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**Abstract:** Objectives: The recognition and management of concussion has become a major health concern within rugby union. Identifying misconceptions and attitudes regarding concussion is valuable for informing player education. Therefore, the purpose of this study was to explore the knowledge of, and attitudes towards, concussion in subgroups of youth rugby players.

**Design:** Cross-sectional survey.

**Methods:** Information sheets and consent forms were distributed at training sessions for multiple teams at each of three schools and three clubs. Players who returned consent forms completed a custom-designed survey at a subsequent session.

**Results:** Two hundred and fifty-five English players, aged 11 to 17 years, completed the anonymous survey. Sixty-one participants reported a total of 77 concussions. Self-reported return to play ranged from 0 to 365 days; only seven players (11%) reported a return to play after the Rugby Football Union's recommendation of 23 days. Although the majority of findings relating to players' knowledge of concussion were positive, a number of important misunderstandings were revealed. While the majority of players reported positive attitudes towards concussion, a substantial minority (up to 30%) reported inappropriate attitudes in response to specific questions. Participants who played at multiple venues did report superior knowledge and attitudes relative to their peers who played at a single venue.

**Conclusion:** Despite generally positive results, youth rugby players were found to hold a number of misconceptions regarding concussion which should be the focus for education initiatives. Considering general subgroups of players by concussion history, age, or playing position appears unlikely to enhance the design of concussion education programmes.

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6 **Misunderstandings of concussion within a youth rugby population**

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## 1 Misunderstandings of concussion within a youth rugby population

2 **1. Introduction**

3 The recognition and management of concussion in youth sport has become a major public health  
4 concern<sup>1</sup>, particularly within rugby union<sup>2</sup>. Concussion has been defined as a “traumatically induced  
5 transient disturbance of brain function and involves a complex pathophysiological process”<sup>1</sup>. The  
6 incidence of child and adolescent match concussion has been reported as ranging from 0.2 to 6.9  
7 concussions per 1000 player-hours<sup>2</sup>, although these figures may well be lower than the reality due to  
8 the difficulty in making a diagnosis at training sessions and fixtures where a sufficiently trained  
9 professional is not available<sup>3</sup>. Additionally, an under-reporting of concussions may further deflate  
10 these figures<sup>4,5</sup>. This under-reporting likely stems from a lack of knowledge regarding the symptoms  
11 and consequences of concussion among players, coaches, and parents, as well as poor attitudes  
12 towards reporting concussion<sup>6-8</sup>. Developing appropriate knowledge about and attitudes towards  
13 concussion is vital, as unidentified concussive injuries, especially among young athletes, lead to an  
14 increased risk of additional and more complicated injuries to the brain, and a delayed recovery<sup>1,9</sup>.  
15 Consequently, understanding stakeholder knowledge and attitude has emerged as a major avenue for  
16 research on concussion<sup>1,3</sup>.

17 Misconceptions about concussion have been identified in various youth sport populations,  
18 primarily from a North American context<sup>5,10,11</sup>. Within the sport of rugby union, research is more  
19 limited. In a New Zealand context, a survey of parents suggested very good general knowledge on the  
20 signs and symptoms of concussion, as well as appropriate attitudes towards management<sup>7</sup>. However,  
21 parents showed a lack of knowledge regarding specific return to play protocols. In an Australian  
22 context, major misconceptions have been identified in coaches’ knowledge about concussion<sup>8</sup>. For  
23 example, fewer than 50% of coaches recognised the increased risk of suffering a second concussion if  
24 a player returned to play before the first concussion had fully healed, while fewer than 25% of  
25 coaches were aware that recovery time for youth players is longer than that for adults. Four papers  
26 have identified similar misconceptions held by players: two from Irish samples<sup>12,13</sup>, one from  
27 Australia<sup>14</sup> and one from New Zealand<sup>15</sup>. For example, within the New Zealand context 25% of

1 players mistakenly believed that losing consciousness was necessary for an injury to be classified as  
2 concussion<sup>15</sup>. Together, these studies highlight both the importance of assessing the knowledge base  
3 of key stakeholders with regard to concussion management, and also that the findings from different  
4 populations (e.g., parents v players, populations from different countries) cannot be generalized.

