Evidence in support of the ban to tackle in school rugby. A response to World Rugby.

General comments

The restructuring of the manuscript has improved the flow of the argument.

Specific comments

Background

Page 4, line 34. I suggest you provide a citation to the work by Fuller and Drawer 1 here.

3rd RESPONSE

Done

Page 4. Lines 54-56. The papers cited (2, 6-11) identify that the tackle is the element of rugby responsible for the greatest number of injuries, and the authors are correct in inferring that these are related to contacts/collision. The mechanisms that underpin tackle injuries and modify the risks in the tackle have not yet been extensively studied in children's/youth rugby, at least to my knowledge. There is some work by Burger et al. 2, and the paper you have cited by McIntosh et al. 3, but as yet nothing of that covers the range of children's ages that is of similar scope to the work by Fuller et al. 4 and Quarrie and Hopkins 5 in the professional men's game.

3rd RESPONSE

Nothing to add here

Page 5 lines 2 and 3.

Although the term 'injury mechanisms' has been used in various contexts (and not always consistently), Bahr & Krosshaug 6 attempted to clarify the meaning of the term as it applies to the inciting event of a sports injury:

"Therefore we suggest that a full description of the mechanisms for a particular injury type in a given sport should include information on different levels. The description of the inciting event could be grouped into four categories, as shown in table 1. Hence, the term ''injury mechanism'' is here used to describe: (a) vital aspects of the playing (sports) situation—that is, the situation described from a sports specific point of view; (b) athlete and opponent behaviour—that is, a qualitative description of the athlete's action and interaction with the opponent; (c) gross biomechanical characteristics—that is, a description of whole body biomechanics; (d) detailed biomechanical characteristics—that is, a description of joint/tissue biomechanics."

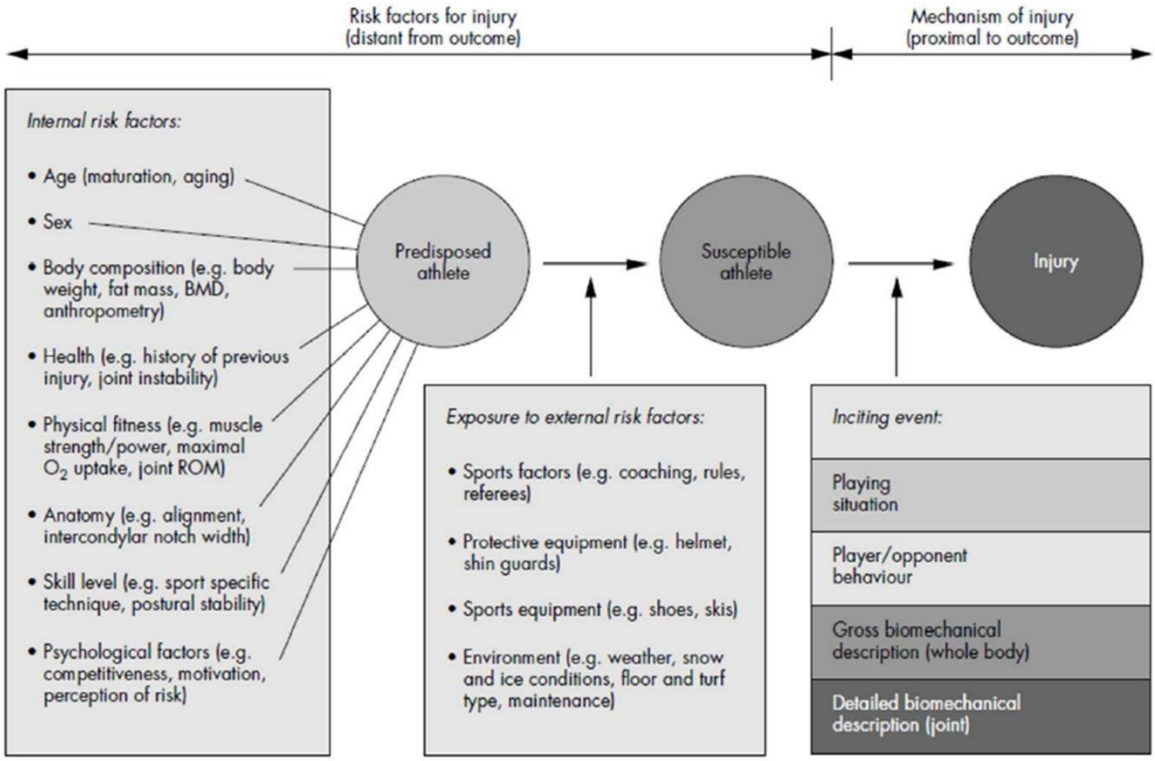


Figure 3 Comprehensive model for injury causation. BMD, Body mass density; ROM, range of motion.

As the authors have stated, the primary risk factor for injury in rugby has been identified as the tackle. I will leave it to the authors to decide whether they wish to retain the current text ("we are surprised that they state that the mechanisms and risk factors for injury have not been thoroughly identified") given the information about the use of the term 'mechanisms' in sports injury epidemiology above.

3rd RESPONSE

Thank you for this reference, it is very helpful and we have made use of it. We are interested in what can be done by the rugby playing authorities and responsible state bodies in reducing the risk of injury in rugby. Intrinsic risk factors and biomechanics are not the focus of our paper, we state that we are interested in extrinsic factors and have identified the tackle as being the number one causal factor, which the reviewer agrees is the case.

We have written

"Tucker's claim that "the specific mechanisms and risk factors for injury" have not been "thoroughly identified and understood" in this context is puzzling. Fuller and Drawer define a risk factor as "a condition, object or situation that may be a potential source of harm to people" whereas risk is defined as "the probability or likelihood" that such a risk factor will lead to harm. (Fuller and Drawer, 2004) Risk factors might be situational (e.g. facilities, equipment) or event based (e.g. tackling) and can be either intrinsic (e.g. age, physicality) or extrinsic (e.g. laws of the game). From a public health

perspective it is not necessary to understand intrinsic player risk factors such as player physique or behaviour (Bahr and Krosshaug, 2005) when extrinsic risk factors are so clearly established."

