes to the typical structure and patterns of activity that are representative of the sport. Part of the reason for this is that after a law is modified, players and coaches generally attempt to use it to gain a competitive advantage over their opposition.

5.2 Phase of Play

The patterns in table III show that the phases of play associated with the greatest number of spinal injuries in rugby are the tackle and the scrum. Only about 6% of rugby-related spinal injuries were not associated with the tackle, the scrum, or the ruck and maul. As mentioned earlier, one of the primary limitations of this information is that we have no way of knowing how many scrums, tackles, and rucks and mauls were typical within rugby within each country studied over the various time periods, nor how many players were active within the region from which each study was taken.

Keeping these factors in mind, there do appear to be differences between countries in the proportion of injuries associated with phase of play. The fact that the relative frequency of occurrence by phase varies across the countries suggests that there may be avenues for injury prevention, which can be pursued by analysing the factors that contribute to these observed differences. Injury prevention initiatives that deal with the situation specific to the country could then be put in place.

A number of researchers have suggested that injury prevention messages directed at the scrum, which occurs in a relatively 'controlled' situation (compared with variability inherent in the tackle) could play a major role in decreasing the number of spinal injuries occurring in the sport. In New Zealand, seven scrum-related spinal injuries in the first 4 months of 1996 prompted compulsory safety courses for coaches. From 1976 to 1996, the proportion of spinal injuries in New Zealand from

Table III. Distribution of cervical spinal injuries in rugby by phase of play

Study	Country	Period of study	Tackle injuries		Scrum injuries		Ruck and maul injuries		Other/unknown		Total
			n	%	n	%	n	%	n	%	n
Secin et al.[29]	Argentina	1977-1997	5	27.8	11	61.1	2	11.1			18
Rotem et al.[63]	Australia	1984-1996	8	30.8	14	53.8	4	15.4			26
Taylor and Coolican[6]	Australia	1960-1985	8	21.6	23	62.2	5	13.5	1	2.7	37
Sovio et al.[8]	Canada (British Columbia)	1975-1982	2	22.2	7	77.8					9
Armour et al.[1]	New Zealand	1976-1995	39	32.8	53	44.5	17	14.3	10	8.4	119
Palairet and Xiong[37]	New Zealand	1996-2000	18	48.6	14	37.8	4	10.8	1	2.7	37
Kew et al.[4]	South Africa	1963-1989	59	50.4	25	21.4	21	17.9	12	10.3	117
Silver[42]	UK	1952-1982	23	36.5	14	22.2	20	31.7	6	9.5	63
Silver [64]	UK	1983-1987	5	26.3	7	36.8	6	31.6	1	5.3	19
Wetzler et al.[36]	US	1970-1984	18	30.5	34	57.6	7	11.9			59
Williams and McKibbin[35]	Wales	1966-1984	9	30.0	12	40.0	9	30			30
Total			**194**	**36.3**	**214**	**40.1**	**95**	**17.8**	**31**	**5.8**	**534**

scrums was 46.9% (combining data from Armour et al.,[1] and Palairet and Xiong[37]). In the 4 years subsequent to the courses (1997 to 2000), the proportion of scrum-related spinal injuries was 26.7%.[37] Unfortunately, the decrease in the number of scrum injuries has coincided with an increase in the number occurring in the tackle, leaving the number of spinal injuries occurring per year relatively constant through the period. This again highlights the point that until we better isolate the mechanisms responsible for injury and collect more reliable 'denominator' measures (including typical patterns of activity during matches), evaluating the effectiveness of any interventions will be difficult.

Research conducted in South Africa over the period 1985 to 1989 identified that the proportion of spinal injuries occurring in the tackle had increased, and that the fraction of injuries resulting in tetraplegia was higher in the tackle than in the scrum.[65]

5.3 Mechanisms of Injury

The majority of articles published in the sports/medical literature relating to spinal injuries have been case reports. While case reports are not able to provide strong evidence as to the *relative* risk of factors associated with spinal injuries (because the number and circumstances of the given risk factor(s) in which injuries were not sustained are not measured), they are useful in describing the mechanisms associated with those injuries that have occurred. Thus, detailed reports of the ways in which players sustained their injuries in various phases of the game have been presented. A useful summary and explanatory graphics of the most common mechanisms of spinal injuries in rugby has been presented by Noakes and du Plessis.[66]

5.3.1 Mechanisms of Scrum Injuries

Within rugby generally, and particularly within scrums, the most commonly reported injury mechanism is hyperflexion of the cervical spine, with or without rotation.[13] This mechanism is demonstrated in figure 3. The proportion of scrum injuries attributed to either scrum engagement or collapse varies greatly across studies (table IV).

