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Original research

Differences between the sexes in concussion knowledge and attitudes in community football (soccer) players in New Zealand

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ABSTRACT

Objectives: To evaluate self-reported concussion knowledge and attitudes in community football players in New Zealand, comparisons were made between the sexes and those with and without history of concussion.
Design: Cross-sectional cohort study.
Methods: The Rosenbaum Concussion Knowledge and Attitudes Survey (RoCKAS) was used for data collection and analysis. Players were recruited through the New Zealand Football registered player database.
Results: Seventy-four players had data eligible for inclusion (55 % female). Thirty-four players (45 %) had previously diagnosed concussion (56 % female). Mean Concussion Knowledge Index (CKI) scores were significantly ($p = 0.002$) higher for male (20.8 ± 1.4) than female (19 ± 3.7) players. There were no significant sex differences in mean Concussion Attitude Index (CAI) scores (female 63.7 ± 11.4, male 65.6 ± 6.0; $p = 0.427$). Surprisingly, 32 % female and 39 % male players indicated that they would play on with symptoms of concussion. Comparison within female players showed a significantly higher CKI (20.3 ± 1.7 versus 18.8 ± 2.6; $p = 0.025$) and higher CAI (66.5 ± 4.9 versus 64.1 ± 5.9; $p = 0.151$) in players with a history of concussion. There were no within male player trends for CKI or CAI.
Conclusions: Male players had a notably higher concussion knowledge (CKI) than female players. Females with a previously diagnosed concussion also had a notably higher CKI than female players with no concussion history. Therefore, healthcare professionals could play a key education role when managing players with concussion. Given over a third of players indicated that they would play on with symptoms of concussion, education should focus on short- and long-term impacts of concussion and potential consequences of concussion.

Practical implications

- Concussion education strategies could focus on ensuring that players understand the short- and long-term impacts of a concussion and the potential consequences of the injury if not reported and managed.
- Sport medicine and other healthcare professionals engaging with community players have a key education role in further increasing concussion knowledge and promoting a safe attitude towards the injury.
- It must not be assumed that female players are more likely than male players to report concussion injury and ongoing symptoms.
- There may be differences in underlying reasons for reporting a concussion, or not, between male and female players. This needs further investigation and should be considered within education strategies.

1. Introduction

In New Zealand there are an estimated 35,000 traumatic brain injuries (TBI) every year with ~95 % classified as mild TBI (also known as concussion).[1] Yet the national injury insurance scheme only receives ~22,000 concussion claims per year, suggesting that ~30 % concussions may go unrecognised and unreported. Approximately 30–40 % of those concussion claims are from playing sport.[2]

Rugby (union) has been the focus of sport concussion research in New Zealand.[3] Although the risk is lower, other team-based sports, including football (soccer), also carry a risk of concussion[4] which has been less well recognised in New Zealand.

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Football is the worlds' most popular sport with over 270 million people involved worldwide.[5] Whilst there are mental and physical health benefits of playing team sport[6] there is a risk of football-related injury, including concussion.[7] Concussion carries risk of long-term consequences including increased risk for cognitive decline and neurodegeneration in later life.[8] Early recognition and management of concussion substantially improves outcomes and recovery time.[9,10] Awareness of concussion in sport has increased due to social and traditional media raising the profile of the injury. This is particularly true for collision sports in which routine, purposeful body-to-body collisions are a legal and an expected part of the game (e.g., Rugby codes, American Football, and Ice Hockey) where risk of concussion is accepted to be high.

There are sex differences in sport-related concussion in team sports (e.g., football, hockey, basketball). Females typically have a greater incidence of concussion,[4] report a higher symptom burden and often take longer to recover and return to play.[11] These differences are particularly evident in football.[11,12] Sex differences may be due to gendered reporting bias where female players are more likely to report injury and ongoing symptoms.[13,14] Little is known about levels of knowledge and attitudes towards concussion in football in New Zealand and there is limited research investigating potential reporting bias or sex differences amongst tiers two and three[15] (community) football players.

Sustaining a single concussion that is recognised, well managed and given time to fully resolve is unlikely to lead to long-term detrimental consequences. Concussion knowledge and attitudes play a role in prevention, recognition, and management of this injury. In community sport where there are lower levels of medical support, there is greater reliance on players, coaches and caregivers to recognise and report a suspected concussion.[12,16] Although concussion knowledge does not always translate to desired behaviour,[17–21] understanding current levels of concussion knowledge and attitudes in football is an important start point. Identifying knowledge gaps may contribute to developing more effective injury prevention and concussion education strategies tailored to different genders.

The purpose of this cross-sectional study was to evaluate via online survey the self-reported concussion knowledge and attitudes of community football players in New Zealand.

2. Methods

Ethical approval for the study that complies with The Declaration of Helsinki was granted on 23 August 2022 by Auckland University of Technology Ethics Committee (AUTEC 22/192).