With respect to the authors' responses to my previous comments, please see the reasoning below:

I think the paper can be strengthened considerably by focussing on the following:

1) The lack of quality injury surveillance research at the child/youth level of rugby means that the risks are not currently well established (Tucker et al. acknowledge this in their paper);

WE HAVE WRITTEN AND PUBLISHED REPEATEDLY ABOUT THE NEED FOR QUALITY NATIONAL INJURY SURVEILLANCE DATA, HOWEVER WE DO NOT AGREE WITH THE SECOND STATEMENT THAT THE RISKS ARE NOT CURRENTLY WELL ESTABLISHED. THE RISKS ARE WELL ESTABLISHED, AS FRIETAG ET AL SHOW THERE ARE A WEALTH OF STUDIES ALL SHOWING THE HIGH RATE OF INJURIES IN RUGBY AND THAT MOST INJURIES OCCUR IN THE TACKLE PHASE OF THE GAME. COLLISION SPORTS INCLUDING RUGBY HAVE BEEN SHOWN TO HAVE HIGHER INJURY RATES INCLUDING CONCUSSION RATES THAN OTHER NON-COLLISION CONTACT SPORTS. (SPINKS AND MCCLURE, 2007, PFISTER ET AL., 2016) RUGBY HAS BEEN SHOWN TO HAVE HIGHER CONCUSSION RTAES THAN ANY TEAM SPORT INCLUDING OTHER COLLISION SPORTS (PFISTER ET AL., 2016).

PFISTER, T., PFISTER, K., HAGEL, B., GHALI, W. A. & RONKSLEY, P. E. 2016. The incidence of concussion in youth sports: a systematic review and meta-analysis. Br J Sports Med, 50, 292-7.

SPINKS, A. B. & MCCLURE, R. J. 2007. Quantifying the risk of sports injury: a systematic review of activity specific rates for children under 16 years of age. Br J Sports Med, 41, 548-57; discussion 557.

2) The above fact means that people are unable to make informed decisions about the size of the risks they are accepting when they participate in rugby. Children are recognised as being less able to comprehend and make appropriate decisions with respect to risk than adults (which is why their parents/schools are responsible for them). The current lack of quality injury surveillance information places parents, schools, and clubs in the position of putting children into situations where there is inadequate information available to properly assess the risks to which they are being exposed;

AUTHORS' SECOND RESPONSE

THE "ABOVE FACT" IS NOT A FACT, IT IS WRONG. THERE IS A LACK OF INFORMATION MADE AVAILABLE TO CHILDREN AND PARENTS BUT THIS IS NOT BECAUSE IT DOESN'T EXIST, REPEATED STUDIES SHOW OVER TIME AND ACROSS COUNTRIES ARE CONSISTENT IN SHOWING THE HIGH RISK, THIS IS WHY WE WROTE TACKLING RUGBY: WHAT EVERY PARENT SHOULD KNOW ABOUT INJURIES .

3rd RESPONSE

Nothing to add to this

Incidence and estimation of risk – Page 5 line 46 through to Page 6 line 10

Page 6. Lines 4-5. You claim here that “the high risks and rates of rugby injury are well established and consistent across many studies throughout the world”. Please check this with reference to your later statement (Page 7. Line 31-32) where you state “studies of rugby injury are highly heterogeneous”. Can you please clarify the sense in which you are using the term ‘consistent’, because the statements appear on the face of it to be claiming different, and somewhat contradictory, things. Can the findings from the studies be both consistent and heterogeneous?

3rd RESPONSE

Looking again at the meta-analysis in Frietag et al, there were five studies combined where injuries were measured irrespective of need for medical attention or time away from play (figure 1) and eight combined where injuries were measured which required at least seven days away from play (figure 2).

Figure 1

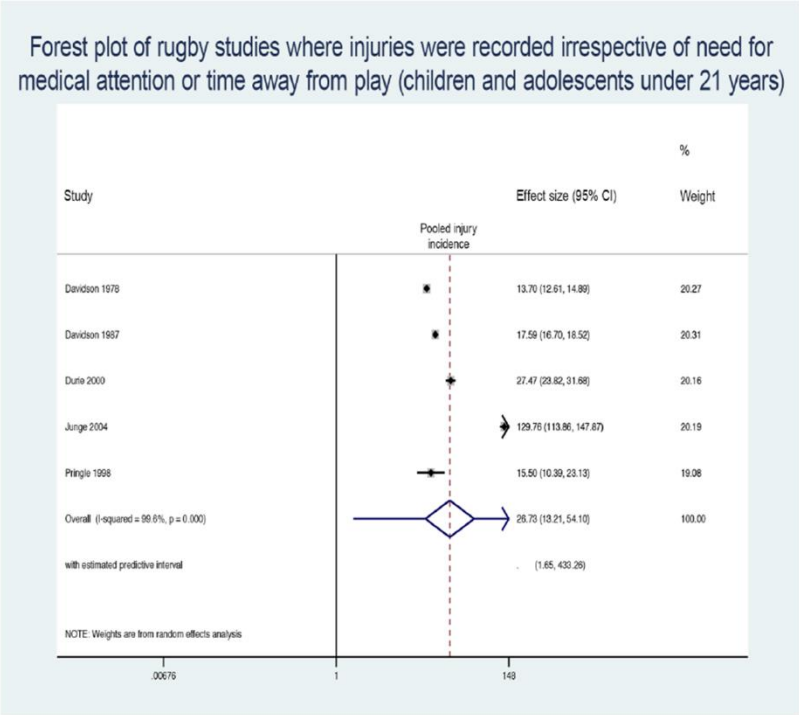
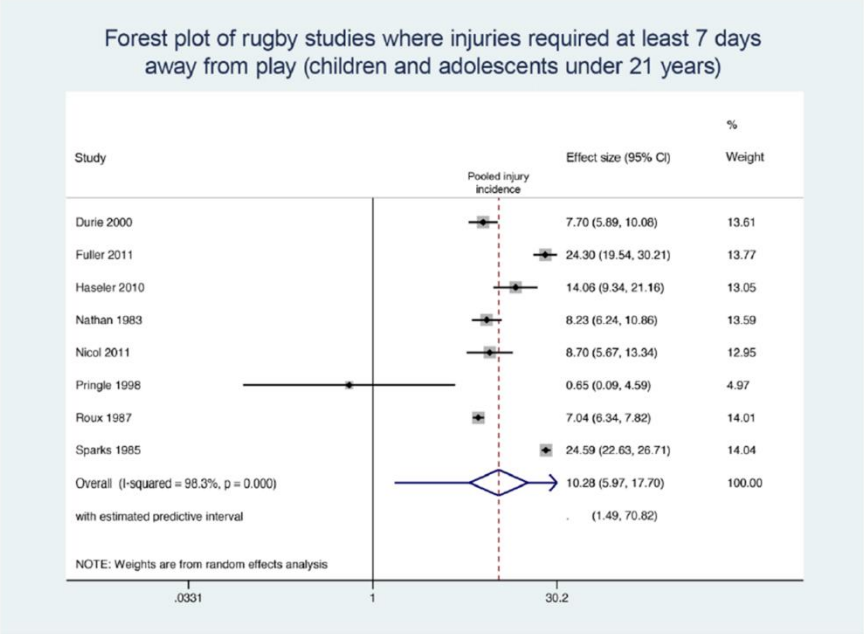