As observed by Armour et al.,[1] a player who is paralysed upon scrum engagement will tend to collapse the scrum, so distinguishing the exact mechanism of injury within the scrum is not always straightforward. Injuries associated with scrum impact tend to occur when the front rows of the scrums crash together with some of the players unready. The players who are not ready may attempt to pull out of the engagement. The remaining players may drive directly into their opponents' torsos. The mechanism of injury in this situation has been described by Scher.[68]

5.3.2 Mechanisms of Tackle Injuries

Although case reports of mechanisms for tackle injuries in rugby have appeared, there does not appear to be a consensus among researchers about what the most common mechanism for injuries in the rugby tackle situation is. The tackle situation is more dynamic than the scrum, and it appears that players injured in the tackle often have less awareness of how the injury occurred than those injured in the scrum. Within New Zealand, the proportion of players spinally injured while tackling and while being tackled was approximately even,[1,37] a pattern that has been observed in other tackle injuries.[32] Types of tackles identified in case reports as being particularly dangerous in rugby include high tackles,[22,69,70] double tackles[20] and in rugby league 'spear tackles'.[71] Spear tackles in rugby and rugby league refer to tackles in which a player is lifted and then driven headfirst into the ground (as opposed to spear tackles in American Football, which refer to tackling with the vertex of the head as the first point of impact). In American Football, the mechanism of tackle injuries was clearly identified as being associated with vertex impacts that result in compression of the spinal cord.[72] Although it is uncommon for rugby players to attempt to impact their opposition with their head during a tackle, vertex impacts in rugby are presumably just as dangerous as those in American football. Although injuries caused by vertex impact resulting from rugby tackles have been reported,[73] it ap-

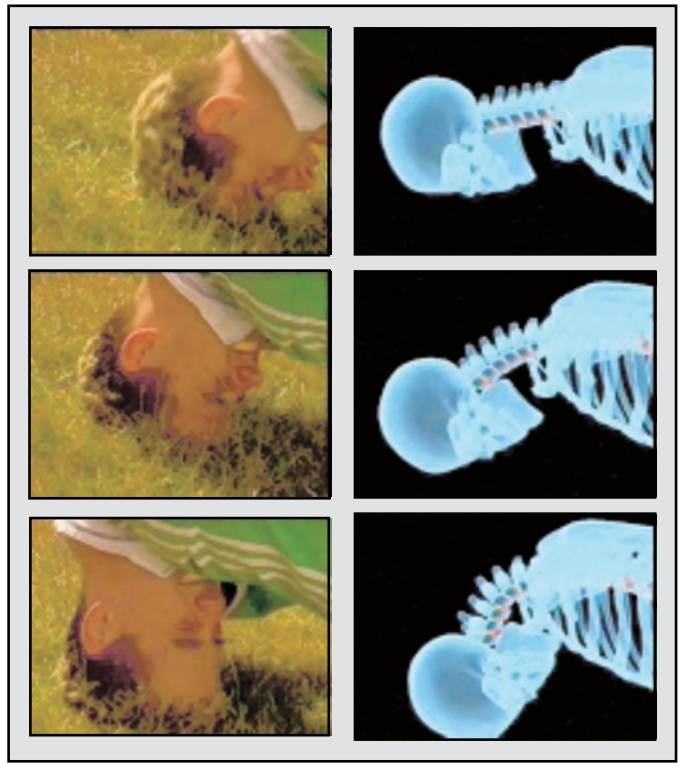

Fig. 3. Hyperflexion of the cervical spine resulting in fracture dislocation.

pears that the primary mechanism of injury within the rugby tackle is hyperflexion of the neck. Hyperflexion injuries in the tackle situation can occur to either the ball-carrier or tackler when they enter the contact situation with their neck flexed.[13]

Further videotape and epidemiological evidence is required to clarify the extent to which mechanisms in rugby tackles[13,66,68] differ from those in American Football tackles.

