Concussion in youth rugby union and rugby league: a systematic review

Graham Kirkwood,[1] Nikesh Parekh,[2] Richard Ofori-Asenso,[1] Allyson M Pollock[1]

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[1]Centre for Primary Care and Public Health, Queen Mary University of London, London, UK
[2]Lewisham and Greenwich NHS Trust, London, UK

Correspondence to
Professor Allyson M Pollock, Centre for Primary Care and Public Health, Queen Mary University of London, Yvonne Carter Building, 58 Turner Street, London E1 2AB, UK; a.pollock@qmul.ac.uk

Accepted 20 December 2014
Published Online First 13 January 2015

ABSTRACT

Background Children and adolescents who play rugby are at increased risk of concussion and its effects. Competitive rugby union and rugby league feature as major sports in the school sport curriculum in the UK. There is a need for a thorough understanding of the epidemiology of concussion in youth rugby, the mechanisms involved in injuries and predisposing risk factors.

Data Sources The publication databases Pubmed, Embase and SportDISCUS were searched in April 2014 for primary research studies of child and adolescent rugby union and rugby league (under 20 years) in English language with data on concussion injuries. The review was conducted within a larger all injury systematic review on rugby union and rugby league where key words used in the search included rugby, injury and concussion with child, adolescent, paediatric and youth.

Results There were 25 studies retrieved with data on child or adolescent rugby and concussion, 20 were on rugby union, three on rugby league and in two the code of rugby was unspecified. There was significant heterogeneity in the definitions of injuries and of concussion. The incidence of child and adolescent match concussion ranged from 0.2 to 6.9 concussions per 1000 player-hours for rugby union and was 4.6 and 14.7 concussions per 1000 player-hours for rugby league, equivalent to a probability of between 0.3% and 11.4% for rugby union and of 7.7% and 22.7% for rugby league.

Conclusions There is a significant risk of concussion in children and adolescents playing rugby union and rugby league evident from the studies included in this systematic review. There is a need for reliable data through routine monitoring and reporting in schools and clubs and in hospital emergency departments in order to inform prevention. Concussion protocols should be implemented and tested.

INTRODUCTION

Concussion is a frequently reported injury in rugby union and rugby league.[1 2] It is now the most commonly recorded injury in professional rugby union in England and is increasing in incidence.[3] Concern about the long-term consequences of multiple sport related concussions and associated repetitive head trauma have been growing.[4–6] World Rugby (formerly the International Rugby Board (IRB)), the world rugby union governing body, acknowledges the risks associated with head injury and concussion 'even if this risk is unquantifiable and unknown'.[7] An association has been found between repeat concussions and poorer cognitive function in young adult male rugby players, at least 3 months after their last concussion.[8] There is also evidence of an association between repeat concussions and depression, mild cognitive impairment, poorer memory and verbal fluency and electrophysiological abnormalities diagnosed in later life among former American football and ice hockey players.[9–12] There have also been multiple autopsy findings of chronic traumatic encephalopathy (CTE), similar to that found in ex-boxers and military veterans, in the brains of former professional athletes in American football, ice hockey and wrestling[4–6 13] and in the brains of former rugby players.[6 14 15]

Children are more likely to experience concussion than adults and take longer to recover.[16–18] There is evidence that concussion is a relatively more common injury among rugby playing children and adolescents than it is among adult players.[19] Youth players are at increased risk of what is known as 'second impact syndrome', a potentially fatal phenomenon where a player sustains a second head injury without fully recovering from the effects of the first.[20]

UK government policy is to have at least 6000 partnerships in place between schools and local sports clubs by 2017, and rugby union and rugby league are among the five sports selected to increase the prominence of competitive sport in schools in England.[21] This is despite evidence from Australia that rugby union and rugby league are the two sports most likely to be discouraged by parents concerned about injury.[22] There are two codes of rugby, union and league, with rugby union the more popular of the two, played in 119 countries with around 40 countries playing rugby league.[23 24]

The aim of this review was to better understand the epidemiology of concussion in youth rugby union and rugby league. The primary objective was to systematically review the literature for primary research studies on concussion in both codes of youth rugby. Variables of interest were the incidence of concussion and concussion as a proportion of all rugby injury. Secondary objectives were to review the literature for data on any association between sustaining a concussion and phase of play, position of play and sex of the player.