Figure 2



The I-Squared statistic and 95% estimated predictive interval [1] both give evidence of heterogeneity between the studies which will account for some of the between study variation in results. However we think it is still fair to say that the results of the individual studies used in both the above meta-analyses are consistently high, except possbily the Pringle study in the second comparison which appears to be an outlier.

Our reasoning that risks of injury are high is based on the subsequent conversion of the rates of injury to probabilities of injury for a child or adolescent rugby player being injured over a season of 15 games of 50 min duration, calculated as 28.4% (15.2% to 49.1%) for injuries irrespective of the need for medical attention or time loss from rugby activities and 12.1% (7.2% to 19.8%) for injuries requiring at least 7 days absence from games. We think what we have stated, that "the high risks and rates of injury in rugby are well established and consistently high across many studies throughout the world, notwithstanding the considerable heterogeneity in study design, differences in injury definitions used and differences in magnitude of effect" is fair in light of this evidence. We leave it up to others to justify these rates of injury as not being high.

Incompatible injury definitions – Page 6, line 12 through to page 7, line 14.

The underpinning premise of the argument with respect to more versus less inclusive injury definitions by Tucker et al. is sound. I accept that with information available, however, the authors are correct in their assertion regarding the rate being higher if the less inclusive definition is applied.

[1] "where the true effects are to be expected for 95% of similar (exchangeable) studies that might be conducted in the future" INTHOUT, J., IOANNIDIS, J. P., ROVERS, M. M. & GOEMAN, J. J. 2016. Plea for routinely presenting prediction intervals in meta-analysis. *BMJ Open,* 6**,** e010247.

It is my view that this is likely due to an artefact associated with the inter-study heterogeneity that has been identified by Freitag et al. 7 In general, if studies are conducted using the same definitions and data collection procedures, then less inclusive definitions will result in lower reported injury rates.

3rd RESPONSE

We agree the result we have found here is counter-intuitive. Our hypothesis for why this is so, is that the nature of the game played in these studies is different, the definition of injury as only 24 hours away from play implies that the child was likely to play rugby again in 24 hours, a definition more akin to a club tournament or academy situation, which may in turn imply a different style of rugby being played, more akin to the professional game. What we have shown though is that Tucker et al are wrong to cast doubt on Freitag et al's results based on this and the approach taken by Freitag et al stands in its own right.

Page 6. Lines 25-26. I don't think the word 'Council' is required here, nor the C in the acronym.

3rd RESPONSE

We have now written:

"Freitag et al used the injury definitions for rugby union approved by the council of the International Rugby Board (IRB) in 2007 (now called World Rugby) (Fuller et al., 2007) to calculate two pooled incidence figures for match injuries. "

I am not going to insist that any other changes be made to this section, but would like the authors to consider how much weight they believe it adds to their argument that tackles should be banned in schools' rugby. If anything, I believe it can be substantially shortened with little impact on the primary thesis of the manuscript.

3rd RESPONSE

We think the rest of this section is necessary to fully answer the criticism made by Tucker that Freitag made an erroneous comparison with the rates calculated in the Williams analysis of the professional game. We accept that the comparison made here is not strictly like with like, however we think Tucker is stretching this small issue to try and cast doubt on Freitag et al's entire analysis. In actual fact as we have shown, the relationships between injury definitions and particular cohorts of players involved in particular studies is more complex than Tucker et al appreciate or acknowledge.

Combining ages and risks – Page 7, line 17 through to Page 8 line 8.

I appreciate that you have identified that study heterogeneity is an issue within the manuscript (page 7, lines 32-36). The statements you have made in your responses to the previous review comments, and those in the paper, however, (e.g. “thus it is well established that the rates and risks of injury are high”) indicate that you don’t seem to accept that this means that conclusions drawn regarding rates and risks based on the studies covered by the Freitag et al. 7 meta-analysis need to be tentative. Your claim that the studies “are consistent in showing the high risk” is simply not supported by the evidence you have provided.

3rd RESPONSE

Please see above response to same point made earlier.

