Title:

Match injuries in English youth academy and schools rugby union

Running Title:

Injuries in English youth rugby union

Authors:

Deborah S Palmer-Green[1,2], Keith A Stokes[1], Colin W Fuller[3], Michael England[4], Simon P T Kemp[4], Grant Trewartha[1]

Affiliations:

[1] Sport, Health and Exercise Science, University of Bath, Bath, UK.

[2] Centre for Sports Medicine, University of Nottingham, Nottingham, UK.

[3] International Rugby Board, Dublin, Ireland.

[4] Rugby Football Union, Twickenham, UK.

Corresponding Author:

Grant Trewartha,

Sport, Health and Exercise Science,

Department for Health,

University of Bath,

Bath, UK.

BA2 7AY

Tel: +44 1225 383055

Fax: +44 1225 383833

Email: g.trewartha@bath.ac.uk

Institution:

This study was performed within the Sport, Health and Exercise Science group at the University of Bath.

Acknowledgements:

We would like to thank the academy managers, medical and strength and conditioning personnel at the rugby academies of the following clubs: Bath, Gloucester, Leeds, Leicester, London Irish, Northampton, Newcastle, Sale, Saracens, Wasps and Worcester; and the rugby coaches, and medical staff at the following schools and colleges: S.W.E.R.A., Ivybridge, Barnard Castle, Bryanston, Hartpury, Hymers, Millfield, Nottingham High, and Sedbergh, without whose input during data collection this study would not have been possible.

TITLE

Epidemiological study of match injuries in English youth academy and schools rugby union

ABSTRACT

Background: Numerous injury epidemiology studies have reported injury patterns in senior rugby union but investigations in youth rugby are limited.

Hypothesis/Purpose: The aim of this research was to determine the incidence and nature of match injuries in English youth rugby union, making comparisons between two different levels of participation.

Study Design: A prospective cohort design

Methods: A two season (2006/07; 2007/08) study obtained information on injuries sustained in male youth (16 – 18 yrs) rugby union players from 12 English Premiership academies (n = 250) and 7 schools (n = 222). Match exposure (player-hours) and injury details were recorded.

Results: Match injury incidence was 47/1000 player-hours for the academy and 35/1000 player-hours for the school groups; these rates were statistically different ($P = 0.026$). The most common injury site was the lower limb and the most common injury type was a ligament sprain, with injuries to the knee and shoulder region resulting in the greatest burden of injury for both groups. The tackle event was the most common cause of match injury for both academy (51% of injuries) and school (57% of injuries) groups.

Conclusion: Overall the incidence of injury for youth rugby was lower than for previous studies in senior rugby but injury patterns (location, type) and causes were similar. The study confirmed that match injury incidence was significantly greater in elite academy youth rugby union than schools rugby. The results suggest that specific focus for injury risk management in youth rugby should be on players' tackle technique, and prevention strategies for knee and shoulder injuries.

Key Terms: sport; injury; epidemiology; youth; injury risk

What is known about the subject:

Injury rates in senior elite rugby union are considered high in relation to other team sports. Some small-scale studies on youth rugby union have suggested injury rates are lower than senior rugby.

What this study adds to existing knowledge:

This study provides a large-scale longitudinal study of English elite youth rugby at two different levels and demonstrates that injury rates are lower for youth rugby but not as low as most other studies have previously found.

The injury incidence was 34% greater at the higher playing level of elite academy rugby than school rugby but the severity of recurrent injuries was greater in schools.

Similar injury patterns (location, type, event) were observed between groups and to senior rugby but emphasized the need to focus on reducing tackle event injuries in youth rugby players

INTRODUCTION

Rugby union is one of the most popular worldwide sports, ranking second in participation rates only to soccer as a football code. However, rugby union has increasingly come under scrutiny from an injury perspective because the incidence of injury at the professional level is one of the highest of any team sport[5] albeit with similar injury rates to other full-contact sports, such as rugby league,[19] Australian Rules Football,[36] American Football[25] and ice-hockey.[29] Compared with semi-contact team sports such as soccer, rugby union has four times the incidence of injury, with the potential for more serious injuries.[33] Injury incidence and severity have been reported for senior amateur and professional rugby union with the consensus that injury rates increase with competitive level.[1-3, 5-7, 23, 40]

Young people are thought to be at relatively greater risk of injury if they are exposed to high levels of sport participation during the time when musculoskeletal developmental changes are occurring.[17] Injury risk in youth sport is multi-factorial, and is modified by skill level,[9, 38] physical characteristics[30] and competitive environment.[38, 39] However, injury surveillance within youth age group rugby union is somewhat limited in scope and scale, and comparisons suffer due to the variety of methodologies employed. Existing data generally show that incidence rates in youth rugby union are lower than in senior rugby union,[20, 34] with increasing incidence in the older youth age groups.[14, 20] Injury patterns, in terms of location and types of injury, are broadly similar to senior rugby.[14, 24, 32, 34] England has the highest youth rugby union participation in the world,[22] but to date only small-scale injury surveillance studies have been conducted within the English game at youth level.[20]

Therefore, the aim of this study was to describe the nature of injuries resulting from match play within English youth rugby union, including a comparison between two levels of play within the same age group; namely professional academy *versus* school rugby.

METHODS

The study was an observational prospective cohort design that used a questionnaire-based data collection procedure. Data collection occurred over two complete seasons (2006/07 and 2007/08) and involved twelve English Premiership youth academies and seven senior school rugby union teams. The Premiership academy players represent the elite level of youth rugby (15% of the academy cohort represented national age-group teams during the study). The school players were recruited from very established rugby-playing schools which generally performed well in national-level schools competitions. Players participating in the study were aged 16-18 years and were excluded if they had not reached 16 years by the start of the rugby season in question or would have reached 19 years during the season. Written informed consent was obtained from individual players and passive consent forms were sent to all parents / legal guardians to provide an opportunity to opt-out. The cohorts comprised 250 academy players (2006/07: 131; 2007/08: 119) and 222 school players (2006/07: 139; 2007/08: 83), with 46 academy and 10 school players participating in both seasons. There were 121 forwards and 129 backs in the academy cohort, and 122 forwards and 100 backs in the school cohort. Body mass and body height were recorded for each player at the beginning of the season.

