Non-reporting of sport-related concussion symptoms: a cross-sectional study of community rugby league players in the UK

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ABSTRACT:

Recognizing and removing players with suspected sport-related concussion is crucial for community sports.

Objectives: Quantify rates and factors associated with non-reporting of concussion symptoms in community rugby league.

Methods: Overall, 484 community rugby league players ≥18-years, and 965 parents of rugby league players <18-years completed an online survey, regarding concussion history, knowledge, prevalence and reasons for non-reporting of concussion, long-term implications and perceptions of concussion.

Results: Thirty-five percent of players ≥18-years, and 22% of parents of players <18-years reported at least one concussion in the last two seasons. Forty-three percent of ≥18-years and 5% of parents of players aged <18-years surveyed stated they didn't report concussion-related symptoms sustained during 2020 and 2021 seasons. The two most common reasons for non-reporting of concussion symptoms were *'didn't want to be ruled out of a match'* and *'didn't want to let down team'*. Players ≥18-years who received external coaching pressures around concussion were more likely to not report concussion symptoms. Over 40% of parents and players were concerned about the potential long-term implications. Ten percent of players ≥18-years and 7% of parents of players <18-years, would encourage their family members/children to not play rugby league.

Conclusions: Non-reporting rates of suspected concussion symptoms in adult community players were twice as high as professional rugby league, with similar reasons (wanting to play,

and not let the team down). Engaging coaches to prioritize brain health and providing broader and appropriate education on concussion should be focused on, given the concerns reported by community players and parents.

What is already known on this topic:

Recognising and removing players who have experienced a sport-related concussion is a priority for community sports. Player awareness of sport-related concussion symptoms, and willingness to report these to medical staff and coaches is essential to allow clinical assessments to be undertaken if the inciting event has not been observed (e.g., during training or match-play). Rugby league has relatively high rates of sport-related concussion and non-reporting (17-20%) of sport-related concussion symptoms and the reasons why have been explored at an elite level. In community rugby league, reporting of symptoms is important as first aiders are responsible for player care, and non-reporting becomes a player welfare concern. The majority of registered rugby league players in the UK play at community level, it is important to investigate this cohort as no data currently exists.

What this study adds:

Over one third of rugby league players ≥18years, and one fifth for players <18years (reported by parents) reported a sport-related concussion within the last two seasons. Furthermore, non-reporting of sport-related concussion symptoms was over twice as prevalent in adult community (43%) than professional rugby league players (17-20%). Twenty-five and 22% of players ≥18years did not report sport-related concussion symptoms for fear of missing out on playing time or letting their teammates down, which is consistent with professional rugby league players. Adding to this, players ≥18 years who reported to have received external coaching pressures around a concussion, were more likely to underreport a suspected concussion symptoms. Over 40% of parents and players were concerned about the potential long-term implications from concussion. Ten percent of players ≥18-years and 7% of parents of players <18-years, would encourage their family members/children to not play rugby league.

How this study might affect research, practice or policy:

In community rugby league, 43% of players ≥18years did not report suspected sport-related concussion symptoms, which is greater than in professional rugby league. Whereas parents

of players <18years report most of their children's symptoms of sport-related concussion. In practice, first aiders should be aware that almost 1 in 2 community rugby league players did not report sport-related concussion symptoms, therefore they should increase their clinical suspiciousness when dealing with sport-related concussion. Not reporting sport-related concussion symptoms is complex and needs further investigation. To address non-reporting, organizations should appropriately educate players, parents, coaches and support stakeholders (e.g., first aiders) about the consequences of sport-related concussion's, with a focus on behaviour change and removing any negative perceptions around sport-related concussion symptom reporting. Given the similarities in reasons for not reporting sport-related concussion symptoms between studies internationally, a global cross-sport and unified approach is required.

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INTRODUCTION

Sport-related concussion (SRC) account for up to 20% of all traumatic brain injuries (TBIs),[1] with half occurring in children and adolescents.[2] Non-reporting of SRC symptoms can mislead a clinical diagnosis and adversely affect recovery strategies, causing risk of potentially worsening symptoms and neurological consequences.[3,4]