All 104,000 players registered with New Zealand Football (NZF) in the 2023 season were invited to take part in the study. Participants were recruited via email and social media. NZF provided information about the research to the six regional federations to distribute to affiliated clubs. Potential participants were directed to an online version of the Rosenbaum Concussion Knowledge and Attitudes Survey (RoCKAS) survey via a link shared through player databases and through federation and club social media channels. Responses were monitored and federations sent reminders to their football communities twice throughout the season (17 weeks) to encourage participation. At season end, a third and final reminder was sent to players during the off-season to further increase participation. The survey, completed between 01 February 2023 and 19 February 2024, was anonymous.

Inclusion criteria for participants were; (i) Aged 16 yrs. or older, (ii) Be an amateur (non-professional) player – tier two or three on the participant classification framework,[15] and (iii) Have been involved in football within the previous 12 months. Exclusion criteria were; (i) Professional player, and (ii) Failing the internal validity index consisting of three true/false items in section one of the RoCKAS with a score of <2.[22]

Data were collected through an online survey (supplementary material) administered on the Alchemer platform (https://app.alchemer.com). Player demographics collected included age group, gender (terminologies used were 'female', 'male', 'non-binary' and 'prefer not to say'), level of participation of football, years of playing experience, residing region, and history of previously diagnosed concussion.

The RoCKAS[22] survey was utilised for data collection and analysis. RoCKAS was developed to examine concussion knowledge and attitudes in high school students and has been used in adult populations.[23–26] RoCKAS has been psychometrically tested and has good validity and reliability to measure concussion knowledge and attitudes (knowledge items, $r = 0.67$; attitude items, $r = 0.79$) and appears to be less susceptible to social desirability in its measures of attitude than other similar tools.[22] RoCKAS has an Intraclass Correlation Coefficient (ICC) of 0.79 ($p < 0.001$) and an internal consistency with a Cronbach's alpha score of $\alpha = 0.76$.[27]

RoCKAS consisted of 55 items across five sections. Question format varied; sections one and two were TRUE/FALSE items, and section five was a checklist. A correct answer in these sections scored one point. Collectively these sections included 25 items and were used to determine the Concussion Knowledge Index (CKI) with a total possible score of 25 points. Sections three and four were used to determine the concussion attitudes index (CAI) and included 15 items utilising a five-point Likert scale. Participants scored five points for the safest answer and one point for the least safe answer for a total score range of 15–75. RoCKAS included three items that tested validity of participant responses (items four, ten and fifteen in section one). If less than two validity items were answered correctly, the survey was considered invalid and therefore excluded from analysis (see Supplementary Table I). RoCKAS was modified to make terminology in some items reflects the New Zealand context (Supplementary Table II). The primary outcome measures were CKI and CAI.

CKI and CAI were calculated using the RoCKAS scoring key (Supplementary Table I) and tabulated with the other participant items in Excel (Microsoft, USA) for data handling before importing into GraphPad Prism v9.31 (GraphPad, USA).

Table 1
Participant characteristics by age group, participation level, years of playing and previous concussions for 74 amateur football players in New Zealand.

Total	Female	Male
	n (%)[a]	n (%)[b]
	41 (55 %)	33 (45 %)
Age group (yrs.)		
15–19	5 (12.2 %)	1 (3.0 %)
20–24	8 (19.5 %)	3 (9.1 %)
25–29	9 (22.0 %)	3 (9.1 %)
30–34	7 (17.1 %)	6 (18.2 %)
35–39	3 (7.3 %)	1 (3.0 %)
40–44	6 (14.6 %)	4 (12.1 %)
45–49	2 (4.9 %)	6 (18.2 %)
50–54	1 (2.4 %)	4 (12.1 %)
55–59	Nil	5 (15.2 %)
Participation level		
National league	2 (4.9 %)	Nil
Premier[c]	13 (31.7 %)	11 (33.3 %)
U18	1 (2.4 %)	Nil
Local league	25 (61.0 %)	12 (36.4 %)
Masters	Nil	10 (30.3 %)
Years playing		
0–1	1 (2.4 %)	Nil
1–2	1 (2.4 %)	Nil
2–5	8 (19.5 %)	Nil
5–10	10 (24.4 %)	4 (12.1 %)
10+	21 (51.2 %)	29 (87.9 %)
Previous concussion		
Yes	19 (46.3 %)	15 (45.5 %)
No	22 (53.6 %)	18 (54.5 %)

[a] Percentage (%) of count for all female participants.
[b] Percentage (%) of count for all male participants.
[c] Premier League, Championship/Federation League.

Table 2
Mean CKI and CAI scores of all respondents, female and male respondents for each section and total assessment by mean ± standard deviation (SD), statistical significance between male and female respondents.