For the purposes of injury surveillance the start date was taken as 1st July and the end date was 30th June for each season; however competitive matches (and therefore the match exposure) were played between September 1st and April 30th in each season.

All injury definitions used were consistent with the 2007 IRB consensus statement.[15] The primary injury definition used was for time-loss injuries, which were defined as 'any injury that prevents a player from taking a full part in all training and match play activities typically planned for that day for a period of greater than 24 hours from midnight at the end of the day the injury was sustained'. Recurrent injury was defined as 'an injury of the same type and at the same site as an index (new) injury, occurring after a player's return to full participation from the index injury'. Injury severity was defined by the total number of days elapsed from the day of injury until a player returned to full fitness; full fitness being defined as 'the player being able to take a full part in training activities typically planned for that day and available for match selection'. Details of each individual injury were recorded on a specific form utilising the OSICS version 8 [41] coding system, and including the date of injury, classification of the injury at two levels (body site, type of injury), information on the injury event, and the date of return from injury. Match exposure was calculated as the number of matches multiplied by the number of registered players per team multiplied by 1.33 hours, with the appropriate correction applied if a team had less than 15 players registered in the audit. Within academies, match exposure and injury data were collected by the strength and conditioning coach and physiotherapist, respectively. Within schools, the first team coach recorded match exposure and the school nurse or doctor recorded injury data. One criterion used for schools to be included in the study was that a nominated medical professional (either an on-site nurse, physiotherapist or doctor) had to treat all rugby injuries sustained. This restriction was considered important from a data quality perspective but may have biased the school cohort towards the higher end of the overall school playing population in England.

Exposure and injury data for the two seasons were combined. Injury incidence was reported as the number of injuries per 1000 player-match hours with 95% confidence intervals (CI). Injury severity was reported as the mean and median number of days absence from training and match play. Injury burden was calculated by multiplying injury incidence by mean severity and presented as total days absence per 1000 player hours.[16] Significant differences in values for injury incidence and severity were calculated using two-tailed Z tests.[27] Significance was accepted at $P \leq 0.05$ (equal variances assumed) and exact *P* values are reported throughout.

Ethical approval for the study was obtained from the institutional ethics committee.

RESULTS

Academy players were significantly taller ($P = 0.002$) and heavier ($P = 0.001$) than school players. Forwards were significantly taller and heavier than backs for both academy (height: $P = 0.001$; body mass: $P = 0.001$) and school (height: $P = 0.003$; body mass: $P = 0.001$) groups (Table 1).

Incidence and severity of match injury

In total, 2343 player match hours (forwards: 1132; backs: 1211) and 109 match injuries (forwards: 44; backs: 65; new: 96; recurrent: 13) were recorded for academies, and 3843 player match hours (forwards: 2060; backs: 1783) and 134 match injuries (forwards: 69; backs: 65; new: 119; recurrent: 15) for schools during the study. There were a total of 3441 and 3947 lost days of playing and training time because of match injuries within academies and schools, respectively. The match injury incidence was 47 injuries per 1000 player match hours (95% CI 39 to 57) in the academy group, and 35 injuries per 1000 player match hours (95% CI 29 to 41) for the school group. These rates were significantly different (*P*=0.026, Table 2) and the rate ratio was 1.34 (95% CI 1.04 to 1.72). The mean severity of all match injuries was not significantly different between academies and schools (*P* = 0.617) but the mean severity of recurrent injuries was greater in schools (*P* = 0.013) (Table 2).

Nature of match injury

Injury location

The lower limb was the most commonly injured body area for both academies and schools (Figure 1) and this was the same for forwards and backs. For the academy group the mean severity of injuries was highest for the trunk, whereas injuries to the upper limb were the most severe for the school group (Figure 1).

By individual anatomical location, the incidence of match injuries was highest to the ankle/heel, shoulder and knee within academies, with the incidence of ankle/heel injuries higher than in schools (*P* = 0.02). In schools, the incidence of match injuries was highest to the shoulder and head (Figure 2a). The most severe match injuries occurred to the lumbar spine and knee in academies and to the shoulder in schools (Figure 2b). Combining incidence and severity to produce injury burden values as a measure of the overall injury risk demonstrated that shoulder and knee injuries resulted in the highest burden for both the academy and school groups (Figure 2c).

Injury type

The incidence of joint (non-bone) ligament injuries was higher than other injury types in both academies and schools and significantly higher in academies compared with schools (academy: 24/1000 player match hours; school: 14/1000 player match hours; $P < 0.01$) (Table 3). There were no other significant differences between playing groups.

Combining injury location and injury type for specific diagnoses, knee anterior cruciate ligament (ACL) injuries for the academies and shoulder dislocation/instability injuries for schools resulted in the greatest number of overall days lost (Table 4).

Injury event

Injuries were more likely to occur during contact events (academy: 77%; school: 87%) (Table 5). The tackle was the event most commonly associated with injury in both academies and schools, including being tackled (academy: 30% of all injuries; school: 32% of all injuries) and tackling (academy: 21% of all injuries; school: 25% of all injuries). Being tackled (academy: 443 days absence/1000 player match hours; school: 345 days absence/1000 player match hours) and tackling (academy: 325 days absence/1000 player match hours; school: 264 days absence/1000 player match hours) posed the greatest injury burden during matches within both academies and schools (Figure 3), possessing significantly more risk when compared with all other contact events (all $P < 0.05$). Cross-referencing injuries to specific body regions and the match events which caused them, being tackled was the most common cause of all lower limb injuries (academy: 35% [95% CI 23 to 47]; school: 44% [95% CI 32 to 56] of lower limb injuries) while tackling was the most common cause of all upper limb injuries (academy: 48% [95% CI 30 to 66]; school: 53% [95% CI 36 to 70] of upper limb injuries). In academies, the majority of knee injuries were associated with being tackled (70% of knee injuries), and this injury combination represented the greatest burden. In schools, 41% of all shoulder injuries were sustained during tackling and these injuries resulted in the greatest number of overall days lost.