Rugby league has relatively high rates of SRC[5] and non-reporting (17-20%) of SRC symptoms at the professional level.[6,7] In community rugby league, rather than having the support of an elite comprehensive medical team (e.g., medical doctors, physiotherapists, sports scientists, sports rehabilitation specialists), it is typically first aiders who are responsible for the surveillance and identification of a SRC. Therefore, the athlete self-reporting symptoms is crucial to managing potential SRC's.[8] At this level of play, the non-reporting of SRC symptoms is a major player welfare concern. The clinical consequences of not reporting SRC symptoms

includes potential for persistent symptoms,[9] delayed return to play[9], employment, school and academic performance decline,[10,11] altered brain function,[12] and a higher risk of short-term and long-term injury.[9] Missed SRCs may result in an increased risk of long-term negative health effects, cognitive impairment, or mood disturbance, which can be exacerbated in younger players.[9,11,12]

The interconnections between knowledge, attitudes, and cultural and societal norms regarding SRC are intertwined, although the complexities of these relationships and their transferability can be intricate.[13] In addition to understanding SRC and holding certain beliefs, norms encompass cultural expectations and social standards of behaviour.[13] Pertaining specifically to SRC, these norms involve intentions to report injuries, past behaviours related to seeking medical help for SRCs, the perception of support and encouragement from various stakeholders for reporting SRCs, parent and coaching support, as well as the impact of concussions on missing games and training sessions.[13] Exploring different groups of athletes through research will contribute to a deeper comprehension of these dynamics.

Non-reporting of SRC have been found in professional rugby league.[6,7] Community rugby league has more participants, yet no data exists on non-reporting of SRC symptoms. The aim of this study was to quantify the non-reporting of SRCs in community (≥18years) rugby league players and in parents of rugby league players <18years, and to establish why players may not report symptoms of suspected SRCs. The secondary aim was to examine associations between non-reporting of SRC symptoms with player demographics and related factors. These findings may assist targeted player education and behaviour change initiatives, with the objective of reducing the non-reporting of SRC symptoms.

METHODS

Study Design

A cross-sectional study was conducted to quantify the non-reporting of SRCs, the symptoms, and factors associated with non-reporting of SRC symptoms in community rugby league players (≥18years) and parents (of players <18years). Community teams registered with the Rugby Football League (RFL) were invited to participate in the online survey. Ethics approval was granted by Leeds Beckett University *(87996)*. Patients and/or the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Survey

Two online (Qualtrics, Provo, Utah) surveys (one for players and one for parents; Supplementary Table 1) were modified from surveys used in similar published studies[6,7]; and were distributed during the 2022 pre-season to players (≥18years) and parents of players <18years participating in community rugby league.

The survey (see Supplementary Table 1.) assessed participant demographics, SRC history (i.e., number of diagnosed concussions in the previous two seasons), reporting (i.e., non-reporting was defined as those that did not report potential concussion symptoms, or tried to hide it from a coach or member of medical staff), knowledge, external pressures (i.e., coaching pressures related to playing with a SRC or symptoms), long-term implications and understanding of symptoms, to ascertain the general SRC comprehension and behaviours of the cohort. Each question was evaluated individually in the analysis; therefore, the results were compared to the overall cohort number that answered the survey (unless specified). The non-reporting of SRC and symptoms data was collected from two questions (“Have you felt you [or your child] have suffered a concussion in the past two seasons and not reported to a member of the medical staff or coach during matches, training and outside rugby”, and “Have you ever NOT reported concussion symptoms, or tried to hide a potential concussion from the medical staff or coach?”) .Players were informed that completion of the survey was voluntary and anonymised for name, team, and gender. The symptoms listed were a combination of the 2022 RFL Medical Standards and SCAT5 signs and symptoms.[14,15] Three non-diagnostic and

generalised symptoms (tooth ache, single joint pains, and weight gain) were added to assess the participant's true understanding.[16]

A link to the online survey was provided to 13,597 ≥18-years and 10,531 parents of <18-years community rugby league players. Response rates were 484 (3.6%) ≥18-years players and 965 (9.2%) parents of <18-years players. Inclusion in the analysis was predicated on the participant completing the demographic section. Not all the participants answered every question in the survey, thus participant response rates are provided for each question.

Data Analysis

Data analyses were undertaken using Microsoft Excel 2019 (Microsoft Corporation, Washington, USA), the R computer programming language (V4.2.0, Vienna, Austria) within the RStudio 2020 environment (RStudio, PBC, Boston, MA), and IBM SPSS statistics 27.0 (SPSS Inc, Chicago, USA). Responses were described as percentages. Descriptive analyses and frequency comparisons were performed in SPSS by first splitting the data into categories: players who did not report suspected SRC symptoms, the reasons for not reporting SRC symptoms, had an appropriate level of knowledge about SRC, are concerned about the long-term implications of SRC, effect on work or education, external coaching pressures, and if would encourage their/family members to not play rugby league; and then comparing to players by age, years playing rugby league, professional experience, level of play, and primary playing position. Correct and incorrect answers for SRC symptoms were compared. The non-reporting of possible SRC and or symptoms, was analysed independently to the question asking for the number of previous diagnosed concussions in the previous two seasons. A player or parent may not have disclosed potential SRC's and symptoms in their career, irrespective to the number of concussions diagnosed in the previous 2 seasons.

