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REVIEW

# Injury in rugby league

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**KEYWORDS**

Rugby league;  
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**Summary** It was the purpose of this review to document the range, incidence, location and mechanism of injury occurring in the sport of rugby league. Rugby league is a collision sport played in Europe and the Pacific regions including Australia. The sport is well established and has competitions ranging from junior to elite professional. Due to the contact nature of the game, injury is relatively common. The most common injuries are musculotendinous in nature and afflict the lower limb more frequently than elsewhere. Despite the high incidence of minor (sprains/strains) to moderate musculoskeletal injury (fracture, ligament and joint injury) and minor head injuries such as lacerations, nasal fractures and concussions, rare more serious spinal cord and other injuries causing death have also been recorded. The literature on rugby league injury is small but growing and suffers from a lack of consistent definition of what an injury is, thereby causing variability in the nature and incidence/prevalence of injury. Information is lacking on the injury profiles of different age groups. Importantly, there has been little attempt to establish a coordinated injury surveillance program in rugby league in the junior or professional levels. The implementation of such programs would require a universal definition of injury and a focus on important events and competitions. The implementation could provide important information in the identification and prevention of risk factors for injury.

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## Introduction

It is widely recognised that high speed, body contact collision sports are an important source of injury to participants. This is perhaps best exemplified by rugby league. Rugby league is a highly physical sport, requiring a combination of speed, strength, stamina and agility.<sup>1</sup> Rugby league has been described as the main professional team sport played in Eastern Australia.<sup>2</sup> It has a professional league in Europe<sup>3</sup> and is played in New Zealand, the Pacific Islands and South Africa.<sup>4</sup> Each team comprises 13 players plus four on the interchange bench. The field is rectangular, 100 m in length. Each game is played over two continuous 40-min halves plus stoppage time. The primary method of play progression is by running the ball. The opposition attempts to prevent this by tackling the player in possession, who can pass the ball backwards to a team-mate or kick it forwards. An offside rule applies. The ball carrier can be tackled by any number of players. Each team gets six tackles per possession, after which the opposition gains possession. Each player has an offensive and defensive responsibility. Scoring occurs by placing the ball over the try line at the end of the field followed by a place kick at goal.

Due to the inherent nature of the game whereby hard body contact repeatedly occurs, injuries are inevitable.<sup>2</sup> Players are involved in 20-40 physical confrontations per game<sup>5</sup> and wear minimal or no protective equipment. Questions have been raised regarding the frequency and type of injuries sustained and the steps needed to guard against them.<sup>6</sup> Injury surveillance has come from professional, semi-professional, amateur and junior levels. Few studies share the same injury definition or data collection method, making comparisons and conclusions troublesome. It is beyond the scope of this paper to provide a critical analysis of epidemiological methods. A criticism of rugby league is that a coordinated injury surveillance of an entire professional competition has not been established. Player injuries in professional rugby league are of extreme importance to the players for their livelihood and to the team for success.<sup>7-9</sup> At the amateur level a statistically significant increased incidence of injury has been shown to occur in poorer performing clubs,<sup>9</sup> although the impact of injuries

on performance at higher levels has yet to be scientifically documented.<sup>10</sup> The nature and severity of injuries may affect long-term vocational opportunities afforded to retired players.<sup>6</sup> Injuries to amateur players are of importance as significant direct and indirect economic costs result from loss of employment or study time.<sup>11</sup>

A review has reported the injuries associated with rugby league.<sup>12</sup> Though this review was recent, it was limited in its scope as it failed to review all aspects of the literature critically or comment on epidemiological methods in presenting its content and discussion. These omissions and a potential for a selection bias may have resulted in conclusions that could not be fully supported by the discussion. Other reviews published recently have focused on professional injuries using only injury surveillance literature with a common injury definition,<sup>13</sup> while Gibbs's<sup>2</sup> early review of the literature in 1994 focused on mechanisms of injury and was limited by the small literature base present at the time.