DISCUSSION

This study determined the incidence, severity, nature and match events relating to injury in English Premiership academy and school rugby union. The main findings are: (i) match injury incidence was approximately 34% higher in the academy group than the school group and this difference was statistically significant, (ii) severity of new injuries was not significantly different between groups, but severity of recurrent injuries was greater in the school group, (iii) the lower limb was the most common injury location for both academy and school players, (iv) joint ligament injuries were the most common type of injury and (v) the tackle was the most common injury event during matches for both academy and school players.

The incidence of match injuries within this study was higher than reported in most previous youth rugby union research where a similar injury definition was used. Kerr *et al.*[26] reported 17 injuries/1000 player match hours for American collegiate (17-21 yrs) rugby compared with values of 47 and 35 injuries/1000 player match hours for academy and school players, respectively, in the present study. In two smaller studies which conformed to the IRB consensus statement for reporting injuries, the match injury incidence for Scottish schools rugby with a wider age range (11-17 years) was reported at 11/1000 player match hours,[34] although the injury rate at U17 level in a single English community club was 49/1000 player match hours (approximate 95% CI: 26 to 74 injuries/1000 player match hours).[20] Two studies published prior to the IRB consensus statement reported injury incidences in youth rugby of 28 injuries/1000 player hours in New Zealand[24] and 13 injuries/1000 player hours in Australia (14-16 yrs)[32] but these studies combined match and training data[24, 32] which reduces the incidence value since training injury rates have consistently been reported as being considerably lower.[4]

Despite the injury incidence values in the present study returning higher values than most previous studies in youth rugby, the incidence in both groups were considerably less than those previously reported for elite senior male rugby union, for example 91 injuries/1000 player hours for English Premiership club rugby[5] and 84 injuries/1000 player match hours for RWC 2007.[12] A study of international level U20 rugby[14] (higher level and older participants than the present study) returned a match injury incidence rate of 57 injuries/1000 player hours, suggesting that injury rates progressively increase with playing level and age. This finding is in line with most other commentaries on comparative injury rates between youth and adult sport which suggest that injury rates are lower for youth sport.[24, 32]

There is a common claim that higher levels of play are associated with a higher injury incidence.[1-3, 6, 7, 23, 40] Within the present study there was a significant difference in the incidence of match injuries between academies and schools, where the incidence was 34% higher in the professional academies. Academy players had greater height and mass than their school counterparts, and larger players have been reported to have a higher risk of injury.[28] In addition, while fitness testing data were not explicitly collected in the current study, it is reasonable to assume that the professional academy players were physically fitter and stronger due to more sophisticated strength and conditioning programmes and more training time (on average two and a half times the amount of training compared with schools players[37]). On the one hand, better conditioning and preparation could be protective for players[8, 35] but on the other hand stronger and fitter players will generate higher forces during collision phases of the game and are likely to be involved in more contact events, thus exposing them to more potential injury events and therefore increasing the risk of injury. Presently, it is difficult to interpret clearly the independent or combined effects of playing level, player size and player fitness/strength on injury risk but the present data suggest that that there might be a trade-off between level of physical preparation and intensity of rugby such that injury rates between playing levels are greater in higher level youth rugby.

There was no difference in the overall severity of injuries sustained by academy and school players, although a noticeable result was that the mean severity of recurrent injuries was significantly higher in schools (46 days) compared with academies (18 days) despite the mean severity of new injuries being similar in schools (27 days) and academies (33 days). Unlike schools, academy players did not take part in a formal structured academy league season in the playing seasons studied. Hence they potentially had less competitive pressure to return to match play after an index (new) injury occurred. This lack of pressure is likely to allow for more lengthy rehabilitation and a delay in making the decision that a player has returned to full fitness. By contrast, pressure to return to play within schools competing in the National Schools Cup (the primary competition for English schools rugby) may reduce the time for those players to complete rehabilitation and to return to play. Assuming the level of medical support is less in schools (typically nursing support with visiting GPs) than in academies (typically physiotherapist support with access to sports medicine trained doctors) then it might be predicted that schools would take longer to return players to training and competition following injury, however school players were in fact returned to play sooner than academy players (by 6 days on average). This early return from injury may then be the reason for the greater severity of recurrent injuries sustained in the school environment (by 28 days on average). This potential issue of pressure to return to play, either from the player themselves or others, is recognised as one of the 'decision modification' factors proposed in the model of Creighton[10] which needs to be taken into consideration when deciding a return to participation. The present result of recurrent injury severity points to a need for coaches and medical personnel at schools to consider their return to play decision making processes and on average allow greater rehabilitation time for injuries before players return to full training and competition.

Findings in the present study generally agree with previous research that the most common location for injury is the lower limb[3, 24] and the most common type of injury is a joint (non-bone) ligament sprain.[3, 26] When considering injuries to individual body locations, the present study demonstrates an overall pattern which is also similar to previous research[5], with injuries to the knee and to the shoulder representing the highest burden for both levels of play within English youth rugby union. This provides useful information about the direction for future injury prevention strategies.

In terms of the events associated with match injuries, the tackle (being tackled and tackling) produced the highest percentage of injuries for academy (51% of all injuries) and school (57% of all injuries) players. These findings are consistent with previous research where the tackle was the most common match event associated with injury in both senior[1 3, 18] and youth rugby union,[18, 26] with greater rates of injury reported for the player being tackled.[5] The proportion of injuries relating to the tackle event in the current study may even be higher than previously found. For example Brooks et al[5] returned approximately 38% of all injuries due to the tackle event for English Premiership players and Fuller et al[12] returned approximately 35% of all injuries due to the tackle event in RWC 2007. The burden of injuries from tackling or being tackled was also significantly higher than all other injury events for both academies and schools. This finding again reinforces the recommendations from previous rugby injury studies which advocate that attention should be paid to the development of good tackling technique,[11] although it must be remembered that one reason for the high incidence of tackle injuries is the greater number of tackle events per game when compared with other contact events.[13]

Combining the injury location and injury event data, being tackled was the greatest cause of all lower limb injuries (academy: 35%; school: 44%) while tackling was the greatest cause of all upper limb injuries (academy: 48%; school: 53%). Shoulder injuries, in particular dislocations, were most often associated with tackling, with 41% of all shoulder injuries in the school group sustained during tackling and these injuries resulting in the greatest number of overall days lost. A focus on shoulder injuries is important when developing preventative strategies, not just because of their incidence but also their severity.[21] Driving into another player during the tackle or falling onto the shoulder or an outstretched arm in an “at threat” position of abduction and external rotation have been cited as the main mechanisms for shoulder injury.[31]