Section	Total	Female	Male	*p value
	Mean ± SD	Mean ± SD	Mean ± SD	
1 (max score = 14)	13.59 ± 1.56	9.29 ± 1.50	10.3 ± 1.17	
2 (max score = 3)	2.53 ± 0.53	2.46 ± 0.55	2.60 ± 0.50	
5 (max score = 8)	7.76 ± 0.64	7.7 ± 0.67	7.8 ± 0.57	
Total CKI (max = 25)	20.0 ± 2.00	19.0 ± 2.20	20.8 ± 1.40	p = 0.002
3 (score range 5–25)	21.95 ± 2.26	21.83 ± 2.15	21.69 ± 2.44	
4 (score range 10–50)	43.65 ± 4.07	43.46 ± 3.77	43.88 ± 4.39	
Total CAI (possible 15–75)	65.42 ± 5.61	65.29 ± 5.34	65.57 ± 5.57	p = 0.427

SD = standard deviation; CKI = Concussion Knowledge Index; CAI = Concussion Attitude Index.
* p difference between male and female players.

Descriptive statistics were generated to provide general information about the population demographics and to summarise CKI and CAI scores. Data are reported as mean ± standard deviation (SD) for CKI and CAI scores to characterise the sample. Frequency and percentage of correct or safe/desirable answers were calculated. Graphs were plotted in GraphPad Prism v9.31.

Due to sample size, normal distribution could not be confidently assumed. Normality and lognormality were tested using Anderson–Darling, D'Agostino & Pearson's, Shapiro–Wilk and Kolmogorov Smirnov tests, and did not indicate Gaussian distribution. Box plots were presented given non-normally distributed data. The Mann Whitney *U* test was utilised for pair wise comparisons of total CKI and CAI scores between males and females. Mann Whitney *U* tests were also performed within males and females to evaluate whether CKI and CAI differed between those who did or did not report a history of medically diagnosed concussion. Alpha level was set at $p < 0.05$ for all statistical tests.

3. Results

Ninety-seven football players participated in the study (54 % female). Twenty-three responses were excluded due to incomplete survey answers, resulting in 74 responses eligible for analysis (55 % female) (see Table 1). Thirty-four players (45 %) reported a previously diagnosed concussion.

Table 3
Percentage and number of participant responses to symptoms they identified as concussion symptoms.

Symptom	Female	Male	Overall
	% (n=)	% (n=)	% (n=)
Hives	29 (12)	45 (15)	36 (27)
Headache	**100 (41)**	**97 (32)**	**99 (73)**
Difficulty speaking	95 (39)	100 (33)	97 (72)
Arthritis	24 (10)	30 (10)	27 (20)
Sensitivity to light	**93 (38)**	**94 (31)**	**93 (69)**
Difficulty remembering	**100 (41)**	**100 (33)**	**100 (74)**
Panic attacks	88 (36)	97 (32)	92 (68)
Drowsiness	**98 (40)**	**100 (33)**	**99 (73)**
Feeling in a "fog"	**95 (39)**	**97 (32)**	**96 (71)**
Weight gain	48 (20)	48 (16)	49 (36)
Feeling slowed down	**88 (36)**	**94 (31)**	**91(67)**
Reduced breathing rate	92 (38)	91 (30)	92 (68)
Excessive studying	20 (8)	18 (6)	19 (14)
Difficulty concentrating	**98 (40)**	**100 (33)**	**99 (73)**
Dizziness	**100 (41)**	**100 (33)**	**100 (74)**
Hair loss	24 (10)	24 (8)	24 (18)

True concussion symptoms are indicated in bold.

3.1. Concussion Knowledge Index scores

The total mean Concussion Knowledge Index (CKI) score was 20.0 ± 2.0 (see Table 2). Male players had a significantly higher mean CKI than females (20.8 ± 1.4 vs. 19.0 ± 2.2; $p = 0.002$) (see Fig. 1).

Nearly all players (98 % females, 100 % males) knew that a person did not have to be knocked out to sustain a concussion (evidenced by Section 1, question 5, '*In order to be diagnosed with a concussion, you have to be knocked out*'). All (100 %) players knew that '*Concussions can sometimes lead to emotional disruptions*' (Section 1, question 16).

The question most frequently answered incorrectly was Section 1, question 11, 'After a concussion occurs, brain imaging (e.g., CAT Scan, MRI, X-ray, etc.) typically shows visible physical damage (e.g., bruise, blood clot) to the brain.' Only 24 % of female, and 48 % of male players, answered this question correctly.