5 Adequate knowledge is important for young rugby players to understand and deal  
6 appropriately with their concussion; however, knowledge alone does not always lead to appropriate  
7 behaviour<sup>10, 16, 17</sup>. For example, within a New Zealand rugby context, nearly 30% of players believed  
8 that a player with a suspected concussion should continue to play in important games<sup>15</sup>. Furthermore  
9 76% of young rugby players were aware of a concussed teammate who had been pressured to  
10 continue playing<sup>15</sup>. The above findings make clear that in addition to promoting players' knowledge  
11 of concussion, it is vital that player education initiatives continue to emphasise positive attitudes  
12 towards concussion management.

13 To date, limited research has examined subgroups within youth rugby populations who might  
14 be more at risk of concussion due to poor knowledge or attitudes. If misconceptions or biased  
15 attitudes were found to exist within these subgroups, then education initiatives could be shaped  
16 accordingly. One variable which has been investigated is history of concussion, but worryingly, it  
17 appears that a history of concussion does not promote superior knowledge or behaviours relative to  
18 players without a history of concussion<sup>13, 14</sup>. Due to the differences in game activities required by  
19 different positions<sup>18</sup>, playing unit (i.e., forward v backline) is an obvious candidate for investigation.  
20 While no differences have been found between forwards and backline players in the length of time  
21 that players sit out following a concussion<sup>14</sup>, research has yet to directly investigate the knowledge  
22 and attitudes held by individuals from each playing unit. A third variable which might influence  
23 knowledge of, and attitudes towards concussion is player age. Across a range of sports, older athletes  
24 were associated with superior knowledge of concussion, while younger athletes were associated with  
25 better self-reported behaviours<sup>10</sup>. However, the influence of age on knowledge and attitudes relating  
26 to concussion has not been investigated within a rugby union population. Finally, the Developmental  
27 Model of Sport Participation emphasises the importance of players being exposed to a broad range of  
28 social contexts for optimal development<sup>19</sup>. With regard to concussion education, it might be

1 hypothesised that players who participate in multiple contexts (e.g., school and club) would show  
2 superior knowledge of, and attitudes towards concussion relative to players who participate in a single  
3 context. In summary, the objective of the current study was to establish the extent to which  
4 concussion history, playing position, age and number of playing venues influenced knowledge of and  
5 attitudes towards concussion in a sample of youth rugby players.

## 6 **2. Method**

7           With institutional ethical approval (Application 1516\_21), coaches and secondary school  
8 teachers from three state schools and three rugby clubs in the counties of Hertfordshire and Sussex in  
9 the south of England were contacted via email for participation in the study. Once approval from the  
10 administrators and teachers/coaches at the school or club had been granted, informed consent was  
11 sought from the rugby players and their parents. Subsequently, players who returned completed  
12 consent forms were asked to complete the survey independently. To encourage honest responses, the  
13 submitted surveys did not include any identifying information. Data collection was carried out in  
14 January and February of 2016.

15           The survey instrument drew upon surveys used in previous research on concussion in youth  
16 populations<sup>15, 20, 21</sup>. Questions were modified to ensure that they would be suitable for the target  
17 audience. To ensure that the survey was phrased appropriately, in addition to the research team, the  
18 draft survey was completed and reviewed by an under 15s rugby coach, a secondary school teacher  
19 who was also a rugby coach, a parent of a rugby playing child aged 13 and four rugby playing  
20 children aged between 11 and 17 years. Furthermore, to ensure that the survey was appropriate to  
21 newcomers to rugby, four non-rugby playing children aged 11-17 years also completed the survey.  
22 The final survey initially requested demographic information. This demographic information included  
23 whether a concussion had been experienced, and if so, in which phase of play the concussion  
24 occurred, and how long before the participant returned to play. Subsequent questions addressed  
25 participants' knowledge of the causes, symptoms, consequences, and treatment of concussion, as well  
26 as participants' attitudes towards concussion and its reporting. Questions required a True/False or

1 multiple choice answer. Knowledge and attitude questions are displayed in Table 2, and a copy of the  
2 survey is available from the authors on request.