With regards to methodological considerations, it is recognised that this study only surveyed a small proportion of the youth rugby playing population in England although it did involve the majority of eligible academy level players nationally. The need for appropriate medical support to complete the injury recording probably biased the school cohort to the upper end of the school rugby playing spectrum. The present analysis is also restricted to match-related rugby exposure and the injuries sustained as a direct result of this exposure

CONCLUSIONS

The present study found that the incidence of match injury in English youth rugby union was higher than that reported in most previous studies for youth rugby but lower than reported for senior elite rugby. There were differences in injury rates between playing levels, with 34% higher injury incidence in the academy group. Common injury locations (lower limb), types (ligament) and events (tackle) were generally similar to the results reported in previous epidemiological studies for both junior and senior rugby. However, some recommendations for injury risk management can be specifically tailored for youth rugby union, including continued attention to tackle technique along with targeted injury prevention strategies for the knee and shoulder joint.

COMPETING INTERESTS

None.

REFERENCES

1. Bathgate A, Best JP, Creaig G, Jamieson M. A prospective study of injuries to elite Australian rugby union players. *British Journal of Sports Medicine.* 2002;36:265-269.

2. Best JP, McIntosh AS, Savage TN. Rugby World Cup 2003 injury surveillance project. *British Journal of Sports Medicine.* 2005;39(11):812-817.

3. Bird YN, Waller AE, Marshall SW, Alsop JC, Chalmers DJ, Gerrard DF. The New Zealand rugby injury and performance project: V. Epidemiology of a season of rugby injury. *British Journal of Sports Medicine.* 1998;32(4):319-325.

4. Brooks J, Fuller C. The influence of methodological issues on the results and conclusions from epidemiological studies of sports injuries: illustrative examples. *Sports Medicine.* 2006;36:459 - 472.

5. Brooks JH, Fuller CW, Kemp SP, Reddin DB. Epidemiology of injuries in English professional rugby union: part 1 match injuries. *British Journal of Sports Medicine.* 2005;39(10):757-766.

6. Brooks JH, Fuller CW, Kemp SP, Reddin DB. Epidemiology of injuries in English professional rugby union: part 2 training Injuries. *British Journal of Sports Medicine.* 2005;39(10):767-775.

7. Brooks JH, Fuller CW, Kemp SP, Reddin DB. A prospective study of injuries and training amongst the England 2003 Rugby World Cup squad. *British Journal of Sports Medicine.* 2005;39(5):288-293.

8. Brooks JH, Fuller CW, Kemp SP, Reddin DB. Incidence, risk, and prevention of hamstring muscle injuries in professional rugby union. *American Journal of Sports Medicine.* 2006;34(8):1297-1306.

9. Brust JD, Leonard BJ, Pheley A, Roberts WO. Childrens ice hockey injuries. *American Journal of Diseases of Children.* 1992;146(6):741-747.

10. Creighton DW, Shrier I, Shultz R, Meeuwisse WH, Matheson GO. Return-to-Play in Sport: A Decision-based Model. *Clinical Journal of Sport Medicine.* 2010;20(5):379-385.

11. Fuller C, Ashton T, Brooks J, Cancea R, Hall J, Kemp S. Injury risks associated with tackling in rugby union. *British Journal of Sports Medicine.* 2010;44:159 - 167.

12. Fuller C, Laborde F, Leather R, Molloy M. International Rugby Board Rugby World Cup 2007 injury surveillance study. *British Journal of Sports Medicine.* 2008;42:452 - 459.

13. Fuller CW, Brooks JHM, Cancea RJ, Hall J, Kemp SPT. Contact events in rugby union and their propensity to cause injury. *British Journal of Sports Medicine.* 2007;41(12):862-867.

14. Fuller CW, Molloy MG. Epidemiological Study of Injuries in Men's International Under-20 Rugby Union Tournaments. *Clinical Journal of Sport Medicine.* 2011;21(4):356-358.

15. Fuller CW, Molloy MG, Bagate C, et al. Consensus statement on injury definitions and data collection procedures for studies of injuries in rugby union. *Clinical Journal of Sport Medicine.* 2007;17(3):177-181.

16. Fuller CW, Smith GL, Junge A, Dvorak J. The influence of tackle parameters on the propensity for injury in international football. *American Journal of Sports Medicine.* 2004;32(1 Suppl):43S-53S.

17. Gallagher SS, Finison K, Guyer B, Goodenough S. The incidence of injuries among 87,000 Massachusetts children and adolescents - results of the 1980-81 statewide childhood injury prevention program surveillance system. *American Journal of Public Health.* 1984;74(12):1340-1347.

18. Garraway WM, Lee AJ, Macleod DAD, Telfer JW, Deary IJ, Murray GD. Factors influencing tackle injuries in rugby union football. *British Journal of Sports Medicine.* 1999;33(1):37-41.

19. Gissane C, Jennings D, Kerr K, White JA. A pooled data analysis of injury incidence in rugby league football. *Sports Medicine.* 2002;32(3):211-216.

20. Haseler CM, Carmont MR, England M. The epidemiology of injuries in English youth community rugby union. *British Journal of Sports Medicine.* 2010;44(15):1093-1099.

21. Headey J, Brooks JH, Kemp SP. The epidemiology of shoulder injuries in English professional rugby union. *American Journal of Sports Medicine.* 2007;35(9):1537-1543.

22. IRB. www.irb.com/unions/index.html. Available at: www.irb.com/unions/index.html. Accessed 15 December 2010.

23. Jakoet I, Noakes TD. A high rate of injury during the 1995 Rugby World Cup. *South African Medical Journal.* 1998;88(1):45-47.

24. Junge A, Cheung K, Edwards T, Dvorak J. Injuries in youth amateur soccer and rugby players - compraison of incidence and characteristics. *British Journal of Sports Medicine.* 2004;38:168-172.

25. Kaplan LD, Flanigan DC, Norwig J, Jost P, Bradley J. Prevalence and variance of shoulder injuries in elite collegiate football players. *American Journal of Sports Medicine.* 2005;33(8):1142-1146.