The question answered most differently between females and males was Section 2, question 2, '*It is likely that Player X's concussion will affect his long-term health and well-being.*' Only 30 % of male players knew that this could have a long-term impact versus 95 % of female players. Only 32 % of male players knew that playing with concussion would impact performance. Whereas 95 % of female players recognised that this would be detrimental (Section 2, question 3, '*Even though Player F is*

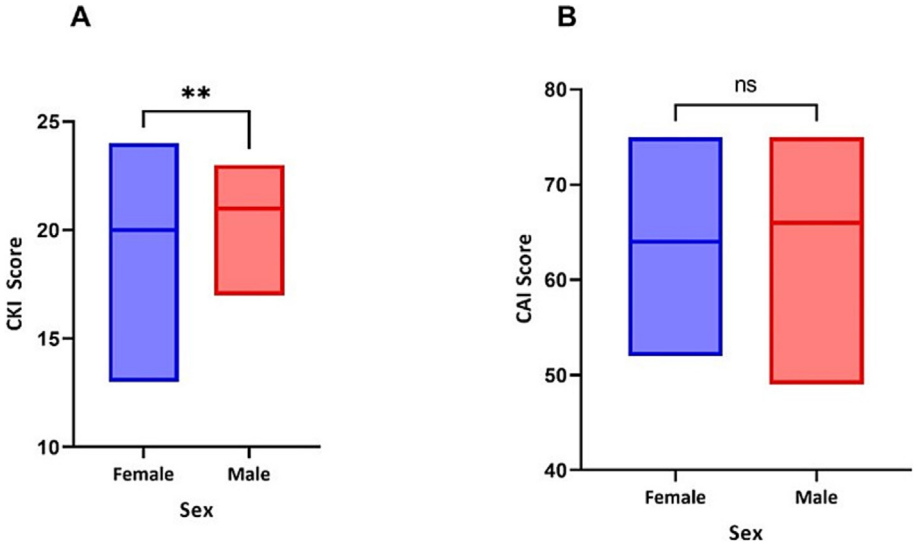

Fig. 1. Differences in mean scores between males and females for (A) CKI ($p = 0.002$) and (B) CAI ($p = 0.538$).

Table 4
Differences between male and female Concussion Knowledge Index and Concussion Attitude Index scores by mean ± standard deviation (SD), statistical significance and effect size with and without prior concussion.

	Prior concussion	No prior concussion	*p-value
	Mean ± SD	Mean ± SD	
CKI			
Male	20.80 ± 1.26	20.71 ± 1.65	0.837
Female	20.26 ± 1.66	18.75 ± 2.61	0.034
CAI			
Male	66.67 ± 6.21	64.24 ± 5.74	0.263
Female	66.53 ± 4.86	64.05 ± 5.93	0.151

SD = standard deviation; CKI = Concussion Knowledge Index; CAI = Concussion Attitude Index.
* p difference within sex by concussion history.

still experiencing the effects of the concussion, her performance will be the same as it would be had she not suffered a concussion').

4. Concussion Attitudes Index scores

The total mean Concussion Attitudes Index (CAI) score was 65.4 ± 5.6 (see Table 2). Male players did not have a significantly higher mean CAI than females (65.6 vs. 65.3; p = 0.427) (see Fig. 1).

Of 18 items that comprised the CAI score, no question was answered 100 % correctly by either male or female respondents. The highest percentage of correct responses was for Section 4, question 1 '*I felt the Coach A made the right decision to keep Player R out of the game*', 84.8 % of male and 80.5 % of female players selected the safest responses.

Both male and female respondents' lowest rate of safe/desirable responses was for Section 3, question 1 '*I would continue playing a sport while also having a headache that resulted from a minor concussion*', with 68 % of female and 61 % of male players gave a safe response.

Over 90 % male and female respondents correctly identified symptoms of a concussion (see Table 3). Difficulty speaking, panic attacks and reduced breathing rate were symptoms most frequently incorrectly identified as concussion symptoms by both male and female players.

4.1. Impact of previous concussion

Of 34 players that reported a previously medically diagnosed concussion, 19 (55 %) were female and 15 (45 %) were male. Female players with a history of concussion had a significantly higher CKI when compared with females with no previous concussion (20.3 ± 1.7 vs. 18.8 ± 2.6; p = 0.034). There were no statistically significant differences for any other comparisons (see Table 4 and Fig. 2).

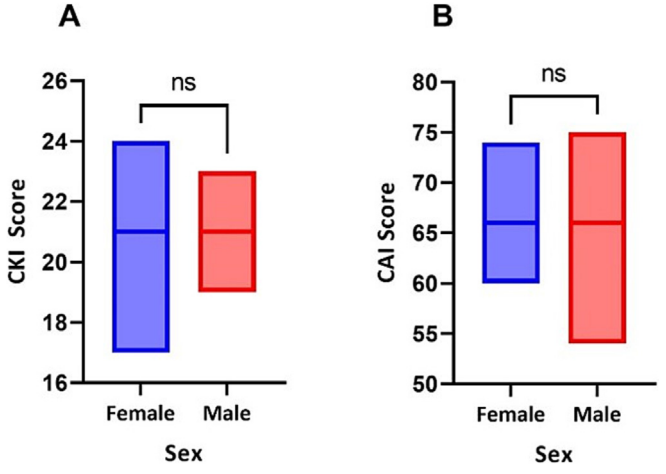

Fig. 2. Mean scores for males and females with a history of concussion showed no differences by sex for (A) CKI (p = 0.403) and (B) CAI (p = 0.843).