3 To address the possibility that survey responders would answer questions in a manner that  
4 would be viewed favourably by the researchers (i.e., social desirability bias), short form A of the  
5 Crandall Social Desirability test for children<sup>22</sup> was also included in the survey. There is no categorical  
6 standard for determining socially desirable answers, but consistent with previous research<sup>23</sup>, socially  
7 desirable answers were defined as those in which the participants score was greater than or equal to  
8 1.5 standard deviations above the sample mean.

9 Descriptive statistics were generated through Microsoft Excel. Answers to the 10 knowledge  
10 and 11 attitude questions were scored 1/correct or 0/incorrect, to produce overall scores (medians and  
11 median absolute deviations (MAD)) for both knowledge and attitude. As these overall scores were not  
12 normally distributed, Mann Whitney U tests were used to determine whether the categories of age,  
13 playing unit, number of venues, and concussion history influenced knowledge and attitude scores.  
14 Pearson's correlation coefficient (r) provided a measure of effect size. To control the familywise error  
15 rate, the Holm-Bonferroni procedure<sup>24</sup> was followed. The Holm-Bonferroni adjusted p-values were  
16 obtained by ordering p-values from lowest to highest. The smallest p-value was then multiplied by k,  
17 where k was the number of hypotheses to be tested (in this case, eight). The resulting p-value was  
18 considered to be statistically significant if it was less than 0.05. The next smallest p-value was then  
19 multiplied by k-1, and again compared to 0.05. This process was continued until a null hypothesis was  
20 not rejected.

### 21 **3. Results**

22 Two hundred and sixty-two rugby players initially completed the survey. Seven participants  
23 were identified as showing high social desirability bias. Upon further inspection, these participants  
24 were removed from the sample as they had provided the socially desirable response to all attitude  
25 questions. Consequently, the final sample consisted of 255 players, male (238) and female (17) aged  
26 11-17 years (mean  $\pm$  SD, 13.5  $\pm$  1.33 years) with varying experience completed the surveys. As  
27 players in the Under 15-18 category play under a common set of rules, with only minor changes from

1 the adult game (<http://www.englandrugby.com/governance/regulations/>), participants were classified  
2 according to age (131 younger players  $\leq 13$  years; 124 older players  $\geq 14$  years), playing position  
3 (130 forwards; 125 backs), playing location (130 players who played at both school and club, and 125  
4 who played at a single venue only), and concussion history (61 players who self-reported a prior  
5 concussion, 194 players with no history of concussion).

6         Sixty-one participants within the study (24%) reported a total of 77 concussions. Forward  
7 players were more at risk in general, suffering 65 of the 77 total reported concussions. Across all  
8 subgroups, the majority of concussions resulted from tackle situations (Table 1). Self-reported return  
9 to play ranged from 0 to 365 days. Three players did not report a timescale. Only seven players (11%)  
10 reported a return to play after the Rugby Football Union's recommendation of 23 days.

11         The majority of participants (99%) correctly identified a concussion as an injury to the brain.  
12 The remaining three participants, all from the younger player category, misidentified concussion as a  
13 spinal cord injury. Overall, the findings reveal a number of positive messages regarding youth  
14 players' knowledge of concussion (Table 2). For example, 91% of participants could identify that  
15 participants who have suffered one concussion were not less at risk of a second, while 82% reported  
16 that losing consciousness was not required for a player to be concussed. However, the results also  
17 highlight a number of key misunderstandings held by players. For example, 80% of players agreed  
18 with the statement that "Concussions can only occur from a hit to the head". Only 2% of those  
19 surveyed identified correctly that rest was the appropriate treatment for concussion. The majority of  
20 participants (74%) reported that a combination of both rest and medication or physiotherapy was the  
21 appropriate treatment. The remainder of the sample (24%) identified only medication or  
22 physiotherapy as the appropriate treatment for concussion. The sample also performed poorly in terms  
23 of recognising the symptoms that a concussion was getting worse; while 94% correctly identified one  
24 symptom, only one respondent correctly identified all three listed symptoms associated with a  
25 worsening concussion.