Statistical comparisons were made using a generalized linear model with binomial distribution, to examine associations between non-reporting of SRC symptoms and player demographics

and factors (e.g., SRC diagnosis history, SRC education, age, level of play, years playing, professional playing history, position, and external coaching pressures). Differences between player demographics and factors are quantified with odds ratios (OR), and $p<0.05$ was considered statistically significant.

RESULTS

Participant characteristics of community players ≥18years was 24% (n=116) 18-25years, 24% (n=117) 26-30years, and 52% (n=251) >30years. Eleven (n=53), 8% (n=39), and 81% (n=392) of participants played rugby league for 0-2years, 3-5years, and >5years. Thirty-five percent (n=169) of players had played for a professional rugby league academy. Sixty percent (n=290) were forwards (Figure 1). The distribution of players <18years, was 15% (n=145) U9years, 7% (n=68) U10years, 15% (n=145) U12years, 29% (n=280) U14years, 31% (n=299) U16years, and 3% (n=28) U18years. The distribution of players <18years who have played rugby league for 0-2 and 3-5years was 31% (n=150) for each, and ≥5years was 38% (n=184). Ten percent (n=150) of all players in the study had played for a professional rugby league academy, and 48% (n=695) were forwards.

Reported Prevalence of SRC symptoms in the Last Two Seasons:

Community Players ≥18 years (n=484):

During or following a match in the past two seasons, 35% (n=169), 9% (n=43) and 6% (n=29) of players reported being diagnosed with SRC 1-2, 3-5 and ≥5 times. During or following training, 10% (n=48), 3% (n=14) and 1% (n=5) of players reported being diagnosed with SRC 1-2, 3-5 and ≥5 times. Outside of rugby league, 10% (n=49), 3% (n=13) and 1% (n=4) of players reported being diagnosed with SRC 1-2, 3-5 and ≥5 times.

Parents of Players <18 years (n=965):

During or following a match in the past two seasons, 22% (n=212), and 2% (n=19) of parents reported their child had been diagnosed with SRC on 1-2, and 3-5 times. During or following

training and outside of rugby league, 8% (n=77) and 9% (n=87) of parents reported their child had been diagnosed with SRC 1-2 times.

Non-reporting of Suspected SRCs in the Last Two Seasons:

Community Players ≥18 years:

Overall, 43% (n=208) stated they did not report SRC symptoms to coaches or medical staff. During or following a match, 28% (n=135), 2% (n=10) and 1% (n=4) of players responded to not reporting a suspected SRC to coaches or medical staff 1-2, 3-5 and ≥5 times. During or following training, 8% (n=38) and 1% (n=5) of players responded to not reporting a suspected SRC to coaches or medical staff 1-2 and 3-5 times. Outside of rugby league, 7% (n=34) and 1% (n=4) of players responded to not reporting a suspected SRC 1-2 and 3-5 times.

Parents of Players <18 years:

During or following a match, 5% (n=48) of players' parents did not report suspected SRC symptoms 1-2 times. During or following training, 3% (n=30) of players' parents did not report suspected SRC symptoms 1-2 times. Outside of rugby, 2% (n=19) of players' parents responded to not reporting suspected SRC symptoms 1-2 times.

Reasons for Non-reporting of Suspected SRC Symptoms:

Only four parents responded to this question, therefore only the community ≥18-years player results are reported.

Community Players ≥18 years:

Of the 43% (n=208) of players that did not report suspected SRC symptoms, the reasons were; '*didn't want to be ruled out of a match'* (25%, n=52), '*didn't want to let down team'* (22%, n=46), '*despite the symptoms(s), didn't think the symptoms were significant'* (16%, n=33), '*it occurred during an important match or time of the season'* (14%, n=29), '*didn't want to let down the coaches'* (11%, n=23)), '*didn't think the symptoms were related to concussion'* (8%,

n=17), *'didn't want to be ruled out of training'* (6%, n=12), and '*fear that having a concussion diagnosis would affect future selection'* (4%, n=8).