5.3.3 Mechanisms of Ruck and Maul Injuries

Scher[21] outlined three different ways in which spinal injuries were sustained during rucks and mauls. These were:

(i) forced flexion of the ball carrier's neck

(ii) forced flexion of the neck of the player at the bottom of the ruck

(iii) head and neck injury caused by charging into a mass of struggling players.

Although they make up approximately 17% of spinal injuries from the reported case series review papers, there has been little work that has sought to identify the risk factors associated with these phases of play.

5.4 Patterns of Injury by Month of Season

The proportion of all rugby injuries that occur early in the season is high.[74-76] The pattern of spinal injuries has been shown to follow a similar pattern in New Zealand,[1,37] South Africa[4] and the UK.[16] A number of researchers have suggested that the predominance of injuries early in the season emphasises the importance of physical conditioning prior to the beginning of the season.

Table IV. Mechanisms of scrum injuries

Reference	Country	Collapse		Scrum engagement		Popping		Other/unknown		Total
		n	%	n	%	n	%	n	%	n
Secin et al.[29]	Argentina	5	45.5	6	54.5		0.0		0.0	11
Taylor and Coolican[6]	Australia	7	30.4	15	65.2	1	4.3		0.0	23
Armour et al.[1]	New Zealand	26	49.1	23	43.4	4	7.5		0.0	53
Palairet and Xiong[37]	New Zealand	4	28.6	8	57.1	1	7.1	1	7.1	14
Silver[64]	UK	10	71.4	3	21.4		0.0	1	7.1	14
Silver and Gill[67]	UK	4	57.1	1	14.3		0.0	2	28.6	7
Wetzler et al.[44]	US	13	36.1	23	63.9		0.0		0.0	36
Williams and McKibbin[35]	Wales	9	75.0	1	8.3	2	16.7		0.0	12
Total		**78**	**45.9**	**80**	**47.1**	**8**	**4.7**	**4**	**2.4**	**170**

Figure 4 shows the pattern of injuries by time of season in New Zealand.[1] While the lower amount of rugby played from September to February (the off-season in New Zealand) is strongly reflected in the pattern above, the exposure to rugby (and rugby league) between April and August is relatively constant,[76] so it is not just a change in the amount of rugby faced by players.

Currently, there is a lack of research regarding what contributes to this pattern. Here are some potential contributors:

(i) Lack of experience in the skills required in the contact phases of the game. Trial games are likely to pit players with widely varying levels of experience and skill against each other – often players find themselves marking opponents who will end up playing in a different grade from themselves during the season. A mismatch in ability or experience has been identified in some research papers as being a potential risk factor for spinal injuries occurring in the scrum. In the US, researchers who completed a 20-year survey of rugby-related spinal injuries concluded that '9 of the 36 cervical spine injuries (25%) that involved front-row players were documented cases of mismatches of experience'.[44] Factors that increase the likelihood of this occurring include:

- Players are probably more likely to take up a new position at the start of the season.
- New players generally enter the sport at the start of the season.

(ii) Lack of continued practice at the skills involved in the contact phases of the game.

- Players do not usually practice tackling, scrummaging, rucking or mauling in the weeks leading up to the season. This may lead to them being more likely to be placed in physical positions that can result in injury. Upton et al.[77] found that in some South African schools less than 30 minutes was allocated to the practice of tackling and falling techniques prior to the first full-contact match.

(iii) Lack of impact conditioning – players often perform aerobic, anaerobic, speed, strength and power training over the off-season. Conditioning the body to cope with the impacts that are a major part of rugby is ignored by the majority of players (although this is beginning to change). Players, even those who have trained to increase their aerobic fitness and strength are generally at their 'softest' at the beginning of the season.

(iv) The first matches of the season are often trials, where players are likely to play as hard as possible in the attempt to make the team they aspire to. So there is no 'progressive overload' in terms of impact.