26         Table 2 also reveals that the sample held largely positive attitudes towards concussion. For  
27 example, 97% of participants reported that they would tell their coach if they struck their head during  
28 a game, while only 10% of players felt that concussions were less important than other injuries.

1 Worryingly, however, at least 20% of participants reported inappropriate attitudes towards concussion  
2 on questions 12, 15, and 17-19. These five questions relate to feeling a responsibility to play, due to  
3 one's own expectations, or those of teammates or parents.

4 Figure 1 illustrates the differences in knowledge and attitude scores across the subgroups.  
5 Individuals who played for both school and club teams reported significantly higher knowledge scores  
6 (median = 7 correct answers, MAD = 1) than individuals who played at only one venue (median = 6  
7 correct answers, MAD = 1),  $z = -6.879$ ,  $r = 0.164$ ,  $p < 0.001$ . Forwards (median = 7 correct answers,  
8 MAD = 1) demonstrated superior knowledge to backs (median = 6 correct answers, MAD = 1),  $z = -$   
9  $4.643$ ,  $r = 0.135$ ,  $p < 0.001$ . There were no other significant differences in terms of knowledge of  
10 concussion. With regard to attitudes towards concussion, the only significant difference to emerge  
11 was that individuals who played for both school and club teams (median 11 correct answers, MAD =  
12 0) reported a superior attitude compared to individuals who played at only venue (median = 8 correct  
13 answers, MAD = 2),  $z = 4.156$ ,  $r = 0.128$ ,  $p < 0.001$ .

#### 14 **4. Discussion**

15 The purpose of this study was to explore the effect of subgroup membership on knowledge of,  
16 and attitudes towards concussion in a sample of young English rugby players. With 23% of the  
17 sample reporting having experienced a concussion, it appears that concussion effects a substantial  
18 proportion of the youth population. Responses to the survey were in large part positive, particularly in  
19 relation to attitudes towards concussion and its reporting. However, this study clearly highlights that a  
20 number of significant misunderstandings about concussion exist within the surveyed population as a  
21 whole. More specifically, and consistent with previous research, respondents demonstrated poor  
22 knowledge of the symptoms and treatment of concussion<sup>5, 6, 12</sup>. There is a concern that insufficient  
23 knowledge of the diverse, and on occasion delayed, symptoms of concussion, may result in young  
24 athletes not reporting concussions<sup>11, 25</sup>. A major concern with unreported concussions is that players  
25 may return to play prematurely, placing them at risk of further and more complex injuries<sup>1, 9</sup>.  
26 Consistent with previous research in youth rugby union<sup>13, 14</sup>, only 12% of participants reported  
27 adhering to the recommended return to play guidelines. As such, it appears that sustained emphasis is

1 required to ensure that youth players are adequately informed about the symptoms and management  
2 of concussion.

3 Attitudes towards concussion reporting were also generally positive. However, consistent  
4 with previous research in rugby union<sup>13, 15</sup> and in other sports<sup>4, 5</sup>, a substantial minority of the sample  
5 (at least 20%) reported poor attitudes. These attitudes appear to be related to players feeling a  
6 responsibility to play, particularly in relation to important matches. In response to such findings,  
7 researchers are beginning to examine more closely the manner in which concussion education is being  
8 delivered to ensure effective knowledge translation<sup>26-28</sup>. Given the potential for increased knowledge  
9 to encourage athletes to *hide* concussion symptoms<sup>26, 29</sup>, current recommendations stress the need for  
10 concussion education to be an on-going process, focused on population-specific issues, and engaging  
11 the players in the generation and dissemination of information<sup>28</sup>.