This literature review will investigate the research concerning the epidemiology of rugby league injuries. In addition to the above, the game of rugby league has undergone significant change in the recent past, possibly contributing to a different injury profile. More recent literature was emphasised because it would better represent the current nature of the game. In presenting this article the Medline and Cinahl databases were reviewed (English literature from 1990 to present) with the following key words "rugby league" AND injury. Using the above search criteria provided 56 articles from the Medline database and 22 articles from the Cinahl database. After removing duplications and unrelated articles, 46 articles were sourced. Other pertinent literature that added significantly to the knowledge and understanding of rugby league injuries not found on these databases was also sourced. Emphasis was placed on injury surveillance literature over other literature. All injuries incurred in the game were considered with the focus on more severe injuries likely to have more significant consequences to players both during and after their careers. Using these criteria, we cut the sourced literature to 40 to meet journal requirements, making this a limitation of the review. Papers were retrieved either electronically

**Table 1** Prevalence of injury type in rugby league

Injury definition	Level of play/location/duration	Finding	Reference
Any pain or disability suffered by a player during a match or training session, and subsequently assessed by the head trainer during, or immediately following the match or training session	Semi-professional (156 players over 2 seasons)	Muscular injuries 32.9%, contusions 20.2%, joint injuries 15.6% (during matches)	Gabbett <sup>15</sup>
Any pain or disability suffered by a player during a match or training session, and subsequently assessed by the head trainer during, or immediately following the match or training session	Semi-professional (79 players, 1 season)	Muscular injuries 31.8%, contusions 20.2%, abrasions 17.9% (during matches)	Gabbett <sup>16</sup>
That which was subsequently assessed by the head trainer during or immediately after the match	Amateur (9 teams over 3 seasons)	Muscular injuries (haematomas and strains) 28.5%, joint injuries 17.2%, lacerations 14.5%	Gabbett <sup>32</sup>
The onset of pain or a disability resulting from either training for or playing rugby league	Professional (1 club, 1 season)	Haematomas and muscle strains (32.3%), joint sprains 31.8%	Gissane et al. <sup>8</sup>
The onset of pain or a disability that occurred while playing rugby league football	Professional (1 club, 2 grades over 4 seasons)	Muscular injuries 29.9%, joint sprain 23.8%, laceration 17.3%, contusion 10.4%, fracture of dislocation 8.1%, concussion 7.1%, abrasion and skin infection 2.0%	Stephenson et al. <sup>14</sup>
That which caused a player to be unavailable for selection in a match, or participation in a training session or any other injury which required specific medical treatment, other than routine conservative measures	Professional (8 teams 3 grades, 1 year)	Laceration/bruise 37.0%, Other/uncertain 25.1%, joint/ligament 22.3%, muscle/tendon 9.6%, fractures 6.1%	Seward et al. <sup>7</sup>
That occurring during a game that caused a player to miss a subsequent match	Professional (1 club, 3 grades over 3 years)	Ligaments and joints 53.9%, muscles and tendons 21.3%, bone fractures 19.2%, the central or peripheral nervous systems 4.9%, infected skin lacerations 0.7%	Gibbs <sup>1</sup>
Any pain, disability or injury that occurred as a result of a competition game which caused the player to miss subsequent games	Amateur (72 retrospective surveys – 47.2% returned, injuries over 1 season)	Muscular injuries 44.0%, joint sprains 28.0%, fractures 20.0%	Gabbett <sup>11</sup>
Any pain, disability or injury that occurred as a result of a competition match that caused a player to miss a subsequent match	Semi-professional (1 club, 153 players over 4 years)	Joint sprains 34.6%, muscle strains 20.0%, fractures and dislocations 13.5%	Gabbett and Domrow <sup>4</sup>
A physical impairment received during a competitive match that prevented a player from being available for selection to play in the next match	Professional (1 club, 9 seasons)	Joint sprain, 25.2%, muscular injuries 24.2%, fracture or dislocation 13.7%, concussion 6.1%	Gissane et al. <sup>3</sup>

or in print from the libraries of Macquarie University, The University of Sydney or The University of Melbourne.

## Epidemiology

### Injury type

The prevalence of injury type is summarised in Table 1. Because of the speed with which rugby league is played and the body contact and twisting that occurs, musculotendinous injuries are common.<sup>2</sup> Muscular injuries (haematomas and strains) are among the most prevalent injuries in professional,<sup>7,8,14</sup> semi-professional<sup>15,16</sup> and amateur players.<sup>11</sup> When an injury definition is biased towards minor injuries, muscular injuries are the most prevalent injury followed by contusions, joint injuries and abrasions. However, these injuries may not result in missed match time<sup>1,8,17</sup> or detract from player performance. Often at the professional level such injury can be managed effectively with local anaesthetic.<sup>17</sup> When the injury definition becomes biased towards major injuries (resulting in missed matches), joint and ligament injuries become more prevalent as do fractures, dislocations and concussions.