Player and Parent Understanding of Concussion Symptoms:

Overall, symptoms of SRC were identified correctly 58% and 68% of times by players and parents (Supplementary Table 2).

Player Perceptions of Knowledge, Long-Term Implications and Rugby League Participation:

Community Players ≥18 years:

Thirty-three percent (n=159) of players reported receiving SRC education at their clubs. Forty percent (n=193) of players reported a perceived appropriate level of knowledge about SRC and the potential long-term implications at the start of their playing career, *vs.* 65% (n=314) at the time of completing the survey. Eight (n=39) and 17% (n=82) of players reported that they sustained a SRC which "affected their ability to work or attend education due to the required rest period" and resulted in "persistent symptoms". Forty percent (n=194) of players were concerned about the potential long-term implications from SRC, and 10% (n=48) would encourage their/family members children to not play rugby league.

Parents of Players <18 years:

Thirty-one percent (n=299) of parents reported to have received SRC education at their clubs. Forty-seven percent (n=454) of parents reported an appropriate level of knowledge about SRC and the potential long-term implications at the start of their child's playing career, *vs.* 64% (n=617) at the time of completing the survey. The percentage of players' parents reporting that a SRC had affected their child's ability to attend education due to the required rest period, or due to persistent symptoms, were 6% (n=58) and 5% (n=48) respectively. Fifty-three percent (n=510) of parent's surveyed were concerned about the potential long-term

implications from SRC, and 7% (n=67) would encourage their/family members children to not play rugby league.

Reported pressures from coaches:

Community Players ≥18 years:

Of the players who completed the survey, 12% (n=57) reported to having been encouraged by a coach to go back onto the pitch with a suspected SRC, 14% (n=68) reported to have been encouraged by a coach to stay on the pitch with a suspected SRC, and 11% (n=53) reported to have been encouraged by a coach to return to play too early in their recovery from a SRC.

Parents of Players <18 years:

Three percent (n=29) of parents reported that their child had been encouraged by a coach to stay on the pitch and 2% (n=19) had been encouraged by a coach to go back onto the pitch with a suspected SRC. Two percent (n=18) of parents reported that their child had been encouraged by a coach to return to play too early in their recovery from a SRC.

Player responses by demographic and rugby playing history:

Figure 1 shows ≥18years responses to questions on not reporting a suspected SRC, potential long-term implications and knowledge on SRC, coaching pressures, and in which category (i.e., age, playing experience, professional playing experience, primary position, and level of play) they were in. For example, players that did not report a suspected SRC, during or following a match, 3-5 times, 27% were 18-25years old.

***Insert Figure 1 near here**

General Linear Model

Community Players (≥18 years):

Only data from players ≥18years was analysed statistically as the number of responses from parents were small (see Supplementary Table 3.). There were no statistically significant associations between level of play, previous professional playing experience, age, position, previous concussion education, and non-reporting of SRC symptoms. Players who had not received concussion education at their clubs had 50% greater odds of not reporting concussion symptoms (OR 1.56, *p*=0.14, 95% CI 0.90-2.70), however this result did not reach statistical significance. Players with ≥5years of playing experience, were more likely to not report SRC symptoms compared to players with 0-2years (OR 4.15, *p*=0.003, 95% CI 1.51-11.41), and 3-5years (OR 2.36, *p*=0.07, 95% CI 0.96-5.86, insignificant result) of experience respectively. Players who had reported at least 1-2 diagnosed SRCs in the past two seasons (OR 2.54, *p*<0.001, 95% CI 1.41-4.57), 3-5 diagnosed SRCs (OR 7.40, *p*<0.001, 95% CI 2.55-21.45), and ≥5 diagnosed SRCs (OR 6.99, *p*<0.001, 95% CI 1.94-25.18), were more likely to not report SRC symptoms to medical staff compared to players with no previously diagnosed SRC. Players who received encouragement from a coach to stay on the pitch (OR 3.71, *p*<0.001, 95% CI 1.88-7.34), go back onto the pitch (OR 3.57, *p*<0.001, 95% CI 1.87-6.80), or to play early in their recovery (OR 6.14, *p*<0.001, 95% CI 2.74-13.74), with a suspected SRC were more likely to not report symptoms.

