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A systems approach to understanding the identification and treatment of sport-related concussion in community rugby union

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ABSTRACT

Aim: The aim of the present study was to utilise a systems thinking approach to explore the perceived responsibilities for identifying and treating concussion held by different actors across the community rugby system (e.g., players, coaches, parents, medics, referees, and management), as well as their role-specific concussion management strategies.
Methods: A systems approach was taken to assess what different stakeholders within rugby systems perceive their roles to be regarding concussion identification and treatment. Through an online survey, 118 members of the amateur (community) rugby union system were asked about their role-specific concussion management responsibilities and strategies. Respondents included players, parents, medics, coaches, club managers, administrators, and volunteers.
Results: The majority of respondents indicated that they were able to identify the symptoms of rugby-related concussion, however, only medics stated their responsibility to use formal concussion assessments (e.g., SCAT2). A smaller number of the respondents indicated that they were involved in treating concussion within their current role/s (majority of which were medics).
Conclusions: This study illustrated that the current challenges in the identification and treatment of rugby-related concussion in community sport may be due to role/responsibility confusion and possible overreliance on field-side medics. These findings offer insight into the possible limitations of the current concussion management guidelines and may offer empirically based direction for future revisions.

1. Introduction

Sport-related concussive injury is a growing public health concern in Australia and internationally. Concussion refers to a subset of mild traumatic brain injuries (mTBIs) caused by the rapid acceleration and/or deceleration of the brain resulting in a rapid onset of cognitive disruption, which may or may not involve a loss of consciousness (LOC; McCrory et al., 2013). In America, it is estimated that between 1.6 and 3.8 million sport-related concussions occur annually, accounting for up to 9% of all sport-related injuries (King et al., 2014). Previous research has estimated that in Australia, sport-related concussion is the third highest cause of mTBI hospitalisations, after accidental trips/falls and transport-related injuries (Helps et al., 2008). In the context of community-based amateur rugby union (rugby) concussion has been found to account for 10% of all sport-related injuries (Chalmers et al., 2011), and up to 10% of players sustain at least one concussion per season (which equates to almost 8 concussions per 1000 playing hours; Hollis et al., 2009). However given the complex, often dynamic nature of sport-related injuries in fast-paced contact sports such as rugby, concussions often go undiagnosed, underreported, and under treated (Gardner et al., 2014), all of which complicate the calculation of an accurate incidence rate of concussion.

Within ergonomics, it is widely acknowledged that safety is the responsibility of all actors within a system. Furthermore, safety failures are shaped by the decisions of all actors, as such accidents are the product of the interaction between multiple contributing factors, not just a single broken component or responsible person (Rasmussen, 1997). In community sport, the responsibility for concussion management and the implementation and adoption of sports safety measures, including regulations and guidelines for injury management, involves actors from across each level of the system, from the players to the governing sporting bodies. Even though the goal is to improve player safety and injury outcomes, it

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is most commonly the role of the clubs, coaches, and other support staff (rather than the players themselves) to ensure that injury prevention measures are in place (Donaldson and Finch, 2011; Finch and Donaldson, 2010). Numerous studies have demonstrated that physician, trainer, coach, parent, and athlete attitudes and behaviours regarding the identification and treatment of concussion is lacking in consistency and accuracy (see Donaldson et al., 2014 for review). To better understand these issues this study aimed to apply systems thinking to the problem of concussion identification and treatment to understand, (a) which actors in the community rugby system are currently involved; and (b) to determine what concussion management roles and responsibilities they believe they have. This study aimed to consider the role-specific concussion management knowledge of actors from multiple levels of the rugby system, including club management, administration, coaches, medics, referees, parents, and players.

1.1. Existing challenges in concussion management

The identification and treatment of sport-related concussion are consistently identified as the most challenging aspects of sports injury management (Broglio et al., 2014). The past two international consensus conferences on concussion management stated that all athletes, regardless of the level of participation, should be managed using the same treatment and return to play (RTP) paradigm (McCrory et al., 2009, 2013). However, achieving this universally throughout different regions and grades of participation remains a challenge in community sport. Although players in professional levels of competition are assessed and monitored by qualified medical experts, amateur sporting teams do not always have this level of supervision or guidance (Borich et al., 2013; Cohen et al., 2009; Makdissi et al., 2013).