### Injury location

The majority of studies concur that injuries to the lower limb are the most frequent in rugby league, followed by injuries to the head, neck and upper limb, as presented in Table 2. This appears to be regardless of the level of play.

There is a lack of literature on the breakdown of specific injury type. Gibbs's<sup>2</sup> 5-year data of a professional club found that, when ranked as a percentage of total injuries resulting in missed subsequent matches, the leading forms of injury were ankle ligament tears (11%), knee medial collateral ligament (MCL) tears (8%), groin muscle/tendon tears (8%) and concussion (6%). Orchard's<sup>17</sup> 5-year data from a professional club (juniors not included) using a similar injury definition found the most prevalent injuries to be the knee anterior cruciate ligament (ACL) (11%), shoulder sprains and dislocations (10%), knee MCL (6%), ankle joint injuries (6%), hamstring strains, leg and foot fractures and forearm, wrist and hand fractures (all 5%). In total, knee injuries made up 27.7% of all injuries, foot and ankle injuries 19.7% and groin, hip and thigh injuries 14.7%. Being more recent, the data presented by Orchard would likely incorporate recent increased

player intensity. Seward et al.<sup>7</sup> defined an injury as that preventing match selection, training participation or requiring specific medical treatment. They monitored eight professional clubs over one year and found head and facial lacerations (11.4%) to be the most prevalent followed by concussion (8.5%), thigh haematomas (6.3%), lateral ankle ligament sprains (6.0%) and hamstring strain/tears (4.8%). Despite a high incidence of laceration, the majority of such injuries are dealt with at the ground with various procedures including bandaging, suturing and stapling, and do not result in lost match time.<sup>8,18</sup> Gabbett and Domrow<sup>4</sup> recorded match injuries resulting in missed matches over a 4-year period from one club at the semi-professional level. The most common injuries were lateral ankle sprains (12.4%), acromioclavicular joint injuries (8.1%) and knee medial ligament sprains (7.0%). Because of a lack of injury surveillance, it is unclear whether or not injury frequency and type vary between levels of play. Most injury surveillances have been short term and come from single clubs. This may not be representative of an entire competition as injury type and frequency will differ according to training protocols, medical management and team selection policies. Moreover, it has been found that there is a definite element of randomness to a club's injury profile each year,<sup>17</sup> with significant differences between injury rates at different clubs.<sup>9</sup> However, certain injuries such as concussion have been shown to remain constant each year.<sup>19</sup> Longer term surveillance systems may better examine the randomness of the injury profile in clubs and should be investigated further.

### Mechanism of injury

A good understanding of the mechanism of injury is important to develop preventative strategies.<sup>2</sup> Injuries are common because of the significant amount of body contact and physical collision that occurs.<sup>2,20,21</sup> Therefore, injury prevention may not be attainable to a significant degree since most injuries result from physical collisions. The tackle is a very prominent part of the game, which produces more injuries than any other mechanism. The percentage of injuries caused by tackling ranges between 38.2%<sup>16</sup> and 77.2%<sup>22</sup> and is listed in Table 3. Results are mixed regarding the aspect of the tackle causing injury, with some authors finding more injuries occurring to the player tackled<sup>3,4</sup> and others to the player being tackled.<sup>8,9,23</sup>

Concerns have been raised regarding the number of reported concussions in rugby league.<sup>19,22</sup> When an injury definition focuses on missed matches, it