12 The present study extended previous research by considering a number of subgroups which  
13 were hypothesised to influence the extent to which rugby players held poor knowledge or attitudes.  
14 Playing rugby in multiple venues (i.e., school and club) emerged as the most important factor in  
15 determining positive knowledge and attitudes. It is likely that this superior knowledge and attitude is  
16 due to players' exposure to a broader range of messages and messengers across different contexts<sup>19</sup>.  
17 As such, individuals who play rugby in multiple venues may be valuable partners in concussion  
18 education initiatives<sup>28</sup>. Forwards were found to be more knowledgeable than backline players, which  
19 may be due to the higher incidence of concussions within forward players in the examined sample.  
20 However, this greater knowledge did not translate to more positive attitudes. Consequently, the  
21 broader message from the present findings is that education initiatives should not be directed at  
22 specific subgroups of players (i.e., playing unit, concussion history, age). Instead, it is probable that  
23 coaches, parents and administrators will be most effective if they identify any misconceptions and  
24 biases present within the specific group of players that they are dealing with, and to devise a bespoke  
25 intervention accordingly.

26 There were a number of limitations to the current study. Data was collected retrospectively,  
27 relying upon accurate self-report of concussion. As a result, players' misunderstandings about the  
28 nature of concussion may have influenced the reported incidence of concussion<sup>5</sup>. In future, research

1 relying upon self-report should also ask participants to confirm how/if their concussion was formally  
2 diagnosed<sup>13</sup>. Selection bias is potentially an additional issue, as not all of the participants who were  
3 approached completed the survey, either through not returning the parental permission slips, or by  
4 opting out. While the majority of those approached did return the surveys, it is a limitation of the  
5 study that we did not accurately record the return rate. A third limitation was that participants'  
6 experiences of concussion education were not recorded. As a result, it is impossible to infer whether  
7 the misconceptions are due to a lack of education, or ineffective methods of education. As described  
8 above, further research is required to understand how to best educate stakeholders regarding  
9 concussion<sup>26</sup>. A final limitation is that the surveyed population was predominantly male. Although the  
10 available evidence suggests that the incidence, symptoms and duration of recovery from concussion  
11 may be increased in females<sup>1,30</sup>, there is a lack of research investigating knowledge of and attitudes  
12 towards concussion within female populations. Future research should seek to address this issue.

### 13 **5. Conclusions**

14 In summary, the current study has extended previous research on concussion in rugby union  
15 by examining the experience of concussion in an English youth rugby population. Results indicate  
16 that concussion is a significant injury risk for this group. Neither age nor previous history of  
17 concussion influenced player knowledge or attitudes, but participants who played at multiple venues  
18 did report superior knowledge and attitudes relative to their peers who played at a single venue.  
19 Furthermore, although the reported knowledge and attitudes within the sample as a whole were  
20 generally good, a number of major misconceptions were identified which should be the focus for  
21 education initiatives.

### 22 **6. Practical Implications**

- 23 • All stakeholders within English youth rugby union need to continue to promote and evaluate  
24 knowledge of, and appropriate attitudes towards, concussion.
- 25 • Within player education programmes, particular attention should be paid to assisting players  
26 to identify both the immediate and the delayed symptoms of concussion.

- 1       • Player education programmes should also prioritise the management of concussion, and in  
2           particular, adherence to the recommended return to play guidelines.

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1 **References**

- 2 1. Harmon KG, Drezner JA, Gammons M et al. American Medical Society for Sports  
3 Medicine position statement: concussion in sport. *Br J Sports Med* 2013; 47:15–26.
- 4 2. Kirkwood G, Parekh N, Ofori-Asenso R et al. Concussion in youth rugby union and  
5 rugby league: a systematic review. *Br J Sports Med* 2015; 49:506–510.
- 6 3. Gardner AJ, Iverson GL, Williams WH et al. A systematic review and meta-analysis  
7 of concussion in rugby union. *Sports Med* 2014; 44:1717–1731.
- 8 4. McCrea M, Hammeke T, Olsen G et al. Unreported concussion in high school football  
9 players: implications for prevention. *Clin J Sport Med* 2004; 14:13–17.
- 10 5. Miyashita TL, Diakogeorgiou E, Hellstrom B et al. High school athletes' perceptions  
11 of concussion. *Orthop J Sports Med* 2014; 2:2325967114554549.
- 12 6. Gourley MM, Valovich McLeod TC, Bay RC. Awareness and recognition of  
13 concussion by youth athletes and their parents. *Athl Train Sports Health Care* 2010;  
14 2:208–218.
- 15 7. Sullivan SJ, Bourne L, Choie S et al. Understanding of sport concussion by the  
16 parents of young rugby players: a pilot study. *Clin J Sport Med* 2009; 19:228–230.
- 17 8. White P, Donaldson A, Sullivan SJ et al. The accessibility, relevance and practicality  
18 of the AFL concussion guidelines: What do community players think? *J Sci Med*  
19 *Sport*. 2014; 18:e102.
- 20 9. King D, Brughelli M, Hume P et al. Assessment, management and knowledge of  
21 sport-related concussion: systematic review. *Sports Med* 2014; 44:449–471.
- 22 10. Kurowski B, Pomerantz WJ, Schaiper C et al. Factors that influence concussion  
23 knowledge and self-reported attitudes in high school athletes. *J Trauma Acute Care*  
24 *Surg* 2014; 77:S12–17.