Tucker et al. drew attention to the fact that the reported incidence of injuries to players aged under 15 in the review by Freitag et al. ranged from 3.7 injuries per 1000 player hours to 109 injuries per 1000 player hours.

3rd RESPONSE

This is the range of rates found by Frietag et al but the wide range of rates is likely to be largely due to differing injury definition. This full range of studies was not included in the meta-analyses which operated only under single injury definitions, one of the main sources of study heterogeneity.

The extent of the variability in reported rates is reinforced by examining some of the confidence limits reported in Table 1 (e.g. the bottom four rows of the table especially; also the estimated predictive intervals where they are provided). I2 is a problematic statistic for identifying study heterogeneity.8 Even so, the information you have presented in Table 1 indicates that study heterogeneity is a major issue. The information provided indicates that there were systematic differences between the studies that go well beyond the variation expected by chance.

3rd RESPONSE

We accept this, however as we have illustrated above we stand by our statement that the rates and risks of injury are high, as evidenced by the two meta-analyses.

The heterogeneity, and the relatively limited number of studies (in meta-analytical terms) contributing to the pooled incidence rates provided in Freitag et al. means that there remains considerable uncertainty about the true rates of injury in youth and schoolboy rugby.

3rd RESPONSE

We don't think this is the case as we have argued above.

Pooling the incidence data, as was done in the Freitag et al. 7 paper, and which you have done here, provides an estimate of the mean incidence rate weighted by study size. The utility of this estimate for risk management/injury prevention purposes is only as good as the quality of the data from the studies from which it was derived.

3rd RESPONSE

We agree it would have added strength to the analysis if study quality had been assessed.

Roux et al. 9 commented on the effect under-reporting had in their study in 1987 – it might be worth referring to their paper in your comments on caveats?

3rd RESPONSE

Yes thanks, we agree this is important and have added as below:

"Additionally, underreporting of some injuries, particularly concussion, is an issue (Roux et al., 1987) as is changing conduct of youth rugby in terms of rules and player behaviour. Children and coaches may mirror the evolution of the professional game in terms of increasing physicality and rates of injury (Garraway et al., 2000, Henderson, 2000, Quarrie and Chalmers, 2001, Silver, 2001). These issues should be taken into account when combining studies from different eras or attempting to generalise their findings."

I don't believe it is possible to ascertain, based on the current literature, the extent to which the reported rates in child and youth rugby reflect the true incidence of injury, because the reported rates are highly variable, there are relatively few studies from which the estimates are drawn (at least compared with other areas of epidemiological research for which meta-analyses have been performed), and some of the studies are now dated. An estimated predictive interval of 1.65 to 433 doesn't indicate to me that anyone knows what the true incidence of injury is with any degree of confidence! Please provide a comment in the text on what that statistic implies.

3rd RESPONSE

Added description as footnote in table 2, as per footnote 1 above

Part of the reason the Freitag et al. paper has been useful is that it has highlighted the inconsistency of results of the existing studies, which will hopefully act as prompt for people to coordinate and standardise methods to a greater extent in future, so that the rates derived from surveillance studies will better reflect the actual injury epidemiology of youth and school rugby players.

3rd RESPONSE

We agree this would be a very helpful outcome were it achieved. However consensus statements have existed for some time in many sports including rugby and for concussion across sports, it would be useful to know how these were being adhered to.

The authors have drawn attention to a number of caveats, but an issue they have not mentioned is the age of the studies from which the estimates in Freitag et al., 7 and those in the new 'Table 1' are drawn. The pooled incidence figure of 26.7 (95% CI 13.2 to 54.1) appears to have been based on 5 studies, of which the data from two were collected primarily in the 1970's, two in the 1990's, and one in the early 2000's. There is evidence that the nature of rugby at the elite level has changed considerably over time (e.g. size of players; number and characteristics of various activities that make up match play). 10 Similar evidence is lacking for youth rugby, but because of multiple law changes over the past 20 years, and because young players (and coaches of young players) tend to attempt to emulate the players they see in televised matches (or encourage their players to do so), assuming that there have been changes in match activities and injury epidemiology of young players over time would seem reasonable. Given the age of some of the studies reported in Freitag et al. (30 years plus for the studies led by Davidson, 11, 12 30 years for the study by Roux et al.) I recommend that the authors include a comment about the extent to which rates derived from the older studies are likely to be relevant to decision-making with respect to injury prevention in the modern game.

3rd RESPONSE

Thanks for this, have added as a potential source of heterogeneity, as follows:

"Additionally, underreporting of some injuries, particularly concussion, is an issue (Roux et al., 1987) as is changing conduct of youth rugby in terms of rules and player behaviour. Children and coaches may mirror the evolution of the professional game in terms of increasing physicality and rates of injury (Garraway et al., 2000, Henderson, 2000, Quarrie and Chalmers, 2001, Silver, 2001). These issues should be taken into account when combining studies from different eras or attempting to generalise their findings."

Page 8. Lines 8-9. "Thus it is well established that the rates and risks of injury are high". Please explain how the information you have provided in the section regarding the inter-study heterogeneity and the wide intervals on the estimates supports this conclusion.

3rd RESPONSE

Please see above discussion of this

Incidentally, none of the above takes away from the fact that the tackle has consistently been identified as the element of play associated with the greatest injury burden (the product of incidence and severity) in rugby.

3rd RESPONSE

We agree

With respect to the authors' response to my previous comment:

3) Compelling children to participate in an activity with risks that are indeterminate, but for which the available evidence suggests is high, is unacceptable

The authors response was:

WE AGREE THAT COMPELLING CHILDREN TO PLAY COLLISION RUGBY IS UNACCEPTABLE. THERE IS A CONTRADICTION HERE IN WHAT THE REVIEWER SAYS HOWEVER. IF THE AVAILABLE EVIDENCE SUGGESTS THAT THE RISKS ARE HIGH THEN THE RISKS ARE NOT INDETERMINATE. THE EVIDENCE POINTS TO THE RISK OF INJURY IN RUGBY BEING HIGH COMPARED TO OTHER NON-COLLISION SPORTS.