METHODS

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Statement.[25] The reference databases Pubmed, Embase and SPORTDiscus were searched in April 2014 for primary research studies published in English in peer review journals within a larger

To cite: Kirkwood G, Parekh N, Ofori-Asenso R, *et al*. *Br J Sports Med* 2015;**49**:506–510.

systematic review of rugby injury studies. The reference lists of key systematic reviews and other papers from prior work on rugby were also hand searched. Our inclusion criteria were studies which reported data on child or adolescent (under 20 years of age) rugby union or rugby league players with data on incidence of concussion and concussion as a proportion of all rugby injury. All types of study design (ie, prospective, retrospective, observational and ecological) were eligible for inclusion in this review. No date or other restrictions were imposed on our searches.

The following search strategy was used for Pubmed and then adapted for Embase and SPORTDiscus:

((rugby[tiab]) AND ((injury OR injur* OR accident OR accident* OR concussion OR concuss* OR fracture OR sprain OR strain OR contusion OR bruise OR dislocation OR dis-location OR haematoma OR hematoma OR laceration OR cut OR break OR broken))) AND (child OR child* OR adolescent OR adolesc* OR pediatric OR paediatric OR youth OR young OR boy OR girl OR teenage OR teen* OR minor OR school OR college OR university OR student OR pupil).

The studies retrieved by our search were initially screened on the inclusion criteria by title and abstract by one reviewer (GK) with a second reviewer (AF) double-checking studies rejected at this stage. The full text of these selected studies was then retrieved either online or if necessary from the British Library and read, leading to the final selection of studies for the systematic review. (AF, R O-A, SS) Data were extracted from our final group of studies on the topic of concussion (R A-O, GK). Where match concussion incidence was given per 1000 player-hours, the methods developed by Parekh *et al*[26] were used to calculate post-hoc probabilities of injury over a season for a player on the basis of two assumptions: first, that game duration was 70 min as per Under 19 World Rugby (IRB) regulations[27] and second, that the number of games played per season was 15.

Similar recommended definitions of injury exist in rugby union[28] and rugby league[29] and the definitions used in the studies found were extracted in line with these. In particular definitions of injury were analysed to see if medical attention was required and/or if the definition was graded according to time lost from matches and training. Definitions of concussion used in the studies were compared to the Zurich Consensus Statement on Concussion in Sport 2012.[30]

From "Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012" [30]

The suspected diagnosis of concussion can include one or more of the following clinical domains:

- Symptoms—somatic (eg, headache), cognitive (eg, feeling like in a fog) and/or emotional symptoms (eg, lability);
- Physical signs (eg, loss of consciousness (LOC), amnesia);
- Behavioural changes (eg, irritability);
- Cognitive impairment (eg, slowed reaction times);
- Sleep disturbance (eg, insomnia).

If any one or more of these components are present, a concussion should be suspected and the appropriate management strategy instituted.

RESULTS

There were 1579 studies found via the publication database and hand searching (minus duplicates), of which 25 met the inclusion criteria. Details and reasons for exclusion are given in the flow diagram below (see online supplementary figure S1). Of the 25 studies selected for review: five were from Australia,[31–35] four each were from South Africa,[36–39] England[40–43] and New Zealand,[44–47] two each were from Scotland,[48 49] the USA[50 51] and Ireland[52 53] and one was from Canada,[54] in addition to an international study[55] (see online supplementary table S1).

There were 20 studies on rugby union,[32–45 48–52 55] three were on rugby league[31 46 47] and in two studies, the code of rugby was not specified.[53 54] Nineteen studies included men only,[31–40 42–46 48 52 53 55] three included both men and women[49 50 54] and in three the sex of the players was not provided.[41 47 51]

Of the 25 studies, 21 collected data prospectively from matches or training over the course of a season or several seasons or during tournaments,[31–38 40–45 47–51 53 55] three studies collected data retrospectively from rugby players using surveys or questionnaires[39 46 52] and one study analysed hospital emergency department data collected via an injury surveillance system.[54]