5. Discussion

5.1. Female vs. male responses (including CKI and CAI scores)

This was the first study to evaluate concussion knowledge and attitudes in tiers two and three[15] (community) football players in New Zealand. Male players had a significantly (p = 0.002) higher CKI than female players and female players with a history of concussion had a significantly (p = 0.034) higher CKI than female players not reporting a history of concussion. There were no other significant findings. Although the RoCKAS is the most utilised tool for evaluating concussion knowledge and attitudes and provides a useful objective measure, what remains unclear is whether there is a minimum threshold index score for knowledge and attitudes that should be achieved or that relates to a specific outcome. Therefore, it is difficult to infer whether the current CKI and CAI scores should be considered 'high' or otherwise. However, the CKI and CAI scores for male and female players were comparable to those reported in similar studies in football[24–26,28] and other team sports[19–21,23,29] (see Supplementary Table V).

Of local relevance, the study of 533 community Rugby players in New Zealand[19–21] recorded lower CKI (overall 18.6 ± 2.4, women 18.9 ± 2.1, men 18.4 ± 2.6) and CAI (overall 59.3 ± 6.8, women 60.2 ± 6.5, men 58.8 ± 7.0) scores than football players in the current study. Score differences could be due to the rugby study having a larger sample size from the in-person recruitment strategy which may mean that results were more representative of the NZ rugby playing population. This cohort was inclusive of older players whereas the rugby cohort focused on high school players which could also have influenced the higher scores recorded in the football players. It is also plausible that higher CKI and CAI scores in the current study were a result of an increased level of activity around concussion more generally in response to concerns over long-term impacts of concussion and media influence associated with two major sporting events (FIFA Women's World Cup 2023 and the Women's Rugby World Cup 2023) hosted in New Zealand since the previous studies were conducted. In contrast, a relatively recent study[24] in football players in Nigeria reported much lower CKI (14.0 ± 3.0) and CAI (54.5 ± 9.4) scores, which may be a reflection of levels of resource available to provide education and medical support in the two countries.

The lower CKI of female players in this study compared to male players could be due to over 50 % of female players in this study being under the age of 30 with a range of playing experience from one to ten years, whereas male players were older (55 % were over 40 years old) and had a minimum of five years playing experience which may lead to more exposure to concussive injury and concussion education. These factors may have influenced concussion knowledge. CKI scores have previously been positively associated with the number of times concussion education has been received in college age student athletes.[30] These variables were not included in current analyses due to the small sample size and risk of type one error. Interestingly, females make up 22 % of the playing population in New Zealand and represented 54 % of respondents in this study. Although this introduces an element of bias in the findings, it could also be considered a standalone finding. It has previously been observed that females are more likely to engage in and complete surveys than males and that males and females differ in the types of health conditions that interest them and impact their lives.[31] This over-representation of females could indicate that female players are more interested in or concerned about concussion. This may be somewhat reflected in the lower CKI recorded for female respondents.

5.2. Identification of symptoms

Knowing concussion symptoms is critical to recognising the injury. Over 90 % of players in this study correctly identified concussion

symptoms (see Table 4). Symptom knowledge could however be improved further as there were some listed symptoms that were incorrectly identified as concussion symptoms, including: difficulty speaking, panic attacks and reduced breathing rate. This is important to clarify as other medical concerns may present with these symptoms.

The knowledge statement, 'After a concussion occurs, brain imaging (e.g., CAT Scan, MRI, X-ray, etc.) typically shows visible physical damage (e.g., bruise, blood clot) to the brain' (Section 1, question 11) was the least correctly answered statement in the current study with only 24 % of females and 48 % of males answering this correctly. Previous studies in elite female football reported that 53 % answered this statement correctly,[25] in cycling, 44.9 % answered this correctly[32] and in community Rugby in New Zealand where 26 % players answered this statement correctly.[19–21] This result outlined a general lack of understanding of what happens to the brain during concussion and highlights an education opportunity to help players recognise the importance of reporting a suspected concussion. These results also outlined that knowledge around brain imaging was particularly low in the two New Zealand cohorts. There is potential for sport codes to work together on development of consistent concussion education content.