DISCUSSION

This study quantified knowledge and non-reporting of SRC symptoms in community adult rugby league players and parents of <18years players. Secondly, the study identified factors associated with non-reporting of SRC symptoms. Overall, the reported prevalence of SRC symptoms was >30% for rugby league players ≥18years, and >20% for players <18years within the last two seasons. Furthermore, non-reporting of SRC symptoms was over twice as prevalent in adult community (43%) than professional rugby league players[78]. Twenty-five and 22% of players ≥18years did not report SRC symptoms for fear of missing playing time or letting their teammates down, respectively. This finding is consistent with elite players. [6,7] Players ≥18years who reported receiving external coaching pressures around a SRC were

more likely to not report a suspected SRC. Players not reporting concussion symptoms may be a potentially modifiable risk factor,[17] and should be considered by all stakeholders. Creating a culture that both reinforces and encourages concussion reporting with clear support from parents, players, staff, and coaches, may assist with improving rates of SRC reporting.[17,18]

Identifying SRCs in community rugby league is challenging due to poor medical support and limited direct contact time with players. Reporting of SRC related symptoms by players (and parents) is important to help recognise, diagnose, and manage SRCs.[3,19] This study showed 43% of community rugby league players did not report SRC symptoms sustained in the last two seasons. This is higher than professional rugby league (Australasia 17%,[6] and Europe 20%;[7] and other contact sports (21% professional fighters [boxers, mixed martial artists, and martial artists][20] and 28% rugby union[21]). The reasons were consistent with elite rugby league[6] and union,[21] NCAA athletes,[22] and professional fighting.[20] The warrior mentality theme (e.g., being tough and playing through the pain) was identified in community rugby union players,[23] which challenged effective SRC management. The two main reasons for not reporting SRC symptoms ('didn't want to be ruled out of a match' and 'didn't want to let down team') identified in this study, can be attributed to a similar theme. Eleven-14% of players suggested coaches put pressure on players to go back on the pitch, stay on the pitch, or to return to play too early during the post-acute recovery phase. These findings suggest coach-related factors may encourage the non-reporting of SRC related symptoms, which may vary for different cohorts (Figure 1). It may also be recognised that due to limited medical support present in community sport, players may not have the opportunity to report symptoms during training or match-play and may not seek medical advice external to sport (e.g., hospital or doctor)[24], however this was not explored in the current survey. Collaborative efforts across sports, such as leveraging support from other successful sport governing bodies, along with global initiatives that embrace a multidisciplinary approach and engage all support personnel, are potentially beneficial in tackling the issue of non-reporting of symptoms related to SRC. These initiatives could focus on enhancing education for coaches and referees, as well as implementing

behaviour change models to actively address the underlying reasons for non-reporting, ultimately aiming to reduce instances of unreported SRC symptoms.[18,25]

Within the youth cohort of players, non-reporting of SRC symptoms was lower (5%). These results were reported by parents/guardians and may be explained by the increased difficulty in self-identifying SRC symptoms in younger players,[19,26] and therefore lower reporting to and by parents. With only 68% of parents correctly identifying SRC symptoms, there may be some parents who miss SRC symptoms in children, which may result in fewer reported SRC's. Parents of young athletes play an important role in both identifying concussive symptoms but can be unaware of SRC symptoms and may not be familiar with new concussion management guidelines.[27] Individuals may feel pressure from themselves or others to continue playing and this pressure can lead to downplaying SRC symptoms.[28] Coaches and parents can influence SRC care seeking intentions and behaviours,[29] and should encourage good health seeking behaviours. Non-reporting of symptoms was lower in parents (i.e., ~5%), which is important as ~33% of children and adolescents experience ongoing somatic symptoms.[30] Conversely, players <18years may not report symptoms to parents,[3] which should also be considered. Concerningly, players with ≥5years playing experience, were more likely to not report SRC symptoms compared to players with less playing time (See Figure 1.). Targeting players with more playing experience will require a different method to the less experienced cohort and requires further research in education and behaviour change techniques in these populations. Non-reporting of SRCs can have serious consequences for a child's health and is important for parents to be aware of symptoms and seek medical attention.[19,27]

Knowledge of SRC is important,[13] with current findings showing the correct symptoms of SRC were identified by 58% (≥18years) and 68% (<18years/parents) of respondents. [8,4022,23,32] In relation to SRC knowledge, headaches were correctly identified as the most common symptom,[31] but mental health associated symptoms were the least recognised symptoms in this study, consistent with previous research[7,32] These figures are lower than reported in

professional rugby league and community rugby union (76-77%),[7,33] which highlights the need to prioritise appropriate symptom education initiatives to target behaviour change and symptoms understanding in community rugby league players.[18,25] Mental health consequences of SRC should form part of future SRC education initiatives. Players with greater mental health literacy, have greater health-seeking behaviours.[32,34] Studies also show a deficit in mental health symptom understanding among elite and community rugby league players. These studies in combination with ours highlight a clear opportunity to address a caveat in our understanding of concussion reporting.[7,32]