Four studies reported injuries "irrespective of the need for medical attention or time-loss from rugby activities";[33 44 45 53] four studies reported injuries using 'medical-attention' injury definitions;[35 38 41 47] 11 studies used 'time-loss' injury definitions;[31 34 36 37 40 42 43 48 49 51 55] two studies used both 'time-loss' and 'medical attention' injury definitions;[32 50] and the three surveys and the emergency department study did not require any such restrictions on injuries reported.[39 46 52 54]

Eighteen studies did not give any detail on the definition of concussion used[31 33–37 39 43–50 53–55] although most of these studies were on general injury, six studies defined concussion if players had at least one of the clinical domains from the Zurich Consensus Statement on Concussion in Sport 2012 described above although not all clinical domains were included in each study[32 38 40 41 51 52] and one study required LOC in its definition of concussion.[42]

The incidence of match concussion was reported per 1000 player-hours by seven studies[31 32 35 40 44 47 55] and ranged from 0.2[35] to 6.9 (95% CI 4.4 to 9.4)[32] concussions per 1000 player-hours for rugby union and was reported by two studies as 4.6 (0.6 to 8.6)[31] and 14.7 (4.8 to 34.2)[47] concussions per 1000 player-hours for rugby league (see online supplementary table S2). Using the method developed by Parekh *et al*,[26] these incidences convert to a probability for a player over a season of sustaining a concussion of between 0.3% and 11.4% for rugby union and of 7.7% and 22.7% for rugby league. Three rugby union studies reported concussion using alternative denominators, 10.6 (5.7 to 15.4) concussions per 1000 player-seasons,[48] 11.1 (4.8 to 17.4) concussions per 1000 player-games[51] and 5.9 concussions per 1000 player-exposures.[34] Only two studies, both rugby union, reported concussion incidence during training, giving figures of zero concussions[44] and 1.5 (0.2 to 2.8)[51] concussions per 1000 player-practices.

Nine studies gave figures for both concussions and all injuries sustained during matches (see online supplementary table S2)[31–33 35 40 44 47 48 55] and the proportion of all injuries classified as concussions ranged from 1.1%[35] to 12.2%[48] of all rugby union injuries and was 6.8%[47] and 8.1%[31] of all rugby league injuries. Two rugby union studies reported training concussions and injuries with concussions accounting for zero[44] and 1.9%[33] of all injuries sustained in training. Finally, 12 studies, all on rugby union, gave figures for matches and training combined[33 36 37 41–45 49–51 53] (table 1); in these studies the proportion of all injuries classified as concussions ranged from 2.2%[44] to 24.6%[51] of all injuries.

Table 1 Concussion as a proportion of all injuries sustained where figures are reported for matches and training combined

Author/year of publication	Number of players included in study	Total exposure	Number of injuries	Number of concussions	Concussion as a percentage of all injury
Collins *et al* (2008)[50]	Not given	32 014 player-matches and 81 627 player-practices	594	94	15.8
Durie and Munroe (2000)[44]	442	6880 player match-hours+23 868 player practice-hours	270	6	2.2
Junge *et al* (2004)[45]	123	1734 player match-hours+5141 player training-hours	340	10	2.9
Lewis and George (1996)[41]	45	Not given	Not given	Not given	7.1
Marshall and Spencer (2001)[51]	Not given	1081 player-matches+3333 player- training sessions	69	17	24.6
Nathan, Goedeke and Noakes (1983)[36]	Not given	6075 player match-hours+25 110 player training-hours	79	17	21.5
Nicol *et al* (2010)[49]	470	2406 player match-hours; training exposure not given	37	6	16.2
Roux *et al* (1987)[37]	Not given	50 126 player match-hours+259 150 player training-hours	495	59	12.0
Sparks (1981)[43]	Not given	Match+training total=500 000 player-hours	9885	513	5.2
Sparks (1985)[42]	Not given	22 776 player match-hours+17 090 player training-hours	772	49	6.3
Sugerman (1983)[33]	Not given	Match+training total=45 885 player-games	574	48	8.4
Watson (1997)[53]	40	Not given	118	8	6.6