26. Kerr H, Curtis C, Micheli L, Kocher M, Zurakowski D, Kemp S. Collegiate rugby union injury patterns in New England: a prospective cohort study. *British Journal of Sports Medicine.* 2008;42:595 - 603.

27. Kirkwood BR, Sterne JAC. *Essential Medical Statistics*. Second ed: Blackwell Science Ltd; 2003.

28. Lee AJ, Myers JL, Garraway WM. Influence of players' physique on rugby football injuries. *British Journal of Sports Medicine.* 1997;31(2):135-138.

29. Lorentzon R, Wedren H, Pietila T, Gustavsson B. Injuries in International ice hockey - a prospective, comparative-study of injury incidence and injury types in International and Swedish elite ice hockey. *American Journal of Sports Medicine.* 1988;16(4):389-391.

30. Maffulli N. The best athletes are better. *Nature.* 1996;382(6589):294-294.

31. McIntosh AS, Savage TN. *Rugby Union Injury Surveillance Study: Report on Seasons 2002-2004*: University of New South Wales; 2006.

32. McManus A, Cross DS. Incidence of injury in elite junior Rugby Union: a prospective descriptive study. *Journal of Science and Medicine in Sport.* 2004;7(4):438-445.

33. Nicholl JP, Coleman P, Williams BT. The epidemiology of sports and exercise related injury in the United Kingdom. *British Journal of Sports Medicine.* 1995;29(4):232-238.

34. Nicol A, Pollock A, Kirkwood G, Parekh N, Robson J. Rugby union injuries in Scottish schools. *Journal of Public Health (Oxf).* 2010.

35. Olsen OE, Myklebust G, Engebretsen L, Holme I, Bahr R. Exercises to prevent lower limb injuries in youth sports: cluster randomised controlled trial. *British Medical Journal.* 2005;330(7489):449-452.

36. Orchard J, Seward H. Epidemiology of injuries in the Australian Football League, seasons 1997-2000. *British Journal of Sports Medicine.* 2002;36(1):39-44.

37. Palmer-Green DS. *Injury epidemiology and injury prevention in English youth rugby union*, Unpublished PhD Thesis, University of Bath; 2010.

38. Pasque CB, Hewett TE. A prospective study of high school wrestling injuries. *American Journal of Sports Medicine.* 2000;28(4):509-515.

39. Pinto M, Kuhn JE, Greenfield M, Hawkins RJ. Prospective analysis of ice hockey injuries at the junior A level over the course of one season. *Clinical Journal of Sport Medicine.* 1999;9(2):70-74.

40. Quarrie KL, Alsop JC, Waller AE, Bird YN, Marshall SW, Chalmers DJ. The New Zealand rugby injury and performance project. VI. A prospective cohort study of risk factors for injury in rugby union football. *British Journal of Sports Medicine.* 2001;35(3):157-166.

41. Rae K, Britt H, Orchard J, Finch C. Classifying sports medicine diagnoses: a comparison of the International classification of diseases 10-Australian modification (ICD-10-AM) and the Orchard sports injury classification system (OSICS-8). *British Journal of Sports Medicine.* 2005;39(12):907-911.

FIGURE LEGENDS

Figure 1. Body location of match injuries for academy and school players as a percentage of all injuries (with mean severity in brackets).

Figure 2. Specific anatomical location of match injury for academy and school players showing a) incidence (injuries per 1000 player match hours) with 95% confidence intervals; b) severity (mean days absence) with 95% confidence intervals; and c) burden (days absence per 1000 player match hours) with 95% confidence intervals. * significant difference between academy and school at $P \leq 0.05$.

Figure 3 Match injury event burden (days absence per 1000 player match hours) with 95% confidence intervals, for academy and schools.

Table 1. Mean (SD) baseline characteristics for academy and school players (two seasons data combined).

		Academy	School
Height [cm]	Forwards	187.1 (7.4) **††	181.9 (6.6)††
	Backs	179.3 (6.0)	179.2 (5.4)
	All	182.7 (7.6)**	180.7 (6.2)
Body mass [kg]	Forwards	97.1 (10.5) **††	89.2 (12.3) ††
	Backs	80.3 (6.9) *	78.1 (7.2)
	All	87.8 (12.0)**	84.2 (11.7)
BMI [kg/m^2]	Forwards	27.9 (3.0) ††	26.9 (3.3) ††
	Backs	25.0 (1.7) *	24.3 (2.0)
	All	26.2 (2.7)	25.8 (3.1)
Age [years]	Forwards	17.2 (0.6) †	17.2 (0.6)
	Backs	16.9 (0.6)	17.1 (0.6)
	All	17.0 (0.6)	17.1 (0.6)

(significant difference between academy and school * at $P \leq 0.05$; ** at $P \leq 0.01$; significant difference between forwards and backs † at $P \leq 0.05$; †† at $P \leq 0.01$)

Table 2. Match injury incidence (number of injuries per 1000 player match hours, with 95% confidence intervals) and mean (with 95% confidence intervals) and median severity in days absence, for academies and schools.

	Academy		School	
	Incidence (95% CI)	Mean Severity (95% CI) [median]	Incidence (95% CI)	Mean Severity (95% CI) [median]
New	41 (33 to 49)	33 (27 to 39) [20]	31 (25 to 37)	27 (22 to 32) [13]
Recurrent	5 (2 to 8)	18 (8 to 28) [15]*	4 (2 to 6)	46 (23 to 69) [21]
All	47 (38 to 55)	32 (26 to 38) [18]	35 (29 to 41)	30 (25 to 35) [13]

(Significant difference between academy and school * at $P \leq 0.05$)

Table 3. Match injury types expressed as percentage of injuries, incidence (number of injuries per 1000 player match hours, with 95% confidence intervals) and mean severity in days absence (with median values) by injury type for academies and schools.