Less community players and parents (approx. 30%) had annual SRC education compared to professional rugby league players in England (62%)[7], and Australia (85%)[6]. Whilst SRC modules are mandatory within the RFL community game, the delivery of education is not standardised, and reaching all players and parents appears a challenge. Education and knowledge in isolation are weak predictors of behaviours change, therefore community rugby league should ensure the environment supports the reporting of potential concussive symptoms,[3529] Furthermore, improved knowledge of SRC, at the time of the study versus the start of their careers was reported demonstrating some success in recent RFL education programmes.

SRC diagnosis is challenging, and not reporting symptoms is a potentially modifiable yet complex risk factor. Clear messaging (e.g., *if in doubt, sit them out*)[36] and the emergence of novel technology (e.g., instrumented mouthguards,[37] electroencephalography[38], biomarkers,[39] recognition of psychological symptoms,[34] and MRI imaging[40]) may assist the identification, assessment, and diagnosis of SRC, however their feasibility at community level must be investigated. In the community, coaches and support staff play a crucial role in nurturing trusting relationships with players to promote injury reporting and providing guidance, support, and empowerment to players throughout their injury management process.[24] They can

facilitate communication and collaboration among all relevant stakeholders, enabling shared decision-making in the real-time mitigation of injury risks.[24]

This study is not without its limitations. The survey was based on previous research;[6,7] but the reliability and validity has not been assessed. The generalisability of the study is unknown due to potential reporting and sampling bias; however, the number of participants is similar/greater than other studies.[6,7] The questionnaire did not differentiate participant gender, therefore gender-specific results were not possible to analyse. Not every question in the survey was compulsory, and therefore some questions were skipped. Each question was individually answered and did not link with previous or forthcoming questions. In the reasons for not reporting a concussion section, possible answers were given (not open-ended responses), therefore limiting the full scope of answer that the participant could provide. The survey response rates were relatively low; therefore, a greater participation could offer different results. The knowledge section of the survey did not use a validated scale [e.g., Rosenbaum Concussion Knowledge and Attitudes Survey-Student Version [(RoCKAS-S)], limiting comparisons with concussion knowledge studies. This study should be replicated differentiating for gender, include a larger sample size and/or a qualitative component, whilst continuing to evaluate concussion initiatives.

CONCLUSION

In community rugby league, 43% of players ≥18years did not report suspected SRCs, which is greater than in professional rugby league. Parents of players <18years report most of their children's symptoms of SRC.[6] Not reporting SRC symptoms is complex and needs further investigation. To address this non-reporting of SRC symptoms, organizations should appropriately educate players, parents, coaches and support stakeholders (e.g., first aiders) about the consequences of SRCs, with a focus on behaviour change and removing any negative perceptions around SRC reporting. Given the similarities in reasons for not reporting SRC between studies internationally, a global cross-sport and unified approach is required.

Keywords:

Brain injury, Concussion, Community, rugby, player welfare, diagnosis

Data availability:

The datasets (deidentified participant data) generated during and/or analysed are available from the corresponding author on request.

CRediT authorship contribution statement:

Daniel Tadmor: Investigation, Methodology, Writing Original Draft, **Lucy Chesson:** Writing – Review & Editing, **Kevin Till:** Writing – Review & Editing, Supervision, **Gemma Phillips:** Conceptualization, Investigation, Data Curation, Writing – Review & Editing, **Laura Fairbank:** Writing – Review & Editing, Project Administration, **James Brown:** Writing – Review & Editing, **Matt Cross:** Writing – Review & Editing, **Andrew J Gardner:** Writing – Review & Editing, **Sharief Hendricks:** Writing – Review & Editing, **Rich D Johnston:** Writing – Review & Editing, **Cameron Owen:** Writing – Review & Editing, Formal Analysis, **Keith Stokes:** Writing – Review & Editing, **Ben Jones:** Conceptualization, Methodology, Investigation, Data Curation, Writing – Review & Editing, Project Administration.