5.3. Behaviours associated with concussion

The attitude statement '*I would continue playing a sport while also having a headache that resulted from a minor concussion*' (Section 3, question 1; Supplementary Table IV) has been shown to be a reasonable proxy to indicate concussion reporting intention (CRI) in male ice hockey players.[17] This metric has been used in other research.[19–21] Although CRI was not the focus of the current study it was interesting to note that, 68 % of female players and 61 % of male players gave a safe/desirable response to this statement. This was encouraging but also concerning given that over 30 % players indicated an intention to play on whilst experiencing the symptoms of a concussion. This is worthy of further investigation particularly given that it could have been expected that a higher percentage of female players would have given a safer/more desirable response to this statement given the majority (95 %) of female players in the current study knew that a history of multiple concussions could have a long-term impact on health and wellbeing (Section 2, question 2; Supplementary Table III) and that concussion would be detrimental to performance (Section 2, question 3; Supplementary Table III). This was notably higher than ~30 % of male players that reported knowing these points and inferred that male players may lack an understanding of implications of an unreported concussion in the short (immediate performance) and long (health and wellbeing) terms. This finding also suggested that the observed sex differences in concussion were not due to a gendered reporting bias in females. The finding also supported other studies[19–21,25,29] demonstrating that concussion knowledge does not necessarily translate to the safest/most desirable behaviours and that players alone cannot be relied upon to self-report injury. Reporting of concussion is influenced by multiple factors including ability level, gender, not wanting to let teammates down,[33] fear of being removed from competition,[18] self-denial in the 'heat of competition' and underlying motivations to be involved in sport.[34] In community sport, teams often do not have medical support and it is likely that many concussions go unrecognised and unreported. Multiple people can play a role in recognising a suspected concussion, including coaches, family (whanau), teammates, sport medicine support staff (if present), officials and team managers. It is therefore important that future research is conducted to determine the level of concussion knowledge of these key people and whether it could be improved to support increased recognition of the injury.

Respondents to concussion surveys are likely motivated to engage in the survey due to their previous injury experience. Forty six percent of all players in the current study reported a history of medically diagnosed concussion (46 % all female players and 45 % all male players). This proportion was consistent with previous studies in professional football where 43 % female[25] and 50 % male[26] players reported concussion history. Conversely, community rugby players reported a lower rate (33 %) of previously diagnosed concussion.[19–21] Given higher incidence of concussion in rugby than in football,[4] it would be reasonable to expect that the number of previously diagnosed concussions in a cohort of rugby players would be higher than that seen in football players. Concussion education and management strategies have been implemented in community Rugby in New Zealand,[19–21,35] however, there still seems to be under-reporting of concussion, which is a well-documented challenge.[19–21]

The higher CKI in females with a reported history of concussion when compared with those with no reported concussion history may be due to injury serving as education through experience. Prior concussion has been shown to improve CKI and CAI via players learning more through experience than through education alone.[30] Due to the younger age and lower number of years playing football for female players in this study it is plausible that the experience of having a concussion went someway to filling the education/knowledge gap. This highlighted a valuable secondary prevention education opportunity for healthcare professionals when engaging with community players who sustain concussion.

5.3.1. Limitations

The small sample size overall and in each age group mean the study findings may not be representative of the football community and limited the number of variables that could be investigated and the possibility to draw conclusions for specific populations. It is also noteworthy that this study had a small sample and a low response rate (0.75 %) in comparison to other similar studies. This could be attributed to several factors. Firstly, 2023 was the first uninterrupted season since COVID-19, which may have affected participants' motivation to engage in research activities. Studies have shown that post-pandemic periods can lead to lower participation rates due to altered priorities and fatigue from previous disruptions.[36] Secondly, the online recruitment strategy employed for this survey may have been sub-optimal. Online surveys often face challenges such as lower engagement and higher dropout rates compared to face-to-face methods.[37] Additionally, previous research indicates that novel survey topics can initially attract fewer respondents until awareness and interest are built over time.[38]

The low response rate (0.75 %) also introduces the potential for substantial non-response bias and a bias towards those with an interest in, or some experience with, concussion. However, this was the first study to evaluate concussion knowledge and attitudes of community football players in New Zealand, where much of the previous sport concussion research has focused on rugby.

The proportion of respondents with a history of medically diagnosed concussion highlighted a possible bias in this sample; players engaging with the survey likely had an interest in concussion due to prior experience. Future studies need to adopt a wider recruitment approach and encourage responses from players of all age groups and playing experience.

6. Conclusions

Male players had significantly higher concussion knowledge (CKI) than female players. Females with a previously diagnosed concussion had significantly higher CKI than female players with no concussion history. Therefore, healthcare professionals could play a key education role when managing players with concussion. Given over a third of players indicated that they would play on with symptoms of concussion, education should focus on short- and long-term impacts of concussion and potential consequences of concussion if not medically managed. The wider football community should be supported to

promote an environment where concussion recognition and reporting is expected and encouraged. Female players were less likely to report injury and ongoing symptoms than male players. Further research is needed to understand differences between sexes in motivations underlying the intention to report a concussion or not. It would be valuable for larger studies to further investigate concussion knowledge and attitudes of players and of other members of the football community in New Zealand including coaches, team managers and those involved in side-line care. Finally, given the widespread utilisation of the RoCKAS it would be valuable to compare all studies and evaluate how concussion knowledge and attitudes compare across sports, countries and over time.