The reference to 'indeterminate' risks was made mainly with reference to the potential long-term health sequelae associated with playing rugby, as opposed to the injuries players sustain during their careers. For example, the link between playing rugby as a child and potential increased risk of dementia later in life is yet to be properly quantified.

3rd RESPONSE

We appreciate better the reviewer's concern on this, nothing to add.

Table 1. Using a number code to reference the citations, which are already numbers, seems unnecessary. Why not just provide the citation numbers directly in the table?

3rd RESPONSE

Done

The risk of participation in Rugby Union does not stand out beyond that of other popular sports and

The risk of injury in rugby union is low and comparable to other major sports up to the age of 15 years - Page 10, sections 2.2 and 2.3

I think you should combine these two sections, because you are basically dealing with the same issue (whether the risks of participation in rugby are high compared to other sports) in both.

3rd RESPONSE

Sections have been combined

Page 10 Line 4. ‘Rugby Union’ does not require capitalisation here

3rd RESPONSE

Heading has been removed

Page 10. Line 18. ‘although wide variations occurred between studies reporting the risk of soccer injuries’. Note that Spinks and McClure 13 also mentioned that rates reported for ice hockey were widely variable (in the abstract).

3rd RESPONSE

Text now reads

“Spinks and McClure identified ice-hockey, another collision sport, as having the highest rate of injury of any sport in children under the age of 16 years, despite varying definitions of injury, heterogeneity in study methods and a wide range of injury rates. (Spinks and McClure, 2007) “

And

“Spinks and McClure also found football (soccer) to have the lowest rate of injuries. (Spinks and McClure, 2007)”

In your previous response you state:

AUTHORS’ SECOND RESPONSE

APART FROM SOCCER, THE OTHER SPORTS CITED BY BLEAKLEY AND REPRODUCED ABOVE, HIGH SCHOOL FOOTBALL (AMERICAN FOOTBALL) AND WRESTLING ARE BOTH COLLISION SPORTS. RUGBY IS ONE OF ONLY A HANDFUL OF COLLISION SPORTS WHICH EXIST AND ALL APPEAR TO HAVE HIGH RATES OF INJURY. THE COMPARISON WITH SOCCER AND SEVERE INJURY IS INTERESTING BUT DOESN’T ALTER OUR BASIC PREMISE THAT RUGBY, AS A COLLISION SPORT, CARRIES A HIGH RISK OF INJURY. WE HAVE REMOVED BLEAKLEY FROM THIS SECTION AS THE SECTION ON BETWEEN SPORT COMPARISONS IS NOT PART OF THEIR SYSTEMATIC REVIEW AND THEY ONLY BASE THEIR OBSERVATIONS ON A RANDOM SELECTION OF STUDIES. WE HAVE RELIED ON THE TWO SYSTEMATIC REVIEWS WE ARE AWARE OF ON THIS TOPIC, SPINKS AND MCCLURE AND PFISTER, TO MAKE

OBSERVATIONS ON THIS ISSUE. WHAT IS CLEAR FROM PFISTER IS THAT RUGBY HAS A HIGHER RATE OF CONCUSSION THAN ANY OTHER TEAM SPORT.

Bleakley's comparisons, although not part of their systematic review, do appear to be relevant to the current discussion, which I presume is why you had included them in the previous draft. The studies from which the comparisons were drawn investigated NCAA sports, and one of the studies in Bleakley et al. 14 used methods that were 'closely modeled' on the NCAA methods, permitting comparisons to be made. My concern was simply that by not presenting the full picture of what Bleakley et al. 14 asserted the statement you made had the potential to mislead readers about Bleakley's conclusions. I recommend you put the statement you had made back in, along with the piece about severe injuries.