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Declaration of interest:

Daniel Tadmor's PhD is part-funded by Leeds Rhinos rugby club and works as a medical doctor for multiple sports teams. Kevin Till is employed by Leeds Rhinos in a consultancy capacity. Gemma Phillips is employed in a consultancy capacity by the Rugby Football League and Hull Kingston Rovers. Laura Fairbank is employed by the Rugby Football League. James Brown has received research funding from World Rugby. Matt Cross is employed by Premiership Rugby. Andrew J Gardner has a clinical practice in neuropsychology involving individuals who have sustained sport-related concussion (including current and former athletes). He has been a contracted concussion consultant to Rugby Australia. He has received travel funding or been reimbursed by professional sporting bodies, and commercial organisations for discussing or presenting sport-related concussion research at meetings, scientific conferences, workshops, and symposiums. Previous grant funding includes the NSW Sporting Injuries Committee, the Brain Foundation (Australia), an Australian-–American Fulbright Commission Postdoctoral Award, a Hunter New England Local Health District, Research, Innovation and Partnerships Health Research & Translation Centre and Clinical Research Fellowship Scheme, and the Hunter Medical Research Institute (HMRI), supported by Jennie Thomas, and the HMRI, supported by Anne Greaves. He has current philanthropic support from the Nick Tooth Foundation. He acknowledges unrestricted philanthropic support from the National Rugby League (NRL), Cameron Owen's research fellowship is funded by the Rugby Football League, and he has consulted for World Rugby. Keith Stokes is employed by the Rugby Football Union. Ben Jones is employed in a consultancy capacity by Premiership Rugby and the Rugby Football League.

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Figure 1. A heat map showing community rugby league players' ≥18years (n=484) responses in the UK, per demographic and playing history data, collected during the 2022 pre-season. (E.g., for players that did not report a suspected concussion, outside of rugby, >5 times, 100% were 18-25years old).

Supplementary Table 1. The modified UK community rugby league player and parent survey questions and response options based on Longworth et al. (2021) and Tadmor et al., (2023); distributed during the 2022 pre-season.

Question	**Years playing organised rugby league**[a]
Response	0-2 / 3-5 / ≥5
Question	**Current level of play***
Response	Open Age / National Conference League or U18 / U16 / U14 / U12 / U10 / U9[b]
Question	**Have you (or your child) played for a professional rugby league team or academy****
Response	No / Yes
Question	**Age (years)***
Response	18 – 25 / 26 – 30 / ≥ 30 or open answer (under 18's)[c]
Question	**Regular playing position***
Response	Forwards / Backs[d]
Question	**Do you feel you have adequate knowledge of concussion and the potential long-term implications of concussion?****
Response	Yes / No
Question	**Number of diagnosed concussion (by medical staff) in the past 2 seasons;***
Response	***During matches*** (None, 1-2, 3-5, 5+), ***During training*** (None, 1-2, 3-5, 5+), ***Outside of rugby matches or training*** (None, 1-2, 3-5, 5+)[e]
Question	**Have you felt you (or your child) have suffered a concussion in the past two seasons and not reported to a member of the medical staff or coach****
Response	***During matches*** (Never, Yes, 1-2 occasions, Yes, 3-5 occasions, Yes, 5+ occasions), ***During training*** (Never, Yes, 1-2 occasions, Yes, 3-5 occasions, Yes, 5+ occasions), ***Outside of rugby matches or training*** (Never, Yes, 1-2 occasions, Yes, 3-5 occasions, Yes, 5+ occasions)[f]
Question	**Have you ever NOT reported concussion symptoms, or tried to hide a potential concussion from the medical staff or coach?***
Response	No / Yes[g]
Question	**For what reason have you NOT reported a symptom(s) to the doctor during the assessment (*can choose multiple*)?***
Response	I always report my symptoms / I didn't want to be ruled out of a match / I didn't want to be ruled out of training / I didn't want to let down the team / I didn't want to let down the coaches / I didn't think the symptoms were related to concussion / Despite the symptom(s), I didn't think they were significant / It occurred during an important match or time of the season / Fear that having a concussion diagnosis would affect future selection[h]
Question	**Which of these symptoms can be experienced as a result of a concussion – please select all that apply** (Agree/ Disagree)**
Response	See Table 2
Question	**Have you had annual education from your club surrounding concussion symptoms and the potential consequences of underreporting concussion?***
Response	Yes / No / Don't know
Question	**Are you concerned about the potential long-term implications from concussion?****
Response	Yes / No
Question	**Did you feel you had an appropriate level of knowledge at the start of your (or child's) rugby league career about concussion and potential long-term implications?****
Response	Yes / No
Question	**Based on your current knowledge of concussion and the potential long-term implications, would you encourage your/family members children NOT TO play rugby league?****
Response	Yes – I would encourage them NOT to play / No – I would not encourage them NOT to play
Question	**If you have sustained a concussion, did this affect your (or child's) ability to work or attend education?****
Response	No, Yes; it did affect ability due to persistence of symptoms / it did affect ability due to the required rest period.
Question	**Have you (or your child) been encouraged to stay on the pitch by a coach when you may have experienced a concussion****
Response	Yes / No
Question	**Have you (or your child) been encouraged to go back on the pitch by a coach when you should stay off following a suspected concussion****
Response	Yes / No
Question	**Have you been encouraged by a coach to play a match following a suspected concussion when you weren't recovered and/or followed the appropriate graduated return process?****
Response	No / Yes