**Table 2** Injury location in rugby league

Definition	Level of play/location/duration	Figures	Reference
That occurring during a game that caused a player to miss a subsequent match	Professional (1 club, 3 grades over 3 years)	Lower limb 53.2%, upper limb 22.0%, trunk 19.1%, head 5.7%	Gibbs <sup>1</sup>
That requiring a player to miss a subsequent game	Professional (1 club, 2 grades over 6 seasons)	Lower limb 62.1%, upper limb 24.4%, trunk injuries 6.9%, head and neck 5.6%, medical illnesses 0.9%	Orchard <sup>17</sup>
Any pain or disability that occurred as a result of a competition game which caused the player to miss subsequent games	Amateur (72 retrospective surveys – 47.2% returned, injuries over 1 season)	Arm and hand 30.0%, knee 22.7%, ankle and foot 13.6%, shoulder 9.1%, face 9.1%	Gabbett <sup>11</sup>
Any pain, disability or injury that occurred as a result of a competition match that caused a player to miss a subsequent match	Semi-professional (1 club, 153 players over 4 years)	Thigh and calf 21.1%, shoulder 18.4%, knee 15.1%	Gabbett and Domrow <sup>4</sup>
A physical impairment received during a competitive match that prevented a player from being available for selection to play in the next game	Professional (1 club, 9 seasons)	Thigh and calf 23.0%, head and neck 16.7%, thorax and abdomen 12.6%, knee 12.6%, ankle 10.8%, shoulder 11.3%, arm 9.5%	Gissane et al. <sup>3</sup>
That which caused a player to be unavailable for selection in a match, or participation in a training session or any other injury which required specific medical treatment, other than routine conservative measures	Professional (8 teams 3 grades, 1 year)	Lower limb 41.5%, head and neck 28.5%, upper limb 20.9%, trunk 9.2%	Seward et al. <sup>7</sup>
An injury sustained in the field during a competitive match, practice game, or other training activity directly associated with rugby, which prevented the player from training or playing rugby from the time of the injury or from the end of the match or practice in which the injury was sustained	Amateur (6 clubs, 106 players, 1 season)	Lower limb 47.6%, head and neck 23.8%, upper limb 20.6%, trunk and back 4.8%	Babic et al. <sup>9</sup>
The onset of pain or a disability that occurred while playing rugby league football	Professional (1 club, 2 grades over 4 seasons)	Lower limb 36%, the head and neck 34%, upper limb 15%, trunk 9%	Stephenson et al. <sup>14</sup>
That which was subsequently assessed by the head trainer during or immediately after the match	Amateur (9 teams over 3 seasons)	Head and neck 25%, face 13%, abdomen and thorax 13%, knee 11%	Gabbett <sup>32</sup>
Any pain or disability suffered by a player during a match or training session, and subsequently assessed by the head trainer during, or immediately following the match or training session	Semi-professional (156 players over 2 seasons)	Thigh and calf 20.0%, face 13.9%, arm and hand 13.9%, knee 13.2% (playing injuries)	Gabbett <sup>15</sup>
Any pain or disability suffered by a player during a match or training session, and subsequently assessed by the head trainer during, or immediately following the match or training session	Semi-professional (79 players, 1 season)	Thigh and calf 19.0%, face 14.2%, knee 13.8%, arm and hand 12.9% (playing injuries)	Gabbett <sup>16</sup>
The onset of pain or a disability resulting from either training for or playing rugby league	Professional (1 club, 1 season)	Head and neck 21.5%, thigh and calf 20.6%	Gissane et al. <sup>8</sup>

**Table 3** Summary of the percentage of injuries caused by tackling

% Of injuries caused by tackles	Reference
38.2 (direct contact with another player 22.7)	Gabbett <sup>16</sup>
47.6	Babic et al. <sup>9</sup>
46.3	Gabbett <sup>15</sup>
53.5	Gabbett and Domrow <sup>5</sup>
60.7	Gabbett <sup>11</sup>
67.7	Gissane et al. <sup>23</sup>
74.0	Gissane et al. <sup>3</sup>
77.2	Norton and Wilson <sup>22</sup>

is likely that concussion is under-reported to save otherwise musculoskeletally healthy players from missing games to 'recover'.<sup>24</sup> A prospective recording of concussion at the professional level from 175 players over three seasons found that 13–17% of players sustain concussion each season, with 19% resulting in a missed subsequent match.<sup>19</sup> Of concern was that 16% of concussions recorded were repeat injuries. Concussion in Gibbs<sup>1</sup> study causing a missed match occurred at a rate of 5% of all injuries, with only 3% of these players having another episode of concussion in the same season, 2% having two episodes and 1% having three episodes. Orchard<sup>17</sup> established that, for a professional first and second grade squad, 2.2 matches are missed on average per year per squad through concussion. The high prevalence of minor brain injury increases the concern that more severe brain injury can result following these injuries within the first 24–48 h.<sup>19</sup> Those experiencing multiple brain injuries within a short period of time may potentially suffer catastrophic or fatal consequences due to a variety of mechanisms including second impact syndrome.