- 1 11. Register-Mihalik JK, Guskiewicz KM, McLeod TC et al. Knowledge, attitude, and  
2 concussion-reporting behaviors among high school athletes: a preliminary study. *J*  
3 *Athl Train* 2013; 48:645–653.
- 4 12. Baker JF, Devitt BM, Green J et al. Concussion among under 20 rugby union players  
5 in Ireland: incidence, attitudes and knowledge. *Ir J Med Sci* 2013; 182:121–125.
- 6 13. Delahunty SE, Delahunt E, Condon B et al. Prevalence of and attitudes about  
7 concussion in Irish schools' rugby union players. *J Sch Health* 2015; 85:17–26.
- 8 14. Hollis SJ, Stevenson MR, McIntosh AS et al. Compliance with return-to-play  
9 regulations following concussion in Australian schoolboy and community rugby  
10 union players. *Br J Sports Med* 2011; 46:735–740.
- 11 15. Sye G, Sullivan SJ, McCrory P. High school rugby players' understanding of  
12 concussion and return to play guidelines. *Br J Sports Med* 2006; 40:1003–1005.
- 13 16. Finch C, Donohue S, Garnham A. Safety attitudes and beliefs of junior Australian  
14 football players. *Injury Prev* 2002; 8:151–154.
- 15 17. Hendricks S, Jordaan E, Lambert M. Attitude and behaviour of junior rugby union  
16 players towards tackling during training and match play. *Saf Sci* 2012; 50:266–284.
- 17 18. Quarrie KL, Hopkins WG, Anthony MJ et al. Positional demands of international  
18 rugby union: evaluation of player actions and movements. *J Sci Med Sport* 2013;  
19 16:353–359.
- 20 19. Côté J, Turnnidge J, Vierimaa M. A personal assets approach to youth sport, in  
21 *Handbook of Youth Sport*. Smith A, Green K, eds. London, Routledge., 2016.
- 22 20. Cusimano MD, Chipman M, Donnelly P et al. Effectiveness of an educational video  
23 on concussion knowledge in minor league hockey players: a cluster randomised  
24 controlled trial. *Br J Sports Med* 2014; 48:141–146.

- 1 21. Rosenbaum AM, Arnett PA. The development of a survey to examine knowledge  
2 about and attitudes toward concussion in high-school students. *J Clin Exp*  
3 *Neuropsychol* 2010; 32:44–55.
- 4 22. Carifio J. Sensitive data and students' tendencies to give socially desirable responses.  
5 *J Alcohol Drug Educ* 1994; 39:74–84.
- 6 23. Edens JF, Buffington JK, Tomicic TL et al. Effects of positive impression  
7 management on the Psychopathic Personality Inventory. *Law Hum Behav* 2001;  
8 25:235–256.
- 9 24. Holm S. A simple sequentially rejective multiple test procedure. *Scand J Stat* 1979;  
10 6:65–70.
- 11 25. Cournoyer J, Tripp BL. Concussion knowledge in high school football players. *J Athl*  
12 *Train* 2014; 49:654–658.
- 13 26. Mrazik M, Dennison CR, Brooks BL et al. A qualitative review of sports concussion  
14 education: prime time for evidence-based knowledge translation. *Br J Sports Med*  
15 2015; 49:1548–1553.
- 16 27. Tator CH. Sport concussion education and prevention. *J Clin Sport Psychol* 2012;  
17 6:293–301.
- 18 28. Provvienza C, Engebretsen L, Tator C et al. From consensus to action: knowledge  
19 transfer, education and influencing policy on sports concussion. *Br J Sports Med*  
20 2013; 47:332–338.
- 21 29. Kroshus E, Baugh CM, Daneshvar DH et al. Understanding concussion reporting  
22 using a model based on the theory of planned behavior. *J Adolesc Health* 2014;  
23 54:269–274.e262.
- 24 30. Dick RW. Is there a gender difference in concussion incidence and outcomes? *Br J*  
25 *Sports Med* 2009; 43:i46–50.