*same question as Longworth et al., (2021). **new question to Longworth et al (2021) [a]years playing organised rugby league compared to playing for an NRL club. [b]current level of play options changed to Open Age / National Conference League or U18 / U16 / U14 / U12 / U10 / U9 . [c]age grouping categorised into 4 groups or open answer. [d]position classified into forwards and backs. [e]response options altered to separating match, training, and outside rugby. [f]response options altered to separating match, training, and outside rugby. [g]response limited to No / Yes. [h]multiple responses accepted, ruled out of a match and training separated, let down team and coaches separated, fear of future selection separated.

Supplementary Table 2. Correct answers for concussion symptom understanding in community rugby league players (n=484) and parents (n=965) in the UK, during the 2022 pre-season.

	Community results (≥18):	Parents' results (<18):
Symptom:	*Correctly identified:*	
Headache	91%	97%
Feeling off balance	79%	90%
Loss of consciousness	74%	87%
Double vision	74%	86%
Confusion	69%	85%
“Don’t feel right”	67%	77%
Pressure in the head	64%	74%
Nausea or vomiting	64%	86%
Difficulty concentrating	61%	71%
Drowsiness	60%	80%
Feeling like “in a fog”	59%	70%
Difficulty remembering	59%	71%
Neck pain	55%	63%
Sensitivity to light	54%	65%
Weakness or tingling in arms or legs	47%	52%
Feeling slowed down	47%	53%
Fatigue/low energy	46%	53%
Sensitivity to noise	43%	65%
Irritability	39%	49%
Trouble falling asleep	32%	31%
Seizures	31%	57%
Nervous or anxious	31%	32%
More emotional	27%	40%
Sadness	27%	29%
Toothache*	86%	83%
Single joint pain*	91%	89%
Weight gain*	94%	93%
Mean ± SD	**58.2 ± 0.2%**	**67.7 ± 0.2%**

**Incorrect symptom of concussion identified correctly*

Supplementary Table 3. The effect of different variables on the non-reporting of concussion symptoms in community rugby league players >18 years (n=484) in the UK (Generalised Linear Model), collected during the 2022 pre-season.

Variable	Comparison	Odds ratio	p value	95% CI LL	95% CI UL
Number of diagnosed concussions in past 2 seasons, during matches.	(1-2) / (3-5)	0.34	0.053	0.12	1.01
	(1-2) / (5+)	0.36	0.185	0.10	1.33
	(1-2) / None	2.54	<0.05	1.41	4.57
	(3-5) / (5+)	1.06	0.999	0.22	5.09
	(3-5) / None	7.4	<0.05	2.55	21.45
	(5+) / None	6.99	<0.05	1.94	25.18
Previous annual concussion education from club.	Don't Know / No	0.71	0.601	0.31	1.63
	Don't Know / Yes	1.11	0.957	0.46	2.67
	No / Yes	1.56	0.141	0.90	2.70
Current level of play.	NCL / Open Age	1.03	0.876	0.68	1.56
Years playing organised rugby league.	>5 / (0-2)	4.15	<0.05	1.51	11.41
	>5 / (3-5)	2.36	0.069	0.95	5.86
	(0-2) / (3-5)	0.57	0.571	0.15	2.11
Previously played for a professional rugby league team or academy.	No / Yes	0.76	0.193	0.50	1.15
Encouraged to stay on the pitch by a coach when may have experienced a concussion.	Yes / No	3.71	<0.05	1.88	7.34
Encouraged to go back on the pitch by a coach when you should have stayed off following a suspected concussion.	Yes / No	3.57	<0.05	1.87	6.80
Encouraged by a coach to play a match following a suspected concussion when weren't recovered and/or followed the appropriate graduated return process.	Yes / No	6.14	<0.05	2.74	13.74