Interestingly, Hinton-Bayre et al.<sup>19</sup> established that 40% of concussions at the professional level were the result of head high tackles, yet only 41% were deemed illegal and the offending player penalised. Norton and Wilson<sup>22</sup> found that 14.1% of all injuries were associated with illegal play (defined by a referee), with 29% resulting in concussion, all having occurred during a tackle. Gabbett's<sup>11</sup> retrospective survey analysis of amateur players also found 14% of injuries to be associated with illegal play. The governing body of rugby league is concerned with such incidents, which has been demonstrated by the banning of head high tackling techniques and spear tackling (lifting and driving the player head first into the ground).<sup>14</sup> Cervical spine fractures are known to be caused by this method of tackling.<sup>25</sup> In order to enforce such rules,

players must be heavily penalised for such offences and stricter penalties for illegal 'head-high' tackling have been strongly recommended.<sup>19</sup>

When injury surveillances have a bias towards minor injuries that do not result in a missed game, head and neck injuries make up a larger proportion of the total injuries. This highlights the potential for accumulated microtrauma to the head and neck through concussion and whiplash type injuries. One effect of repeated head and neck trauma could be the development or aggravation of cervical stenosis.<sup>26</sup> Such injuries can be career-ending. Serious head and neck injuries are rare,<sup>1</sup> although cervical spinal cord injuries, paraplegia, quadriplegia and death can occur,<sup>24,27</sup> mostly as a result of being tackled.<sup>24,28</sup> A retrospective review of hospital records from the six Australian spinal cord injury units between 1997 and 2002 calculated that the average annual incidence of acute spinal cord injuries for rugby league was 1.5 per 100 000 players.<sup>29</sup> The two-on-one gang tackle has been found to contribute to such injuries significantly.<sup>28,29</sup> Since the scrum has stopped being contested there have been no injuries through this mechanism.<sup>29</sup> Programs to counteract the adverse effects of tackling and laws relating to multiple tacklers in rugby league have been advocated.<sup>29</sup>

Professional rugby league re-introduced the limited interchange rule in 2001 which allows a maximum of 12 player movements per team per game including interchanging for the blood bin and injuries.<sup>30</sup> From 1998 to 2000, an unlimited number of interchanges were possible. Orchard et al.'s<sup>30</sup> 5-year prospective data from a professional club before and after the introduction of the limited interchange rule recognised that, since the introduction of the new rule, players are 38% less likely to leave the field because of injury. It was hypothesised that the rule change may force players to stay on the field while fatigued and to carry minor injuries that may otherwise receive medical treatment. Exacerbation of injury and an increase in incidence of accumulative trauma-based injuries could also occur. However, a prospective three year study conducted at one semi-professional club before and after the introduction of the limited interchange rule (two seasons of unlimited interchange, one of limited interchange) found a reduction in player injuries, particularly muscle strain and running-based injuries and it may be that the resultant reduction in match speed resulted in a reduced injury risk.<sup>31</sup> Though there has been no change in the amount of injured players unable to return to the field, players are significantly less likely to leave the field because of facial fractures and head and neck injuries with limited

interchange.<sup>30</sup> It has previously been reported that, under the limited interchange system, 23% of concussions at the professional level are only detected after the injured player voluntarily leaves the field to report symptoms.<sup>19</sup> Because of the high level of head trauma in rugby league, controlling bodies should consider evoking rule changes so that concussive injuries are considered differently under the limited interchange definition.

Fatigue and/or repetitive microtrauma may have an accumulative effect on injuries over the course of the playing season. Increasing injury rates as the season progresses have been documented, with more injuries in the second half of the season at the amateur<sup>32</sup> and semi-professional level.<sup>15,16</sup> Gabbett<sup>16</sup> put this correlation down to an increase in match intensity towards finals. It could also be the result of players carrying injuries that have not fully resolved. For example, of 100 professional players monitored for two seasons, 23% of players sustained a groin injury which forced them to be unable to complete or miss a match or training session.<sup>33</sup> However, 70% of players had groin pain present for at least seven weeks. Furthermore, it is known that a risk exists for more severe damage when players continue to play with unstable shoulders throughout a season.<sup>34</sup> At the professional level no significant difference between early and late season injuries has been noted.<sup>17,35</sup> However, Orchard<sup>17</sup> documented that 6.2 players from a first and reserve grade squad miss a match each week, with this being slightly less at the start of the season and increasing at the end of the season. During the finals, only 4.3 players missed a match through injury. This was hypothesised to be a result of more aggressive medical management and players being more willing to take risks and carry injuries into important games. An increase in the amount of players playing with anaesthetic injections occurs significantly in finals.<sup>36</sup> Broad range data is yet to be collected on anaesthetic use which should be included in future injury surveillances. No epidemiological study has identified what specific type of injury or what injury location is more likely to be effected by season trends, which should be encouraged in future studies.