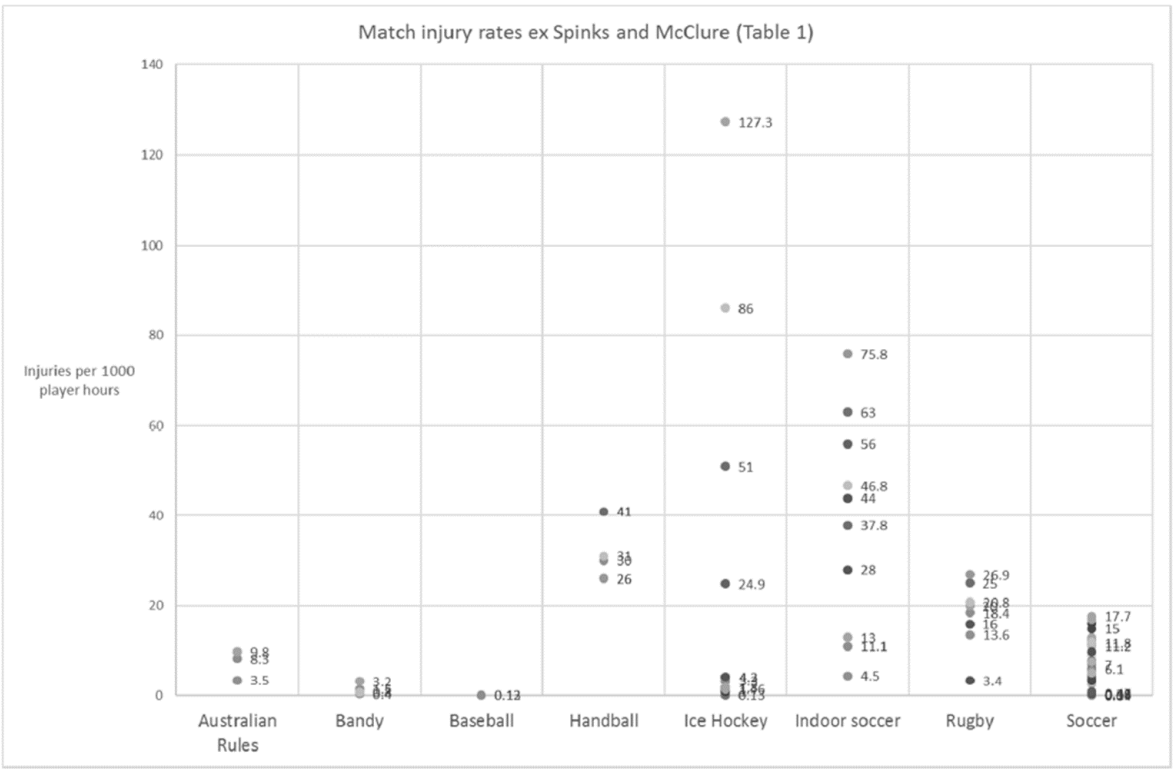
3rd RESPONSE

The following text is now in place:

"Also, Bleakley et al in their systematic review of rugby union injuries in children aged 12-18 years, cite evidence in the discussion that the risk of injury in rugby union in children aged 12-18 years is higher than other sports including football (soccer) and basketball and that the prevalence of severe injury in adolescent rugby players was lower than or comparable to high school American football, football and wrestling athletes. (Bleakley et al., 2011) "

SPINKS AND MCCLURE ONLY IDENTIFY ICE-HOCKEY AS HAVING A HIGHER RATE OF INJURY THAN OTHER SPORTS, IT IS INTERESTING THAT THIS IS ALSO A COLLISION SPORT. THEY DON'T DO ANY META-ANALYSIS AND DON'T RANK OTHER SPORTS, APART FROM FOOTBALL WHICH THEY SAY HAS THE LOWEST RATE OF INJURIES.

The fact that Spinks and McClure 13 didn't make comment about the relative rates of the other sports doesn't mean that the manuscript didn't contain information from which inferences about the relative injury rates in the different sports can be drawn. If the rates reported in Table 1 of the Spinks and McClure 13 paper for match injuries are charted, it provides the following:



As with the findings in Freitag et al., there is a great degree of inter-study heterogeneity – a point that Spinks and McClure 13 made, as did Tucker et al., 15 and as you have done in the current manuscript.

The studies covered by Spinks and McClure 13 were for a range of age groups, and contained many different data collection methods and injury definitions. My interpretation from simply looking at the data is that it doesn't appear that the risks of rugby stand out beyond those of the other sports.

As per my previous comments, however, I would be circumspect about drawing strong conclusions from this information.

3rd RESPONSE

We would also be wary about drawing conclusions from this, as you say these rates are from studies across of range of injury definitions. In our opinion it would require a meta-analysis, at least within single injury definitions as in Frietag to make any sense of this. We have only reproduced the conclusions arrived at by Spinks and McClure themselves.

Page 10. Lines 13-21. Starting with the sentence "Tucker et al. have misstated…".

Your points here aren't actually addressing the issue of whether the risks of participation in rugby stand out beyond those of other popular sports. To link back to your section heading, please provide comment on whether, based on the information provided in Spinks and McClure, the risks of

participation in rugby are inordinately high compared to those of the other children's sports for which injury rates were provided.

3rd RESPONSE

The point we are making here is that there is evidence that rugby has a higher risk of concussion injury than any team sport (in fact any sport apart from one study cited of Tai Kwando). There is also evidence that another collision sport, ice-hockey, has a higher risk of injury than any other sport (Spinks and McClure's conclusion). The issue with respect to injury is with collision sports in general not just rugby, we accept this, however rugby is by far the most played collision sport in UK schools.

Have rewritten as below:

"We refer Tucker et al to two systematic reviews which conclude that collision sports have higher rates of injury than other sports. Pfister et al identified rugby as having a significantly higher rate of concussion than any other youth (under 18s) contact or collision team sport. (Pfister et al., 2016) Spinks and McClure identified ice-hockey, another collision sport, as having the highest rate of injury of any sport in children under the age of 16 years, despite varying definitions of injury, heterogeneity in study methods and a wide range of injury rates. (Spinks and McClure, 2007) Also, Bleakley et al in their systematic review of rugby union injuries in children aged 12-18 years, cite evidence in the discussion that the risk of injury in rugby union in children aged 12-18 years is higher than other sports including football (soccer) and basketball and that the prevalence of severe injury in adolescent rugby players was lower than or comparable to high school American football, football and wrestling athletes. (Bleakley et al., 2011) Spinks and McClure also found football (soccer) to have the lowest rate of injuries. (Spinks and McClure, 2007)

Taking all these results together, it is difficult to see how Tucker et al arrive at the conclusion that the risk of participation in rugby union doesn't stand out beyond that of other popular sports. Our conclusion, in line with other commentators, and confirmed by the evidence, is that rugby along with other collision sports has a high risk of injury compared to other non-collision contact sports and a higher risk of concussion than any team sport, either collision or non-collision. (Fuller et al., 2010, Burger et al., 2016, Hendricks et al., 2015, Quarrie et al., 2017, Roberts et al., 2013, Pfister et al., 2016) Rugby is by far the most played collision sport in UK schools, therefore any public health approach to lower the high rates of sport injury in children needs to look seriously at rugby and how to reduce that rate of injuries, including concussion."

Lines 23-31. These are valid points, although the Pringle et al. 16 data indicate that there wasn't a great deal of difference in the rates of injury between rugby union, a 'collision sport', and netball (would you call netball a non-collision contact sport?) for players aged 6-15.

3rd RESPONSE

Yes, netball would be classified as a non-collision contact sport. In his classification system Rice doesn't list netball, however it would probably be classified as a limited contact sport, as contact would be "infrequent or inadvertent".

Pringle did find the rate of injuries in rugby union was still higher than netball, the rate of injuries in rugby league was much higher.