(v) Harder grounds at the beginning of the season – which leads to increased impact forces when players hit the ground after tackles and during rucks, mauls and collapsed scrums.[25]

(vi) Combined lack of familiarity in the front row – players who are not used to each other may be

unsure of their combined course of action in the event of a collapsed scrum.[35]

5.5 Spinal Injuries Occurring as a Result of Illegal or Foul Play

A number of studies have noted that foul or illegal play contributes to avoidable spinal injuries. In South Africa,[4] only 3% of reported spinal injuries were a result of foul play compared with 11% in the UK,[42] and 26% across all football codes in Australia.[6] In New Zealand, surveys of club players suggest that the proportion of all injuries attributed to foul play has dropped from 13% in 1993 to 7% in 1997 to 1998.[78]

Injuries that result in permanent loss of function because of foul play are unacceptable. Despite rugby players assuming the risks inherent in a physical contact sport, a deliberate act that caused another to be seriously injured could result in criminal or civil proceedings being brought against the player who caused the injury.

5.6 Immediate Management of Rugby Spinal Injuries

Incorrect management of spinal injuries has the potential to result in spinally injured players who would otherwise fully recover, becoming permanently paralysed. This is especially relevant given that research in Ireland[79] and South Africa[80] has identified that in many cases coaches are the only individuals available to provide first-aid to injured players and that a substantial portion of these had received no training in first-aid. It is essential that coaches at all levels of contact rugby are educated with regard to the correct steps to take in the event of spinal injuries. A comprehensive overview of prehospital care of spinally injured athletes has been provided by the National Athletic Trainers Association.[81] At the higher levels of the sport, the responsibility for injury management is more likely to be given to somebody who has some medical training. It is still essential for this individual to be trained in first-aid, as general medical training (and in some cases even sports medicine training) does not necessarily provide specific guidance on immediate management of spinal injuries.[82] Environmental concerns, such as having appropriate first-aid equipment on hand and ambulance access, should also be given high priority in education programmes for club and school rugby administrators.

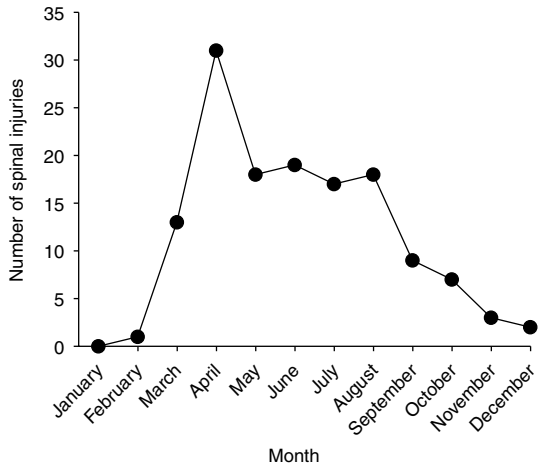

Fig. 4. Spinal injuries in New Zealand by month (1976 to 1995) [from Armour et al.,[1] with permission].

5.7 Summary of Extrinsic Risk Factors for Spinal Injury

- The laws of the game set the structure within which patterns of play are permitted. A number of law changes have been implemented in attempts to lower the incidence of spinal injuries. The degree to which these have impacted on spinal injury rates has been difficult to assess for a number of reasons including lack of measurement of player numbers, variations in classifications of injury across and within countries, and the typical variations that are expected over time in rare, independent events.
- Within the constraints of the information available, it appears that there are differences across countries in the phase of play in which spinal injuries are most commonly occurring. In some countries, the proportion of injuries occurring in the scrum appears to have dropped, and the

proportion occurring in the tackle appears to have increased through the 1990s.
- The incidence of injuries appears to be higher in the early part of the season. This pattern has been noted in a number of countries, and may be related in part to a lack of adequate physical preparation and practice at the contact phases of the game.
- Injuries resulting in permanent disablement as a result of foul or illegal play have been reported in the literature. These are unacceptable, and are likely to result in civil or criminal proceedings against the perpetrator of the act.
- Incorrect management of spinal injuries immediately after they occur has the potential to worsen the prognosis dramatically. It is essential that those responsible for first-aid are trained in how to provide correct immediate management of spinal injuries.