## Injury severity

There is a lack of literature documenting or analysing the severity of injuries. Gibbs<sup>2</sup> established that, of the injuries resulting in missed subsequent matches at a professional club, 37.6% were

minor (resulted in missing one game), 34.8% moderate (missing 2-4 games) and 27.6% major (missing five or more games). Gissane et al.<sup>13</sup> pooled the data of prospective injury surveillances at the professional level that used an injury definition as causing a missed match and calculated 43% of injuries to be minor, 32.9% moderate and 25% severe. Hodgson-Phillips et al.<sup>35</sup> used a similar definition of severity at the professional level but also included transient injuries (no games or training missed). From this, 88.9% of injuries occurring in a match were transient. Of the remaining injuries, 48.1% were minor, 36.4% moderate and 15.6% major. Gabbett<sup>15</sup> analysed semi-professional players and found that 92.9% of injuries were transient resulting in no loss of playing time. Gabbett<sup>10</sup> defined an injury as any pain or disability suffered by a player during a match and subsequently assessed by the head trainer during or immediately following the match. Using this injury definition, 95.9% of injuries were transient. Meir et al.<sup>6</sup> surveyed 47 retired professional players (return rate 60%). The results indicated that 50% of professional players in rugby league will suffer some type of injury during a season with approximately one quarter of those being major, requiring a player to miss five or more consecutive matches. Severe injuries appear to be significantly more common at higher levels of play and between grades at professional clubs.<sup>1,3</sup> Possible explanations include improved player physiological capabilities<sup>37</sup> and body mass,<sup>6</sup> increased intensity of play, increased game time resulting in player fatigue and pressure to play with minor injuries which, when subjected to high stress loads, could result in more severe injuries.<sup>38</sup> In support of this contention, at the semi-professional level injury severity has been shown to be significantly more likely in players with low body mass, and those players with less playing experience have a significantly lower risk of injury (including severe injury).<sup>4</sup> However, no significant difference has been found at the amateur level.<sup>9</sup> Further study should investigate these variables in future injury surveillances.

A retrospective follow up survey of professional players found that most players will have some form of long term consequence from injury.<sup>6</sup> This is most commonly arthritis (65.2% of participants), restricted joint mobility/joint stiffness (52.2%) and chronic back pain (39.1%). Dental problems (17.4%), joint reconstruction (13.0%), chronic headaches (8.7%) and joint replacement (4.3%) also figured. From the survey, the most common reasons for retirement were age and injury (39%), injury (25%) and age (21%). The average age of retirement was 30.5 years. Of note was that 29% of players indicated that injury resulted in early retirement.

Because of a lack of related literature, a well-structured follow up is encouraged.

Although literature is meager, 6-year data from a professional club found that, for every 10 senior players each season, there are four surgical procedures, the majority performed in the off season.<sup>17</sup> This could represent the natural injury profile of the game, ineffective conservative management strategies or players being willing to carry injuries throughout the season, thereby risking aggravation and increased damage. Of the total surgical procedures performed, the most common operations noted were: groin surgery (13%), fracture fixation (13%), knee arthroscopy (12%) and knee reconstruction (8%). Similar findings were reported by Gibbs.<sup>1</sup> There is a requirement for similar literature to be published and for a follow up on retired players to examine the medical consequences following a career of high-level rugby league participation.

## Injury recurrence

Figures documenting injury recurrence is limited. Orchard's<sup>17</sup> single professional club data calculated the sites most susceptible to recurrence to be back injuries, rib injuries, hamstring and quadriceps strains. Of the 141 injuries occurring in Gibbs's<sup>1</sup> 3 year single professional club data, there were 13 recurrences. Eight of the 141 injuries were related to an aggravation of an injury from the previous season. Gabbett's<sup>11</sup> retrospective survey analysis of amateur players (with a return rate of 47.2%) found 58.8% of participants to miss a game through an injury. Of these injuries, 70% were new, 25% recurring and 5% exacerbated. Gissane et al.<sup>8</sup> calculated 23.8% of injuries to be a recurrence of a complaint sustained earlier in the season for one year at a professional club. Future injury surveillance programs should investigate the injuries more likely to become recurrent which may allow identification of risk factors for injury which could assist in prevention efforts and management of injury.