	Academy			School		
Injury type group	% of injuries	Incidence (95% CI)	Severity (median)	% of injuries	Incidence (95% CI)	Severity (median)
CNS/PNS	4	2 (0 to 3)	20 (20)	9	3 (1 to 5)	16 (19)
Contusion/laceration/lesion	19	9 (5 to 13)	15 (9)	18	6 (4 to 9)	7 (5)
Bone stress/fractures	6	3 (1 to 5)	46 (33)	8	3 (1 to 4)	43 (38)
Joint (non-bone) ligament	51	24 (18 to 30) **	35 (18)	39	14 (10 to 17)	46 (25)
Muscle & tendon	18	9 (5 to 12)	39 (20)	24	8 (5 to 11)	20 (9)
Other	2	1 (0 to 2)	16 -	2	1 (0 to 2)	20 -

(CNS/PNS = central and peripheral nervous system. Median values are not presented where there were less than 3 injuries in the category displayed. Significant difference between academy and school * at $P \leq 0.05$; ** at $P \leq 0.01$)

Table 4. Match injuries causing the greatest overall total days lost for academies and schools.

Academy			School		
Injury	Number of injuries	Days Lost	Injury	Number of injuries	Days Lost
Knee ACL	3	554	Shoulder dislocation / instability	8	986
Knee meniscus / cartilage	4	367	Knee general	14	431
Shoulder rotator cuff	6	297	Wrist/Hand/Finger general	9	363

NB. ‘general’ injuries occur when a specific diagnosis has not been possible.

Table 5. Match injury events expressed as percentage of injuries and incidence (number of injuries per 1000 player match hours, with 95% confidence intervals) and mean severity in days absence (with median values) by injury type for academies and schools.

Injury Event	Academy			School		
	% of injuries	Incidence (95% CI)	Severity (median)	% of injuries	Incidence (95% CI)	Severity (median)
Collision	6	3 (1 to 5) [t,u,n]	10 (5)	4	1 (0 to 3) [r,t,u,n]	32 (20)
Ruck/maul	14	6 (3 to 9) [s,t,o]	27 (20)	16	5 (3 to 8) [c,s,t,o]	15 (7)
Scrum	3	1 (0 to 2) [r,t,u,n]	30 (27)	7	2 (1 to 4) [r,t,u]	30 (8)
Tackled	30	12 (8 to 17) [c,r,s,o]	36 (21)	32	10 (7 to 13) [c,r,s,o,n]	34 (14)
Tackling	21	9 (5 to 13) [c,s,o]	36 (18)	25	8 (5 to 11) [c,s,o]	33 (20)
Other contact	3	1 (0 to 3) [r,t,u,n]	18 (24)	3	1 (0 to 2) [r,t,u,n]	36 (48)
All Contact	77	32 (25 to 39)	32 (20)	87	27 (22 to 32)	30 (16)
All Non Contact	23	10 (6 to 14) [c,s,o]	30 (20)	13	4 (2 to 6) [c,t,o]	26 (11)

Pairwise comparisons for contact injury events are reported by the following convention: [c]= different from Collision; [r]= different from Ruck/maul; [s]= different from Scrum; [t]= different from Tackled; [u]= different from Tackling; [o]= different from Other; n= different from Non-contact, all at $P \leq 0.05$. The specific event associated with the match injury was recorded for 101 out of 109 injuries for the academy group and 121 out of 134 injuries for the school group, with 100% in Table 5 equating to the number of injuries with known events.