6. Examination of Changes in Frequency and Severity of Spinal Injury Over Time

While it appears that the frequency of spinal cord injuries to rugby players has increased over the past 30 years, it is difficult to know what proportion of the increase is attributable to:
- greater awareness of the problem due to increased publicity
- better record keeping and greater depth of study
- changes in playing populations
- changes in exposure per player per season
- changes in patterns of activity in matches, including an increase in competitiveness of play
- changes in the anthropometric and physiological characteristics typical of players
- increased rate of admission of players to spinal units to ensure optimal treatment.

Part of the difficulty in comparing injury rates between countries (or studies) is the difficulty in classifying spinal injuries. Because the diagnosis can change substantially from the initial appraisal to the time a player leaves a spinal unit, it is difficult to standardise measures of injury severity. In addition, as Taylor and Coolican[6] pointed out, while the American Spinal Injury Association (ASIA) classification (outlined in section 6.1) gives broadly useful groupings of motor and sensory function, a large degree of variation exists within category 'D', which can range from relatively mild to quite severe impairment (the same applies to the Frankel classification system,[83] which is similar to the ASIA system).

6.1 The American Spinal Injury Association Classification System of Spinal Injuries

The ASIA classification system of spinal injuries[84] provides groupings of motor and sensory function under the following categories:
A = Complete loss of sensation and movement below the level of the injury (wheelchair bound)
B = Incomplete loss of sensation, loss of movement (wheelchair bound)
C = Incomplete loss of movement in lower limbs (wheelchair bound)
D = Incomplete cord injury – severe injury/perhaps able to walk/perhaps wheelchair bound
E = No permanent damage.

A South African review[85] suggested that the number of rugby-related spinal injuries admitted to the Spinal Cord Injury Centre at Conradie Hospital in Cape Town had risen from 5.4 per year for the period 1981 to 1987, to 8.7 per year from 1987 to 1996. A similar increase has been observed in New Zealand. The number of spinal injuries admitted to the Burwood Spinal Unit in Christchurch, New Zealand resulting from rugby during the period 1979 to 1988[57] was 28. Fifteen of these players were complete tetraplegics (Frankel A classification) and two were incomplete tetraplegics (Frankel B). The proportions falling into each Frankel classification are shown in figure 5.

For the subsequent 10-year period, (1989 to 1998) a large increase in the number of spinal injuries was reported (53 injuries; T Hughes, unpublished data). The average severity, however, was lower (figure 6).

Over the second 10-year period, nine injuries resulted in complete tetraplegia. Several researchers have drawn attention to the number of

serious neck injuries sustained in rugby that do not result in damage to the spinal cord.[48,85] It has been suggested that for every serious spinal cord injury sustained by rugby players, there may be as many as ten 'near miss' injuries to the neck that do not result in spinal cord involvement.[4] Two particular observations that resulted from studying these injuries were the occurrence of spinal cord concussion injuries, in which players experienced transient paralysis, and the large number of players who had degenerative changes of the cervical spine (as described in section 4.5.2).[85] A question of interest regarding the so-called 'near miss' injuries is whether risk factors for spinal injury in rugby vary across the spectrum of severity of injury. If the factors that predispose players to the more severe injuries differ from those that predispose players to the less severe injuries identification of risk factors via prospective methods will be more difficult. Sufficient data to examine the differences will take longer to collect than if similar risk factors predisposed to injuries across the spectrum of severity.

7. Comparison of Injury Rates Across Studies/Countries

Until standard definitions of injury are used and accurate estimates of player populations are available, comparing incidence rates across rugby playing nations is not particularly useful.

The best estimates currently available for Australia suggest a rate of injuries resulting in tetraplegia or quadriparesis of 6.5/100 000 participants per year during the period from 1984 to 1996.[63] For the purposes of comparison, if the number of players in New Zealand through the same period had been approximately 120 000 (as it is currently estimated to be), the rate would have been 2.3/100 000 participants per year. A recent report from Fiji indicated that the incidence of rugby-related spinal injuries in that country resulting in death or tetraplegia may be as high as 10/100 000 players per year,[45] although the sample size is small and may reflect seasonal variation.