1 **Table 1**

2 Comparison of how concussions occurred by phase of play, age and playing position

Phase of play	Overall		Younger Players		Older Players		Backline Players		Forward Players		Multi-Venue Players		Single Venue Players	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Tackle	35	45.5	18	41.9	17	50	7	58.3	28	43.1	23	51.1	12	37.5
Maul	17	22.1	14	32.6	3	8.8	0	0	17	26.2	4	8.9	10	31.3
Ruck	14	18.2	5	11.6	9	26.5	2	16.7	12	18.5	10	22.2	7	21.9
High Ball	4	5.2	3	7.0	1	2.9	2	16.7	2	3.1	2	4.4	2	6.3
Foul Play	7	9.1	3	7.0	4	11.8	1	8.3	6	9.2	6	13.3	1	3.1
Total	77		43		34		12		65		45		32	

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1 **Table 2**

## 2 Youth rugby players' knowledge of and attitude towards concussion

<b>Questions and correct answers</b>	<b>Incorrect Answer</b>	<b>Correct Answer</b>
<b>Knowledge questions</b>		
1. Concussion is	3 (1%)	252 (99%)
2. Concussions can only occur from a hit to the head (False)	204 (80%)	51 (20%)
3. Younger people have a higher chance of concussion (True)	132 (52%)	123 (48%)
4. People who have had one concussion are less likely to have another (False)	24 (9%)	231 (91%)
5. The brain is moved out of place during a concussion (True)	92 (36%)	163 (64%)
6. Do you need to be knocked out for a concussion (No)	46 (18%)	209 (82%)
7. Symptoms of concussion (Multiple choice)	126 (49%)	129 (51%)
8. There is a possible risk of death if a second concussion occurs before the first has healed (True)	82 (32%)	173 (68%)
9. Symptoms of concussion can last for several weeks (True)	74 (29%)	181 (71%)
10. After a concussion, your emotions (anger, sadness etc.) can change quickly and intensely (True)	88 (35%)	167 (65%)
<b>Attitude questions</b>		
11. I would tell my coach when I have hit my head (True)	6 (2%)	249 (98%)
12. I would continue playing despite hitting my head (False)	91 (36%)	164 (64%)
13. If I had a headache/dizziness after a hit to the head I would continue playing (False)	43 (17%)	212 (83%)
14. I feel concussions are less important than other injuries (False)	25 (10%)	230 (90%)
15. I have a responsibility to play while experiencing concussion symptoms (False)	77 (30%)	178 (70%)
16. Other players have a responsibility to play while experiencing concussion symptoms (False)	42 (16%)	213 (84%)
17. My parents would encourage me to carry on playing in a rugby match after hitting my head (False)	60 (24%)	195 (76%)
18. If it is an important game it is more important for a player with a concussion to return to play than to sit the match out (False)	52 (20%)	203 (80%)
19. My team mates would expect me to carry on playing in a match after a head injury (False)	57 (22%)	198 (78%)
20. Coach would encourage me to play the next game after a concussion (False)	10 (4%)	245 (96%)
21. My team mates always tell a coach or parent when they have had a concussion (True)	29 (11%)	226 (89%)

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- 1 Figure 1. The effect of subpopulation membership on (a) knowledge of, and (b) attitudes towards
- 2 concussion. Columns represent median scores, with error bars illustrating median absolute deviation.
- 3 \* indicates differences at the Holm-Bonferroni corrected level of significance.