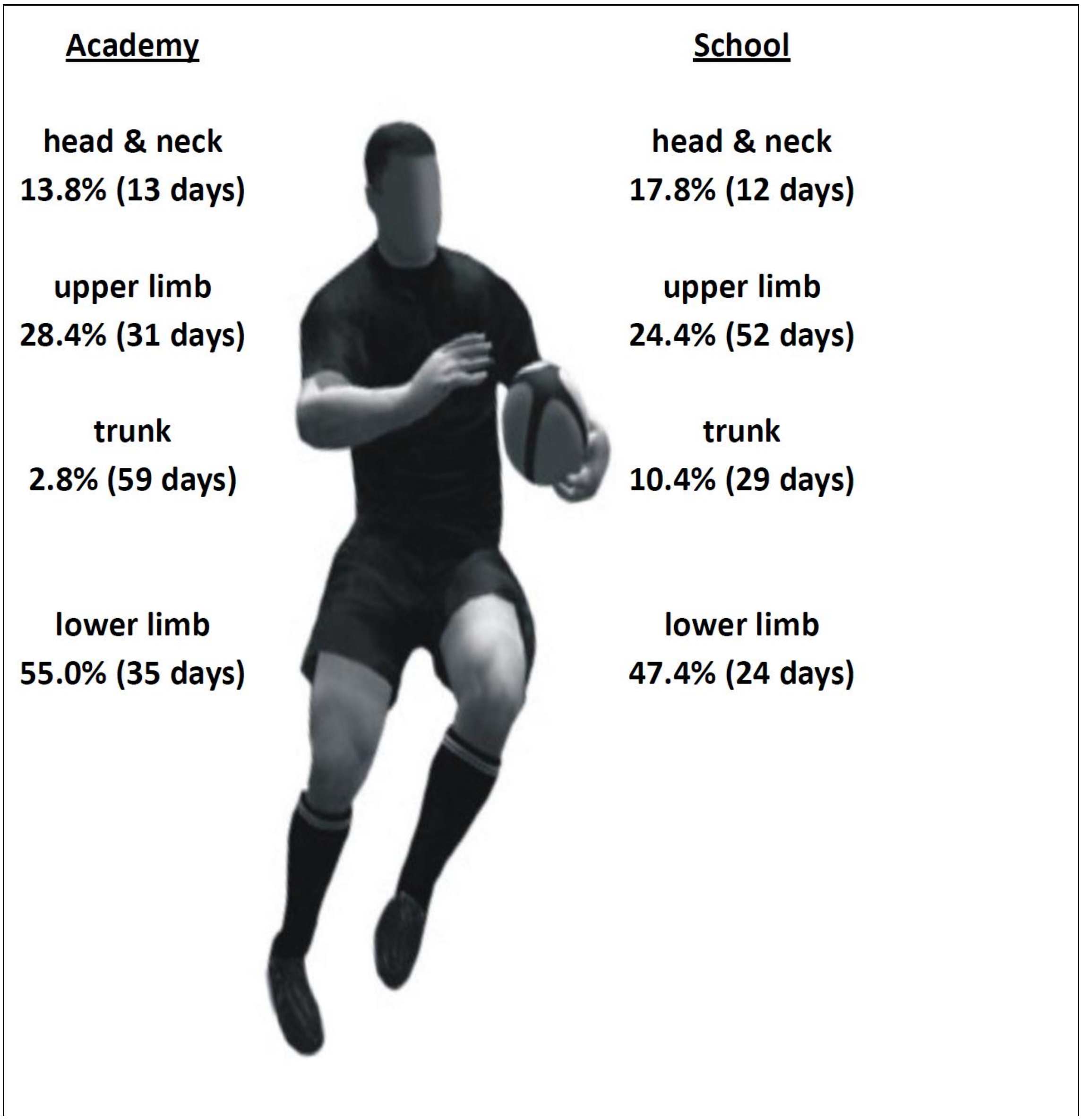
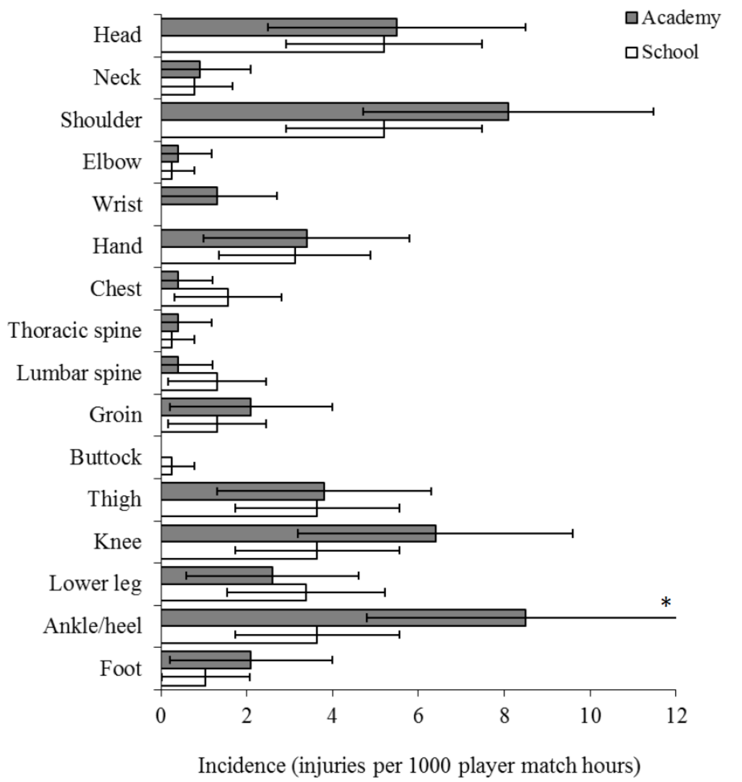
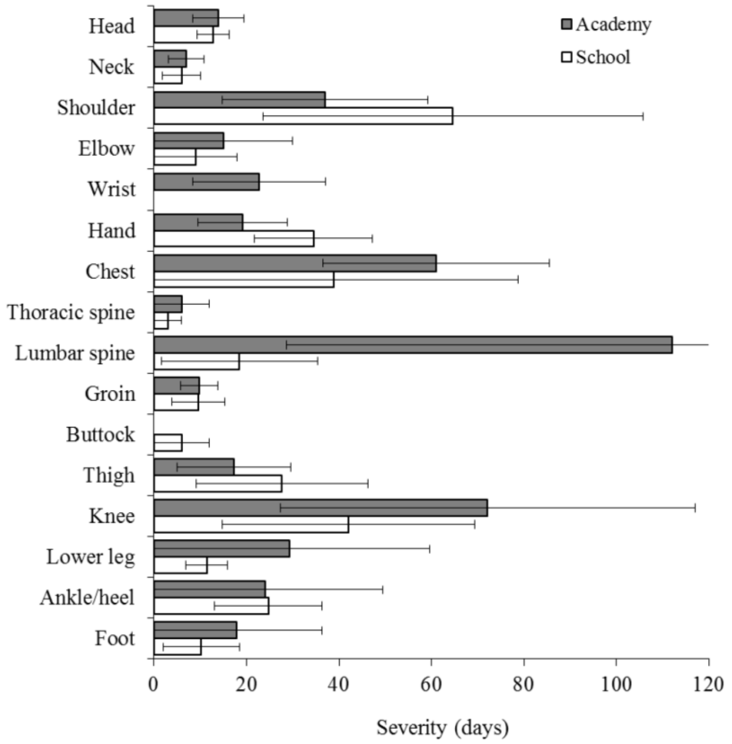

Academy
School
head & neck
13.8% (13 days)
upper limb
28.4% (31 days)
trunk
2.8% (59 days)
lower limb
55.0% (35 days)
head & neck
17.8% (12 days)
upper limb
24.4% (52 days)
trunk
10.4% (29 days)
lower limb
47.4% (24 days)

Figure 1


Academy
School
Head
Neck
Shoulder
Elbow
Wrist
Hand
Chest
Thoracic spine
Lumbar spine
Groin
Buttock
Thigh
Knee
Lower leg
Ankle/heel
Foot
*
0
2
4
6
8
10
12
Incidence (injuries per 1000 player match hours)


Academy
School
Head
Neck
Shoulder
Elbow
Wrist
Hand
Chest
Thoracic spine
Lumbar spine
Groin
Buttock
Thigh
Knee
Lower leg
Ankle/heel
Foot
0
20
40
60
80
100
120
Severity (days)