There were two surveys which collected data on players' prior concussion experience (table 2). A survey of under 20-year-old club and national academy elite rugby union players in Ireland found 48.1% players reported at least one concussion in their career while 27.1% had sought medical attention for concussion.[52] In a large survey across 25 South African high-schools involving 3330 rugby union players, 14.1% of players reported at least one prior concussion with concussions accounting for 15% of all injuries reported.[39] There was also one study which retrospectively analysed routinely administered pre-competition medical questionnaires in New Zealand amateur rugby league[46] finding an average of 4.1 (SD 2.8) concussive incidents among the 42 under 15-year-old rugby league players surveyed and 3.8 (SD 2.5) among the 47 under 17-year-olds surveyed.[46] Finally, one study retrospectively analysed data collected by the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) at emergency departments across Canada and found that 11.0% of all rugby injury diagnoses among 5–19-year-olds were concussions.[54]

There was only one study, on rugby union, with data on concussion and phase of play. Most of the 94 concussions reported (87.2%) were associated with being tackled, tackling and rucks.[50] Only two studies, both on rugby union, had data on position of play and concussion. Fuller and Molly report that of the nine concussions sustained during four international under 20 years tournaments, five were sustained by backs and four by forwards[55] while Marshall and Spencer report that out of the 17 concussions they found, eight were to backs and nine to forwards.[51]

The study by Collins *et al*[50] on rugby union was the only one with data on concussion and the sex of the player concerned. They report that the boys and girls in their study sustained concussions as a proportion of all injury in a similar fashion, with 83 concussions among the boys (16.1% of all injuries) and 11 concussions among the girls (14.3% of all injuries).

DISCUSSION

There is evidence of a significant risk of concussion in children and adolescents playing rugby union and rugby league. The incidence of youth rugby union match concussion ranged from 0.2 to 6.9 concussions per 1000 player-hours, equivalent to a probability for a player over a season of sustaining a concussion of between 0.3% and 11.4%. For rugby league there were two studies which reported 4.6 and 14.7 concussions per 1000

Table 2 Results of questionnaire surveys on injuries and concussion

Study	Total respondents	Number of rugby injuries reported	Number of concussions reported
Baker *et al* (2013)[52]	133	Concussion only study	64 players (48.1% of respondents) reported at least one prior concussion while 36 players (27.1%) sought medical attention for concussion
Fridman *et al* (2013)[54]	56 691 sport related injury attendances analysed	1651	182
King *et al* (2013)[46]	42 under 15 years; 47 under 17 years (213 all ages including adults)	Concussion only study	Under 15-year-olds, 4.1 (SD 2.8) concussive incidents; 1.3 (0.5) loss of consciousness Under 17-year-olds 3.8 (2.5) concussive incidents, 1.1 (0.3) loss of consciousness
Upton *et al* (1996)[39]	3330	5920	888 concussions (15.0% of all injuries reported) 471 players (14.1% of respondents) reported at least one prior concussion

player-hours equivalent to a 7.7% and 22.7% probability of concussion over a season. Surveys found a high prevalence of prior concussion among young rugby union players with 48.1% of 133 interviewees in Ireland and 14.1% of 3330 respondents in a South African survey reporting at least one prior concussion. There is very little research on phase of play, player position or sex in relation to concussion risk. What little there is suggests that being tackled, tackling and rucks are the phases of play most associated with concussion, that forwards and backs have similar levels of risk as do boys compared to girls.

No meta-analysis was possible due to a large degree of study heterogeneity, the largest of all the prospective studies was that by McIntosh *et al* on rugby union with 28 902 player-hours which found an incidence of 6.9 (4.4 to 9.4) concussions (requiring on field treatment or removal from the game) per 1000 player-hours, equivalent to an 11.4% (7.4% to 15.2%) risk of a child or adolescent rugby union player being concussed over the course of a season, or one or two players sustaining a concussion every season in every school or club rugby team of 15 players.

Most of the studies in this review, 19 of 25, came from just four countries, Australia, New Zealand, South Africa and the UK. Kaplan *et al*[56] also found that the vast majority of research on rugby injuries comes from these main rugby playing countries. Similarly it was no surprise that most studies were on rugby union given the differences in popularity of the two codes of rugby.[23 24] The fact that most studies were on men is also not surprising, however, there are now estimated to be 1.5 million female rugby union players in the world, representing around 23% of all registered and unregistered rugby union players worldwide.[23] There is therefore a need for more targeted research on the epidemiology of injury among female rugby players and whether their mechanisms of injury, types of injuries sustained and their severity are similar or different to their male counterparts.