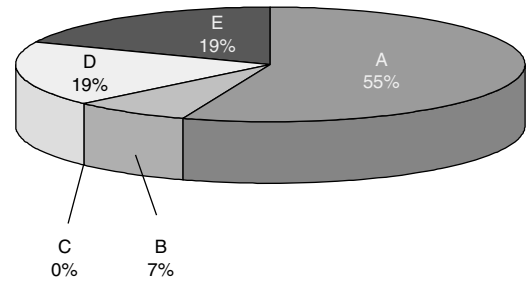

Fig. 5. Frankel classification of rugby-related spinal injuries in New Zealand (1979 to 1988) [Hughes T, personal communication]. **A** = complete loss of function; **B** = motor complete, sensory incomplete; **C** = motor nonfunctional; **D** = motor functional; **E** = complete recovery.

7.1 Comparison of Spinal Injury Rates in Rugby Union with Rugby League and American Football

Rugby League (league) is the football code that is most similar to Rugby Union in terms of the patterns of play that are typical within the sports, although there are a number of key differences. Among these are:

- There are 15 players on a rugby team versus 13 on a league team (there are eight forwards on each team in rugby, whereas there are six on each team in league).
- The scrum is contested much more aggressively in rugby than is the case in league.
- If the ball travels out of play over the sideline, possession is contested in rugby in a lineout, whereas in league possession of the ball automatically goes to the team who were not responsible for taking the ball out of play.
- The games also differ in terms of what occurs after a tackle. In league, the tackled player is allowed to stand up and provide the ball to their team by heeling it backwards with the foot. In rugby, a ruck or maul consisting of variable numbers of players forms over the tackled player, and possession of the ball continues to be contested.

Compared with rugby, a greater proportion of spinal injuries in league tend to occur in the tackle,

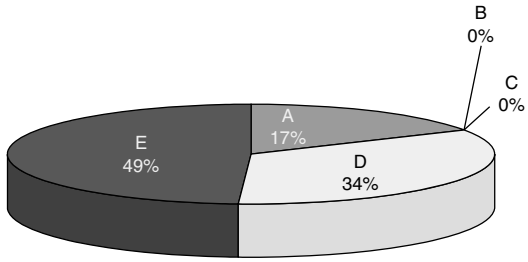

Fig. 6. Frankel classification of rugby-related spinal injuries in New Zealand (1989 to 1998) [Hughes T, personal communication]. **A** = complete loss of function; **B** = motor complete, sensory incomplete; **C** = motor nonfunctional; **D** = motor functional; **E** = complete recovery.

and a lesser proportion occur in the scrum. In New South Wales, Australia, Rotem and colleagues[63] reported that during the period 1984 to 1996, 78% of spinal injuries in league occurred in the tackle, with the remaining injuries (22%) occurring in the scrum. In rugby during the same period, 54% of spinal injuries occurred in scrums, 15% in rucks and mauls, and 31% in the tackle. There were 23 injuries that resulted in neurological deficits in league, which represented a rate of 1.7 injuries/100 000 players per year. In Rugby Union, there were 26 injuries that resulted in neurological deficits, which represented a rate of 6.5 injuries/100 000 players per year. These authors concluded that there appeared to be several options based on their findings:[63]

- Maintain the status quo and accept that each year several union and league players in New South Wales (and elsewhere) will sustain cervical spinal cord injuries that will leave them permanently paralysed below the neck.
- For rugby union, change the rules (laws) to substantially reduce the number of scrum-like plays and change the organisation of the scrum.
- For rugby league, introduce changes to the rules aimed at substantially altering the nature of the tackle.

Although the games are quite different, is interesting to attempt to compare the rate of spinal injuries within rugby and American Football. An annual rate of tetraplegia of 0.5/100 000 players in high school football and 1.2/100 000 players for college football has been reported in the US.[86] From 1995 to 2000, the combined rate of injuries with incomplete neurological recovery for American Footballers at College and High School level has been 2/100 000 players per year.[87] Over the same period in New Zealand (assuming the number of players has been relatively constant at 120 000), the rate has been 2.8/100 000 players per year.[37]

8. Recommendations

The analysis of information obtained through the implementation of a national register of spinal injuries for American Football allowed identification of the main mechanisms of injury in that sport. As a result of changes that were implemented, a substantial drop in injury rate was observed.