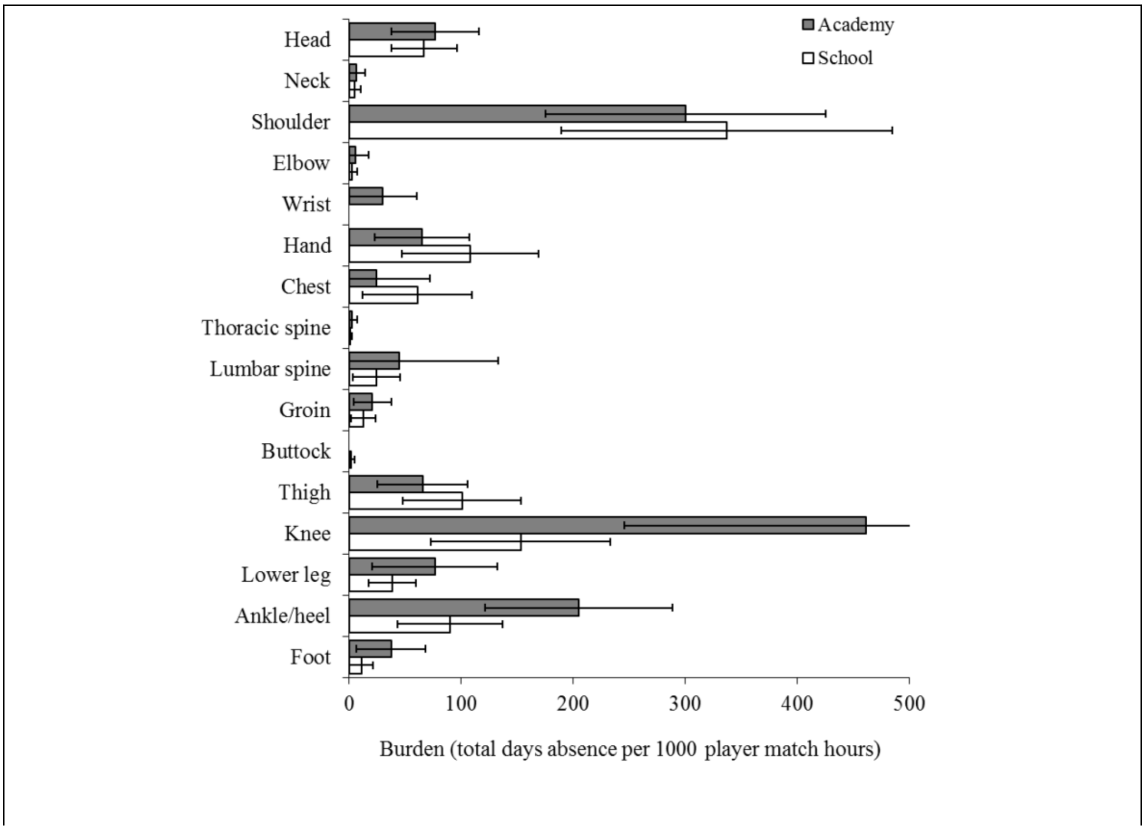

Academy
School
Head
Neck
Shoulder
Elbow
Wrist
Hand
Chest
Thoracic spine
Lumbar spine
Groin
Buttock
Thigh
Knee
Lower leg
Ankle/heel
Foot
0
100
200
300
400
500
Burden (total days absence per 1000 player match hours)

Figure 2

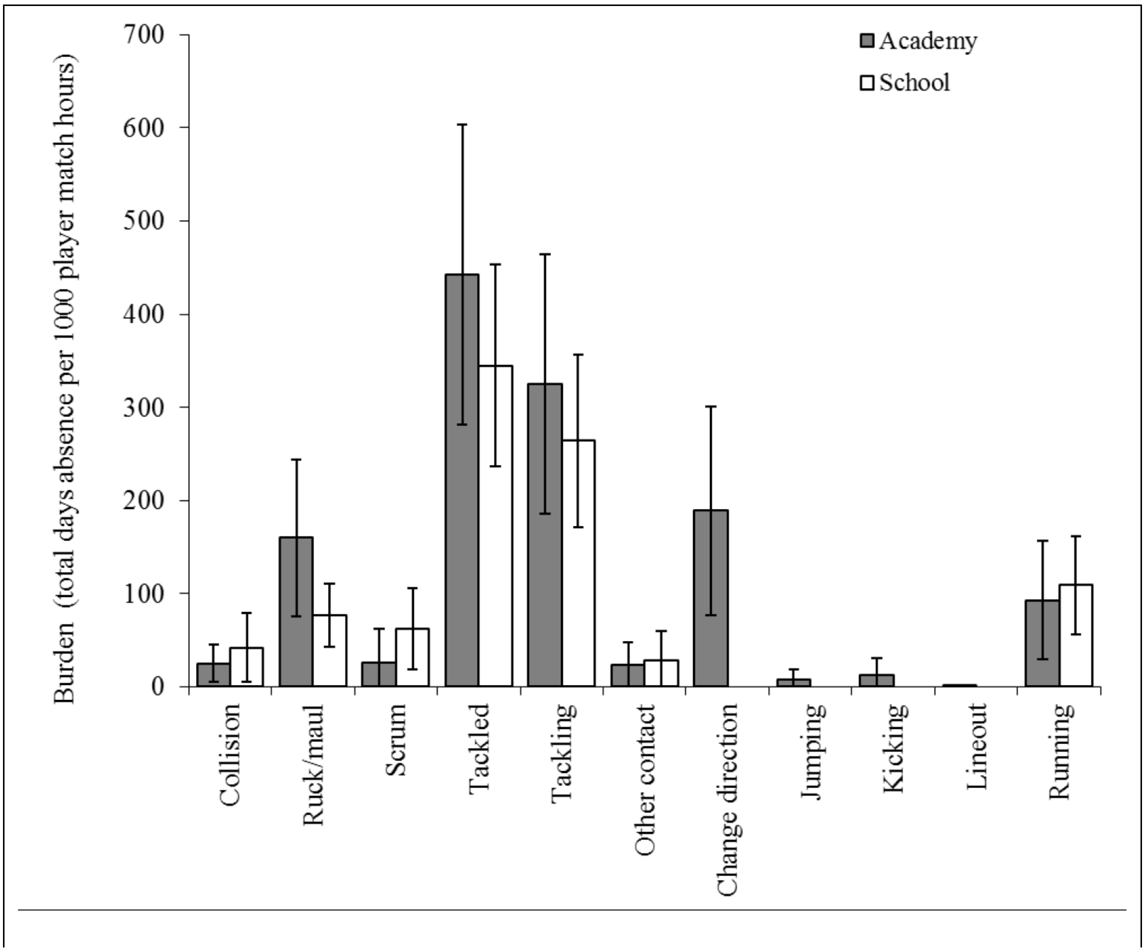

Burden (total days absence per 1000 player match hours)
700
600
500
400
300
200
100
0
Academy
School
Collision
Ruck/maul
Scrum
Tackled
Tackling
Other contact
Change direction
Jumping
Kicking
Lineout
Running

Figure 3