CRediT authorship contribution statement

Natalie J. Hardaker: Conceptualization, Methodology, Resources, Investigation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Patria A. Hume:** Conceptualization, Methodology, Formal analysis, Data curation, Writing – review & editing. **Juno Barnett Collins:** Investigation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Doug A. King:** Conceptualization, Methodology, Writing – review & editing. **Stacy T. Sims:** Writing – review & editing. **James Selfe:** Writing – review & editing.

Code availability

Code is available from the lead author upon request.

Disclaimer

The views expressed in the submitted article are the authors' own and not an official position of the ACC.

Confirmation of ethical compliance

The study was performed in accordance with the ethical standards of the Declaration of Helsinki; ethics approval was obtained from Auckland University of Technology Ethics Committee (AUTEC #22/192) on 23 August 2022.

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Declaration of interest statement

All authors declare that they have no competing interests. Natalie Hardaker is employed by ACC.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsams.2025.02.005.

Data availability

Data are available from the lead author upon request.

References

1. Te Ao B, Tobias M, Ameratunga S et al. Burden of traumatic brain injury in New Zealand: incidence, prevalence and disability-adjusted life years. *Neuroepidemiology* 2015;44:255-261. doi:10.1159/000431043.
2. Theadom A, Mahon S, Hume P et al. Incidence of sports-related traumatic brain injury of all severities: a systematic review. *Neuroepidemiology* 2020;54:192-199. doi:10.1159/000505424.
3. Salmon D, Walters S, Brown J et al. Managing concussion in the real world: stakeholder perspectives of New Zealand rugby's concussion management pathway. *Int J Sports Sci Coach* 2023:1515-1530. doi:10.1177/17479541231218518.
4. Van Pelt K, Puetz T, Swallow J et al. Data-driven risk classification of concussion rates: a systematic review and meta-analysis. *Sports Med* 2021;51:1227-1244. doi:10.1007/s40279-021-01428-7.
5. Kunz M. FIFA 'big count' worldwide football survey. *FIFA Magazine* 2007:10-15. [FIFA].
6. Mandolesi L, P A, Ferraioli G et al. Effects of physical exercise on cognitive functioning and wellbeing: biological and psychological benefits. *Front Psychol* 2018;9:509. doi:10.3389/fpsyg.2018.00509.
7. Owoeye OBA, VanderWey MJ, Pike I. Reducing injuries in soccer (football): an umbrella review of best evidence across the epidemiological framework for prevention. *Sports Med Open* 2020:6. doi:10.1186/s40798-020-00274-7.
8. Livingston G, Huntley J, Sommerlad A et al. Dementia prevention, intervention, and care: 2020 report of the lancet commission. *Lancet* 2020;396:413-446. doi:10.1016/S0140-6736(20)30367-6.
9. Bretzin A, Zynda A, Wiebe D et al. Time to authorized clearance from sport-related concussion: the influence of health care provider and medical facility. *J Athl Train* 2021;56:869-878. doi:10.4085/JAT0159-20.
10. Kara S, Crosswell H, Forch K et al. Less than half of patients recover within 2 weeks of injury after a sports-related mild traumatic brain injury: a 2 year prospective study. *Clin J Sport Med* 2020;30:96-101. doi:10.1097/JSM.0000000000000811.
11. Hardaker NJ, Hume PA, Sims ST. Differences in injury profiles between female and male athletes across the participant classification framework: a systematic review and meta-analysis. *Sports Med* 2024;54:1595-1665. doi:10.1007/s40279-024-02010-7.
12. King D, Hume P, Clark T et al. Use of the concussion check protocol for concussion assessment in a female soccer team over two consecutive seasons in New Zealand. *J Neurol Sci* 2024:460. doi:10.1016/j.jns.2024.123011.
13. Mihalik J, Ondrak KS, Guskiewicz KM et al. The effects of menstrual cycle phase on clinical measures of concussion in healthy college-aged females. *J Sci Med Sport* 2009;12:383-387. doi:10.1016/j.jsams.2008.05.003.
14. Zech A, Hollander K, Junge A et al. Sex differences in injury rates in team-sport athletes: a systematic review and meta-regression analysis. *J Sport Health Sci* 2022;11:104-114. doi:10.1016/j.jshs.2021.04.003.
15. McKay A, Stellingwerff T, Smith E. Defining training and performance caliber: a participant classification framework. *Int J Sports Physiol Perform* 2022;17:317-331. doi:10.1123/ijspp.2021-0451.
16. Feiss R, Lutz M, Moody J et al. A systematic review of coach and parent knowledge of concussion. *J Concussion* 2020;4:1-11. doi:10.1177/2059700219900053.
17. Kroshus E, Baugh C, Daneshvar D et al. Concussion reporting intention: a valuable metric for predicting reporting behavior and evaluating concussion education. *Clin J Sport Med* 2015;25:243-247. doi:10.1097/JSM.0000000000000137.
18. McCrea M, Hammeke T, Olsen G et al. Unreported concussion in high school football players: implications for prevention. *Clin J Sport Med* 2004;14:13-17. doi:10.1097/00042752-200401000-00003.
19. Salmon D, Mcgowan J, Sullivan J et al. What they know and who they are telling: concussion knowledge and disclosure behaviour in New Zealand adolescent rugby union players. *J Sports Sci* 2020;38:1585-1594. doi:10.1080/02640414.2020.1749409.
20. Salmon D, Romanchuk J, Murphy I et al. Infographic. New Zealand Rugby's concussion management pathway. *Br J Sports Med* 2020;54:298-299. doi:10.1136/bjsports-2019-100950.
21. Salmon D, Romanchuk J, Sullivan J et al. Concussion knowledge, attitude and reporting intention in rugby coaches and high school rugby players. *Sports Sci Coach* 2020;16:54-69. doi:10.1177/1747954120961200.
22. Rosebaum A, Arnett P. The development of a survey to examine knowledge about and attitudes toward concussion in high-school students. *J Clin Exp Neurophysiol* 2010;32:44-55. doi:10.1080/13803390902806535.
23. Kraak W, Coetzee L, Kruger A et al. Knowledge and attitudes towards concussion in Western Province rugby union senior club rugby players. *Int J Sports Med* 2019;40:825-830. doi:10.1055/a-0959-2113.
24. Olanrewaju O, Rashid H, Dobbin N. A cross-sectional study examining Nigerian footballers' knowledge and attitudes towards sport-related concussion and associated contextual factors. *Brain Impair* 2023;24:424-440. doi:10.1017/BrImp.2022.37.
25. Shafik A, Bennett P, Rosenbloom C et al. Sport-related concussion attitudes and knowledge in elite English female footballers. *Sci Med Footb* 2023;8:119-125. doi:10.1080/24733938.2022.2161613.
26. Williams JM, Langdon JL, McMillan JL et al. English professional football players concussion knowledge and attitude. *J Sport Health Sci* 2016;5:197-204. doi:10.1016/j.jshs.2015.01.009.
27. Constantine MG, Ponterotto JG, Austin J. Evaluating and selecting psychological measures for research purposes, In: Leong F, ed. *The Psychology Research Handbook (2nd ed)*, 2nd ed., Thousand Oaks, Sage, 2006.
28. Gallagher C, Falvey E. Assessing knowledge and attitudes towards concussion in Irish footballers. *Br J Sports Med* 2017;51:A60-A61. doi:10.1136/bjsports-2016-097270.158.
29. Travis E, Scott-Bell A, Thornton C. The current state of concussion knowledge and attitudes in British American football. *Phys Sports Med* 2024;52:36-45. doi:10.1080/00913847.2022.2156766.