Joseph Torg,[72] who was one of those responsible for setting up a case register of injuries in American Football, summarised the way in which other sports could take advantage of the lessons learned in the American situation as follows:

- continued research
- development of clear and concise definitions of the responsible injury mechanisms based on sound biomechanical, epidemiologic, and clinical evidence
- education of coaches and players
- enforcement of rules is essential.

The risk of not following a systematic approach to data collection and analysis of these injuries is that any developments within rugby (whether through law changes or changes in play as a result of new tactics) cannot be evaluated in terms of safety.

In order to make real changes to the incidence rate of serious spinal injuries throughout the rugby-playing nations of the world, the following recommendations are set forth:

(i) Institute a systematic international case register that has the potential to be replicated throughout the IRB member countries.

(ii) Ensure that each team has assigned to it an appropriately trained person responsible for first-aid

and that processes are in place for minimising harm to players who sustain an injury. This is important at all levels of the sport that involve contact scrums and tackles.
(iii) Ensure that each team has a clearly designated 'injury official', who is responsible for notifying serious spinal injuries to the national administrators of rugby.
(iv) Coaches should attempt to minimise the 'mismatching' of players of different levels of skill during trials.
(v) Educate coaches and players about the importance of progressively preparing their bodies for the impacts that are part of the game. Moving directly from 'no impact' to 'full on games' may mean that players are less able to cope with any impacts that do occur during tackles, scrums, rucks and mauls.
(vi) Players should practice the skills involved in tackling and scrummaging again at the start of each season prior to starting the playing season proper. This could easily be incorporated into pre-season fitness training that is commonly held at clubs. This would also assist those players who lack experience in impact to gain this experience in a more controlled environment than in a game.
(vii) Consider building up to full impact in scrums over the series of trial matches (possibly starting with static scrums in the first trial match or two of the season).
(viii) Continue to ensure that the laws regarding dangerous play are strictly enforced.
(ix) Consider starting the club season slightly later in the year to allow play on softer grounds.

9. Conclusion

An increase in the frequency of rugby related spinal injuries was reported through the latter part of the 1970s and the early 1980s in most countries where rugby is commonly played. While the scrum was the phase of play most commonly associated with spinal injuries throughout the 1980s, there has been a trend through the 1990s of an increasing proportion of spinal injuries occurring in the tackle situation. Within the constraints of the research published to date, it appears that hookers and props have been at disproportionate risk of cervical spine injury, predominantly because of injuries sustained during scrummaging. The majority of injuries from all phases of play have occurred early in the season, when grounds tend to be harder and players are lacking both practice and physical conditioning for the physical-contact phases of the sport. Research into the long-term effects of participation in rugby on the integrity of the spinal column is warranted. Case reports and case-series studies have provided much information regarding the mechanisms and frequency of rugby injuries to the cervical spine and spinal cord. The most commonly reported mechanism of injury has been hyperflexion of the cervical spine, resulting in fracture dislocation of C4-C5 or C5-C6. This differs from the most common mechanism in American Football, in which spinal cord damage results through impact to the vertex of the head. Further investigations should be undertaken to quantify the extent of this difference. A number of injury-prevention measures have been launched, including changes to the laws of the game regarding scrummaging, and education programmes aimed at enforcing safe techniques and eliminating illegal play. Tracking both the trends of incidence of spinal injuries, and the effectiveness of injury prevention initiatives, has proved difficult because of a lack of properly conducted epidemiological studies. Calls for case-registers and effective epidemiological studies have been made by researchers and physicians in most countries where rugby is widespread, but it appears to be only recently that definite steps have been made towards this goal. Well-designed epidemiological studies that entail international collaboration will be able to provide more accurate information about potential risk factors for injury such as age, grade, position, gender and ethnicity than has been the case in the past. These studies will require cooperation among rugby administrators at a variety of levels of the sport, epidemiologists, and orthopaedic and spinal surgeons.

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