## Injury incidence

Given the varying injury definitions, comparisons of and the determination of the actual injury incidence is problematic. It is not easy to compare incidence of injury unless the data is collected and analysed in a comparable way.<sup>35</sup> Injury incidence is summarised in Table 4.

When the professional European season moved from winter to summer, injuries increased between 67%<sup>20,35</sup> and double.<sup>3</sup> Climatic and ground condi-

tion may have contributed to this. Hodgson-Phillips et al.<sup>35</sup> found that the warmer months had a greater prevalence of injuries, possibly because of the impact of harder ground on players or a faster game being allowed with greater player collisions. However, Orchard<sup>17</sup> investigated these aspects of injury and found no significant correlations with weather and ground conditions. As ground conditions are a modifiable risk factor for injury, data on ground conditions and injury risk need to be included in future injury surveillance efforts.

## Juniors

A paucity of injury surveillance exists at the junior level. Although many of the factors influencing injuries in adults may be applicable to juniors, there is a requirement for separate epidemiological studies.<sup>21</sup> The average professional player begins their junior career when they are nine.<sup>6</sup> The immature musculoskeletal system may be more susceptible to injuries, principally because of the collision nature of rugby league. Pringle et al.<sup>21</sup> defined an injury rather subjectively as that which occurred in a match that impaired performance and observed matches involving children aged six to 15. Injuries in rugby league were found to be significantly more common compared to rugby union and netball (24.5 versus 15.5 versus 13.0 total injury rate per 1000 player-hr) and more likely to be severe and result in missing a match (9.5 versus 0.6 versus 6.0 injuries per 1000 player hours). Parents of Australian male children aged 5–12 residing in New South Wales are more likely to discourage or prevent their children from playing rugby league (23.2% of parents) than any other sport.<sup>39</sup> A comparative study using the same injury definition for junior and senior players is required, as the injury location and severity noted in senior players would likely be unacceptable in junior players. The perceptions of parents should be addressed by utilising stricter rules, greater policing of existing rules and modified play, to minimise injury and encourage participation at the junior level.

It appears as if the severity of injury increases with age and grade, although minor injuries can be more commonly reported at younger and lower levels, which may skew injury rates. Estell et al.<sup>38</sup> conducted an injury surveillance at a professional and elite junior club with first grade, reserve grade, under-21, under-19, under-17 and under-15 teams. They found that younger players suffered relatively minor injuries compared to the older players and the severity of injury increased with increasing age group (and grade) almost linearly. No pattern could

**Table 4** Summary of injury incidence in rugby league

Definition	Level of play/location/duration	Figure	Reference
That requiring a player to miss the subsequent game	Professional (pooled data from 4 prospective studies, Seward 93, Gibbs 93, Stephenson 96, Gissane 98)	40.3 injuries per 1000 player game hours	Gissane et al. <sup>13</sup>
That requiring a player to miss a subsequent game	Professional (1 club, 2 grades over 6 seasons)	39.8 injuries per 100 player hours	Orchard <sup>17</sup>
That occurring during a game that caused a player to miss a subsequent match	Professional (1 club, 3 grades over 3 years)	44.9 per 1000 player game hours	Gibbs <sup>1</sup>
Any pain, disability or injury that occurred as a result of a competition match that caused a player to miss a subsequent match	Semi-professional (1 club, 153 players over 4 years)	55.4 per 1000 playing hours	Gabbett and Domrow <sup>4</sup>
Any pain or disability suffered by a player during a match or training session, and subsequently assessed by the head trainer during, or immediately following the match or training session	Semi-professional (156 players over 2 seasons)	824.7 injuries per 1000 player hours	Gabbett <sup>15</sup>
Any pain or disability suffered by a player during a match or training session, and subsequently assessed by the head trainer during, or immediately following the match or training session that resulted in missing subsequent matches	Semi-professional (156 players over 2 seasons)	67.7 injuries per 1000 h	Gabbett <sup>15</sup>
Pain, discomfort, disability or illness (new or recurrent) that the player acknowledged after participating a rugby league related activity/game	Professionals (1 team over 4 seasons)	346 injuries per 1000 player hours	Hodgson-Phillips et al. <sup>35</sup>
Pain, discomfort, disability or illness (new or recurrent) that the player acknowledged after participating a rugby league related game that resulted in a missed match	Professionals (1 team over 4 seasons)	38.7 injuries per 1000 player hours	Hodgson-Phillips et al. <sup>35</sup>
Pain, discomfort, disability or illness (new or recurrent) that the player acknowledged after participating a rugby league related activity/game that resulted in a missed match	Professionals (1 team over 4 seasons)	52.3 injuries per 100 player hours	Hodgson-Phillips et al. <sup>35</sup>
That which was subsequently assessed by the head trainer during or immediately after the match	Amateur (9 teams over 3 seasons)	160.6 injuries per 1000 player game hours	Gabbett <sup>32</sup>
The onset of pain or a disability that occurred while playing rugby league football	Professional (1 club, 2 grades over 4 seasons)	114.3 injuries per 1000 h of match play	Stephenson et al. <sup>14</sup>
An injury sustained in the field during a competitive match, practice game, or other training activity directly associated with rugby, which prevented the player from training or playing rugby from the time of the injury or from the end of the match or practice in which the injury was sustained	Amateur (6 clubs, 106 players, 1 season)	18.22 injuries per 1000 h of match play	Babic et al. <sup>9</sup>
A physical impairment received during a competitive match that prevented a player from being available for selection to play in the next game	Professional (1 club, 9 seasons)	45.5 injuries per 1000 player hours	Gissane et al. <sup>3</sup>