30. Chinn N, Porter P. Concussion reporting behaviours of community college student-athletes and limits of transferring concussion knowledge during the stress of competition. *BMJ Open Sport Exerc Med* 2016;2:e000118. doi:10.1136/bmjsem-2016-000118.
31. Nuzzo JL, Deaner RO. Men and women differ in their interest and willingness to participate in exercise and sports science research. *Scand J Med Sci Sports* 2023;33:1850-1865. doi:10.1111/sms.14404.
32. Hurst H, Novak A, Cheung S et al. Knowledge of and attitudes towards concussion in cycling: a preliminary study. *J Sci Cycl* 2019;8:11-17. doi:10.28985/1906.jsc.03.
33. Sanderson J, Weathers M, Snedaker K et al. "I was able to still do my job on the field and keep playing": an investigation of female and male athletes' experiences with (not) reporting concussions. *Commun Sport* 2017;5:267-287. doi:10.1177/2167479515623455.
34. Warmath D, Winterstein A, Myrden S. Sport motivation as a possible indicator of concussion reporting intentions among young athletes. *Clin J Sport Med* 2021;31:e216-e220. doi:10.1097/JSM.0000000000000804.
35. Salmon D, Chua J, Sullivan J et al. Baseline concussion assessment performance of community-based senior rugby players: a crosssectional study. *Brain Inj* 2021;35:1433-1442. doi:10.1080/02699052.2021.1972452.
36. de Koning R, Egiz A, Kotecha J et al. Survey fatigue during the covid-19 pandemic: an analysis of neurosurgery survey response rates. *Front Surg* 2021;8. doi:10.3389/fsurg.2021.690680. [Systematic Review].
37. Bowling A. Mode of questionnaire administration can have serious effects on data quality. *J Public Health* 2005;27:281-291. doi:10.1093/pubmed/fdi031.
38. Groves R, Presser S, Dipko S. The role of topic interest in survey participation decisions. *Public Opin Q* 2004;68:2-31. doi:10.1093/poq/nfh002.