Lines 38-42. Well picked up – Tucker et al. 15 appear to have transposed the rates for netball and rugby league. The rates of moderate injury were reported as being higher for netball players aged 6-15 than for rugby union– correct? (i.e. rugby union had more minor, and fewer moderate injuries per unit of play time than netball). I recommend you include the content on both all injuries and the moderate injuries to provide as accurate a presentation of their findings as possible.

3rd RESPONSE

The findings from Pringle were included in the systematic review by Spinks and McClure which we have referenced and reported on, we rely on this more powerful summary of the research rather than reporting the results of one isolated study. Also Pringle appears to be an outlier with respect to severe injuries (see figure 2).

In line 38 – check that it wasn't 6-15, rather than 5-15 as you have currently written.

3rd RESPONSE

Thanks, corrected to 6-15

Lines 48-51. Within the limitations already identified by Spinks and McClure, you, and Tucker et al., do you believe the information provided by Spinks and McClure (shown graphically above) indicates that the risk of rugby is disproportionately high in children?

3rd RESPONSE

As we have stated above we do not make any inference from these results for the reasons outlined above.

Evaluation of risk

Page 11. Line 28-30. I am not sure that the percentages you have listed here are accurate. Please check with the original paper. Fifty-seven under 20 players provided 70 reasons for stopping play. 13 of the 70 reasons given (19%) were 'injury'. This is a slightly different thing to saying that 19% of the players stopped playing due to injury. Thirteen of 57 players (23%) stopped playing due to injury,

some of those 13 players listed other reasons as well. Likewise, 20% of the reasons given (14/70) were disillusionment, rather than 20% of the players listing disillusionment (14/57, or 25% listed disillusionment).

Because it would be confusing for readers to be presented with percentages that would sum to over 100%, it is probably better to retain the percentages you have provided, but specify that they were the percentages of reasons given, rather than percentages of players.

3rd RESPONSE

Yes you are correct, thanks. Rewritten as:

"A survey conducted in a Scottish Borders rugby playing district among keen club players found that 19% of the reasons given by under 20 year old players for stopping playing were connected to rugby injury and a further 20% were connected to disillusionment with the game. (Lee et al., 2001) "

With respect to the following exchange:

The authors are denying this fact based on bringing in data from a study that was not included in the review by Frietag et al. The data from the RISUS project by Archbold et al., showed a rate of missed play injuries of 29.1 injuries per 1000 player hours. The authors have not, for some reason, also included data from a paper by Collins et al., which showed a rate of 11.4 injuries per 1000 player hours using a missed >=24 hours of play definition, despite the facts that I drew their attention to this information in the previous review and that they are aware of the work by Collins et al. because it was referenced in the paper by Freitag et al. Why was this data not included in the new comparison (nor, for that matter, in the new Table 1)?

AUTHORS' SECOND RESPONSE

WE HAVE ONLY USED STUDIES IN THE REWORKED META-ANALYSIS WHERE THE INJURY RATE WAS GIVEN IN PLAYER-HOURS, AS WAS THE CASE IN THE ORIGINAL FREITAG REVIEW. NEITHER FRETIAG ET AL OR OURSELVES IN THIS UPDATED META-ANALYSIS ATTEMPT TO CONVERT RATES OF INJURY IN STUDIES WHERE THEY WERE GIVEN IN THE FORM OTHER THAN PER PLAYER-HOURS. WE APPRECIATE THAT BLEAKLEY ET AL CONVERTED THE RATE FROM THE COLLINS STUDY, THIS WAS NOT DONE BY FREITAG ET AL IN EITHER THE CASE OF COLLINS OR ANY OTHER PAPER WHICH GAVE RATES PER ATHLETIC EXPOSURE. IT IS NOT CLEAR HOW BLEAKLEY ET AL CONVERTED THIS RATE AND WHETHER THEY COMBINED PRACTICE AND MATCH INJURIES IN A SINGLE CALCULATION. FREITAG ET AL CALCULATED POOLED INJURY RATES FOR MATCH INJURIES USING A CONSERVATIVE ESTIMATE OF A GAME DURATION OF 50 MINUTES IN THEIR CALCULATIONS. IF A MATCH DURATION OF 50 MINUTES WERE ASSUMED THEN WE CALCULATE A MATCH RATE OF INJURIES FROM THE COLLINS STUDY OF 488 INJURIES / (50 MINS X 32014 EXPOSURES) = 18.3 INJURIES PER 1000 PLAYER-HOURS, HIGHER THAN THAT QUOTED BY BLEAKLEY. WE COULD NOT BE EXPECTED TO INCORPORATE THIS RATE FROM A STUDY WHICH HAS BEEN THROUGH AN UNDEFINED PROCESS IN A SECOND PAPER, WHEN WE DON'T KNOW ANY DETAILS OF THE CALCULATIONS OR METHODS. WE HAVE INCLUDED THE RISUS STUDY AS A FURTHER EXAMPLE AS IT DOES GIVE THE RATE OF INJURIES IN PLAYER-HOURS.

I accept this justification.

3rd RESPONSE

Nothing to add

Section 3.2 How important is correct technique to reducing injury?

Page 11. Lines 46-58.

For the reasons I have previously outlined, I disagree with your interpretation of McIntosh et al. but will let it pass. The findings of Burger et al. in the youth game provides preliminary evidence of this, and in the adult game the work by Fuller et al. and Quarrie and Hopkins have shown pretty clearly that there are substantial differences in injury rates associated with different techniques 2-5, 17-19. I think you should note in the text that there is reasonable evidence from work other than that of McIntosh et al. that different tackle techniques carry different levels of risk. There is, however, more work required to establish the relative risks of tackles at different ages of children's rugby.