LIMITATIONS

There was a high degree of variation between studies in the reported estimates of incidence of concussion and of concussion as a proportion of all injury sustained during child and adolescent rugby. This variation is likely to be, at least partly, due to heterogeneity in study methodology and in particular in the different definitions of injury used between studies.[1 2 29 56] There were also variations between studies in the denominators used for incidence reporting and a failure in some studies to separate matches from training. This high level of heterogeneity between studies meant there were no two studies which collected data in a similar enough fashion to conduct a meaningful meta-analysis of the results.

There can be an under-reporting of concussion by players or coaches which needs to be considered when interpreting the results of this review. Concussions which don't involve LOC or convulsions can be difficult to diagnose, symptoms may be inaccurately reported by athletes or they may withhold information in order to continue playing.[57] There may be signs of some improvement, at least in the professional game, where the higher incidence figures recorded by the English Rugby Football Union (RFU) study may be in some degree due to increased awareness of concussion and a greater focus on understanding of diagnosis.[3] Preliminary data from a Pitch Side Concussion Assessment trial (results due late 2014) show a 25% increase in the number of concussed players being removed from play compared to previous seasons.[3]

CONCLUSIONS AND RECOMMENDATIONS

The association found between contact sports, concussion and cognitive deficits, depression and other health problems among current and former contact sport players along with the multiple autopsy findings of CTE in professional contact sport athletes should ring alarm bells among sports governing bodies and politicians. There is no hard evidence for protective equipment in protecting against concussion.[30 58] As children are more vulnerable to concussion and its effects than adults, it is therefore urgent that rugby and other contact sports are made safer for children and adolescents to play.

1. Rule changes and prevention strategies require evidence to both inform and evaluate them but in the UK the data required for this are lacking. Data collection systems need improvement, there should be injury data collected at every school and club rugby match involving young players and hospital emergency departments need to be able to distinguish between different sports and to collect data on mechanisms involved in injuries.
2. First aiders with knowledge of concussion and full awareness of current concussion protocols such as the RFU return to play guidance should be available pitch side at every school and club rugby match involving children and adolescents. The RFU recommend under 19s in school or college rugby with a suspected or confirmed concussion are only allowed to return to competitive play after clearance by a doctor and that this should not happen before 23 days after the injury.[59]
3. Public health approaches to injury prevention should be adopted by the government, rugby authorities, schools and local authorities to raise awareness among parents and school authorities on the risks of concussion, its management and prevention.
4. Given that rugby is a compulsory sport in many schools in the UK and young rugby players have a significant risk of concussion, there should be no compulsion to play rugby as part of school education.

What is already known?

- Playing rugby is a major cause of injury in children and adolescents.
- Concussion is the most common injury in professional rugby union in England.

What are the new findings?

- Studies show the probability of concussion to a child or adolescent rugby player over the course of a season to be between 0.3% and 11.4% in rugby union and 7.7% or 22.7% in rugby league.
- The largest prospective study available estimates a probability of 11.4% of a child or adolescent rugby union player sustaining a concussion over a season, equivalent to between one and two players in every school or club youth rugby team sustaining a concussion every season on average.

Acknowledgements The authors thank Dr Andreas Freitag (AF) and Dr Sebastian Scharer (SS) for literature searching as part of a larger rugby injury study. The authors thank also the Barts Charity for funding for staff through the Centre for Trauma Sciences project.

Contributors NP and GK contributed equally to this work, AMP conceived the study, GK, RO-A, AF and SS (see acknowledgements) conducted the initial literature search on general rugby injury; GK and RO-A extracted the detailed data on concussion. NP, GK and AMP drafted the manuscript and approved the final version for publication. GK is guarantor.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.

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Graham Kirkwood, Nikesh Parekh, Richard Ofori-Asenso and Allyson M Pollock

Br J Sports Med 2015 49: 506-510 originally published online January 13, 2015
doi: 10.1136/bjsports-2014-093774