Table 4 (Continued)

Definition	Level of play/location/duration	Figure	Reference
Any pain or disability that occurred as a result of a competition game which caused the player to miss subsequent games	Amateur (72 retrospective surveys – 47.2% returned, injuries over 1 season)	26.8 injuries per 1000 player game hours	Gabbett <sup>11</sup>
Pain, discomfort or disability arising during, or immediately after, and as a result of, playing in a rugby league match	Professional (2 grades) and elite junior (4 teams) over 1 season	242.8 injuries per 1000 player game hours	Estell et al. <sup>38</sup>
Pain, discomfort or disability arising during, or immediately after, and as a result of, playing in a rugby league match that resulted in a missed match	Professional (2 grades) and elite junior (4 teams) over 1 season	34.4 injuries per 1000 player game hours	Estell et al. <sup>38</sup>
That which caused a player to be unavailable for selection in a match, or participation in a training session or any other injury which required specific medical treatment, other than routine conservative measures	Professional (8 teams 3 grades, 1 year)	139 injuries per 1000 player hours	Seward et al. <sup>7</sup>
That which caused a player to be unavailable for selection in a match	Professional (8 teams 3 grades, 1 year)	44 injuries per 1000 player hours	Seward et al. <sup>7</sup>

be established for total injuries. Some authors have found a greater amount of injuries in a professional first grade than under 19-teams<sup>16,40</sup> Others have found no difference at a semi-professional<sup>15</sup> and professional level,<sup>13,38</sup> or even an increase in a professional under-21 team compared to a first grade team,<sup>1</sup> even though the matches are of a shorter duration (70 min, not 80). This could be the result of senior players being less likely to miss a game with injury due to financial concerns, not wanting to give up their place in the team or more aggressive medical management. Though it fails to reach statistical significance, the incidence of concussion appears to increase with level of play from under-19 and under-21, to reserve and first grade at professional clubs.<sup>19</sup> Although based on limited data, mismatching players on physical maturity may result in concussion levels up to three times that when playing in an equal competition.<sup>19</sup> At the senior level, injury risk is significantly lower in heavier players while lighter players have a significant risk for more severe injuries.<sup>4</sup> These findings require further research and have implications for junior players where large differentials in player size are frequently encountered.

## Conclusions

Injury surveillance and injury literature in rugby league is small but growing. There is a scarcity of literature involving injuries at the junior level.

The most common injuries in rugby league tend to be collision in nature, with the lower limb mostly effected. Severe injuries occur commonly, especially at higher levels of play. Because of the nature of the game, such injuries may not be avoidable and may have increased recently with evolution in player physical development, speed and rule changes. Forwards are more predisposed to injuries than backs because of the physical nature of their positions. Joint and ligament and musculotendinous injuries appear to be the most common injuries. Of concern is the amount of injuries occurring to the head and neck, including concussions. This is frequently the consequence of illegal play. Although the literature is limited, there appears to be a high rate of surgical intervention required due to participation in the game at the professional level. There is little long-term follow-up on the consequences of injuries from a career in rugby league. This should be encouraged, particular to assess the adverse effects, if any, from the repetitive head and neck trauma. Professional competitions need to set up a full-time injury surveillance to monitor injuries occurring to participants more accurately.

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