3rd RESPONSE

We have rewritten this section taking on board the reviewer's helpful comments. It may well be the case that better technique in tackling leads to fewer injuries although the research as we have highlighted, and as the reviewer has stated in terms of child rugby, is not well developed. This does not mean there is any evidence that removing the tackle from school rugby would lead to a higher rate of injuries at later stages which is the main point Tucker et al are trying to argue. We show there is no evidence for this regarding rugby and only very weak evidence cited from one study of ice hockey with found significance on only one of a range of measures.

The other papers referenced by the reviewer are helpful but we think they refer more to speed of tackle, player position (Fuller et al., 2010) and different types of tackle and tackle height (Quarrie and Hopkins, 2008) and their propensity to cause injury rather than good or bad tackle technique. We have referenced them as below.

"Tucker et al misreport the findings of McIntosh et al as attributing tackle technique to lower injury rates in younger players. (McIntosh et al., 2010) McIntosh et al found that younger (under 15 years) players were more likely to use a passive shoulder tackle whereas older players were more likely to use an active shoulder tackle; but separately they found a significantly lower risk of tackle game injury in younger players than elite players. They conclude however, that no specific tackle technique was associated with a significantly increased risk of injury. They analysed a total of 6618 tackle events, of which 81 resulted in injury, and found no statistical evidence of any difference in the odds of receiving an injury during an active shoulder tackle compared to any one of passive shoulder tackle, jersey tackle, ankle tap or smother ($p>0.05$ for each); the only association with technique was an increased risk of injury when a player was tackled by two players simultaneously as opposed to being tackled by a single tackler. (McIntosh et al., 2010) Tucker et al cite a small study by Hendricks et al which found weak evidence of an association between tackler proficiency and likelihood of concussion. (Hendricks et al., 2015) Burger et al did find evidence that improved tackle

technique on the part of both the ball carrier and the tackler was associated with reduced risk of injury. (Burger et al., 2016) Speed going into the tackle and force of impact (Fuller et al., 2010) as well as tackle height (Quarrie and Hopkins, 2008) also have an impact on injury."

Page 12. Lines 11-17. As noted in the previous review, RCTs are not required to examine the relative risks of different types of tackles in rugby.

With respect to the authors' response to the previous review comment:

WE QUESTION THE FEASIBILITY OF OBSERVATIONAL TRIALS. AS THE REVIEWER WILL BE AWARE, THE RFU "AGE GRADE RUGBY" GUIDANCE SAY TACKLING SHOULD BE INTRODUCED FROM THE AGE OF EIGHT YEARS ON. IS THE REVIEWER AWARE OF SCHOOLS WHERE THIS GUIDANCE IS NOT ADHERED TO, I.E. TOUCH OR TAG RUGBY CONTINUES BEYOND THE AGE OF EIGHT

Observational studies are feasible for youth rugby. This is known because the methods for examining the relative risks of various tackle types have already been applied. The papers by Burger et al. 2 Hendricks et al., 18, 20 McIntosh et al., 3 Fuller et al. 4 and Quarrie and Hopkins 5 were all based on observational methods – there were no 'trials' required, and players were not assigned to groups that may have modified their risks. Tucker et al. state:

"Similarly, the specific types of tackles that are safer or more injurious have only been described in relatively basic terms 38 42 43 in the adult game, and the relative dearth of controlled studies in this area emphasises the fundamental need for ecologically valid research on which real-world decisions can be made".

3rd RESPONSE

We still think this would be the case, but we have removed this as it no longer seems necessary to discuss this as we have shown there is no evidence anyway for Tucker et al's argument over the introduction of the tackle and increased risk of injury.

Tucker et al. are calling for more and better research. That doesn't necessarily mean that RCTs are required – case-control trials, and prospective cohort studies can provide reasonable information to inform decision making in this area. This idea that Tucker et al. are requesting that RCTs are undertaken seems to be something that the authors have inferred and are using to make statements that such trials would be unethical 'using children as guinea pigs would not meet with current standards of ethics approval for children'.

Where a cluster-randomised control trial would be an appropriate method is if people wanted to examine, for instance rates of injury in 'tackle versus non-tackle rugby' and non-tackle rugby wasn't being played currently. However, as the authors correctly identify, randomly assigning children to

'tackle' or 'non tackle' competitions would be unlikely to find favour with ethics committees. If nontackle rugby was already being played, then again, observational methods would suffice (and in some countries touch rugby is widely played), although the evidence obtained would obviously be less robust than that which would be obtained via a well-conducted RCT.

3rd RESPONSE

There may be some scope for comparing collision rugby in its current form in the UK with non-collision rugby if played by similar age groups in other countries. However the likely findings would surely be that collision rugby has higher injury rates than non-collision rugby, what would be the point and would it be ethical to do this?

Risk Mitigation

Page 12 Lines 35-28. The results of the BMJ polls seem to be out of place in a section on risk mitigation. Perhaps move them to the section on evaluation of risk; maybe following line 37 on page 11?

3rd RESPONSE

We have put the results in the "How might it impact on clinical practice in the future?" box at the start

The rights of the child

Page 13. Line 9. "All the evidence available on injury in rugby shows the high risks of injury and that the tackle is where most injuries occur."

All the evidence available on injury in rugby doesn't show the high risks of injury though. As you have identified, the evidence regarding the risks is highly heterogeneous. The evidence regarding whether the risks of rugby are incommensurately high compared to other children's sports is equivocal, and further study is needed before strong statements on that issue can be made.

3rd RESPONSE

As outlined above we don't agree with this and think we have provided evidence to the contrary

In terms of whether the risks are acceptable to participants, Fuller and Ward identified an inverse relationship between the frequency of the incidence and severity of injury, and the acceptability of risk. 21 They also showed that even within groups of stakeholders, there was wide variation in the degree of risk participants were prepared to accept. I will leave it to the authors as to whether they wish to reference that work here.

3rd RESPONSE

Acceptance of risk by participants as in Fuller and Drawers model stage “evaluation of risk” was not addressed by Tucker et al, possibly as the participants are children, a vulnerable group, who should be protected from unnecessary risk.

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