While most symptoms of sport-related concussion resolve within seven to 10 days (McCrory et al., 2013), the International Rugby Board (IRB; World Rugby, 2015) and Rugby Union Australia (ARU, 2015) enforce a mandatory 3 week break from both training and games in age-graded competition (i.e., players younger than 19 years old). The guidance provided by paediatric sports medicine professionals is even more conservative, with some research suggesting that junior players should withdraw from activity for 1–3 months (Barlow et al., 2010; Cohen et al., 2009). Although the appropriate and prompt treatment of concussive injuries has been suggested as a fundamental step in preventing adverse and enduring symptomology (Hollis et al., 2012; Gardner et al., 2014; McCrory et al., 2013), the management of concussion has been found, both in research and anecdotally, to be complicated by underreporting or downplaying injuries and non-compliance with return to play advice (Baker et al., 2013; Hollis et al., 2012; Sye et al., 2006).

In rugby, underreporting has been found to be motivated by lack of awareness of a probable concussion, players not thinking concussion was a serious injury, and/or not wanting to be withheld from participation (Hollis et al., 2012; Gardner et al., 2014; Sye et al., 2006). This was illustrated in a cohort of high school rugby players, in which 78% of players with a suspected concussion returned to play before a medical professional assessed them and declared it safe for them to do so (Sye et al., 2006). Issues with compliance were further observed in a study of community rugby players, of which only 22% reported being given return-to-play advice post-concussion, and of these players, none complied with the return-to-play regulation for returning to either competition game play or a regular team training session (Hollis et al., 2012). Further, while sporting bodies such as the IRB and ARU encourage individuals to recognise the symptoms of concussion, seek medical treatment, and follow sport-specific recovery guidelines, the way in which concussion is actually managed in community rugby, and by whom, is not explicitly defined.

The paucity in concussion identification knowledge within the different levels of participation in community sport has been demonstrated consistently in research. For example, Valovich-McLeod et al. (2007) found that 42% of junior team coaches believed a concussion only occurs when an athlete loses consciousness, with 25% indicating that they would allow the athlete to return-to-play on the same day of injury. A knowledge deficit was also observed regarding the recognition of sport-related concussion between youth athletes and their parents, who were only able to answer 3 out of 5 true-or-false questions assessing sport-related concussion recognition and management (Gourley et al., 2010). Under identification or delayed identification of a concussion may, therefore, be more likely in youth sports consequent of misunderstandings or inconsistent information communicated to the different stakeholders (Cohen et al., 2009; Hollis et al., 2012; Valovich-McLeod et al., 2007). It is proposed that the key issue in sport-related concussion treatment in community rugby is the lack of clarity and consistency in the role-specific responsibilities held by participants within the multiple levels of the rugby system.

Applying a systems thinking approach to this issue will provide clarity on who the different actors are within the system, what they perceive their concussion management roles to be, and what behaviours they undertake to treat sport-related concussion. Using a systems approach will allow gaps and overlaps in concussion management to be identified. To date, there has been limited application of this approach in the sport-related injury prevention context (Kerr, 2014; McGlashan and Finch, 2010), and it has never been applied to understanding how concussive injuries are understood and managed in the sport environment.

1.2. Applying Rasmussen's risk management framework to community rugby

The systems approach to accident causation is a long and established philosophy that has evolved through a number of accident causation models (e.g., Leveson, 2004; Perrow, 1984; Rasmussen, 1997). The systems approach asserts that safety is an emergent property, which is influenced by the interactions of actors and elements across every level of an organizational system (Leveson, 2004). As such, safety is viewed as a 'control problem' (Svedung and Rasmussen, 2002) with safety failures being recognised at the cause of multiple contributing factors which are linked throughout a systems levels. The systems approach therefore argues it is important to examine and understand the relationships that exist between different elements across different levels of an organizational system; not just a single catastrophic decision or action at one level alone. The philosophy has evolved to a point where overall systems comprising government, regulatory bodies, organisations, individuals, technologies, documents, and the environment becomes the unit of analysis when tackling safety issues (e.g., Rasmussen, 1997; Svedung and Rasmussen, 2002).

Rasmussen's (1997) risk management framework is a widely-used systems-based model of accident causation that is currently receiving significant attention in injury prevention in sport and outdoor recreation (e.g., Clacy et al., 2015, 2016; Dallat et al., 2015; Goode et al., 2015; Marras and Hancock, 2014). The framework is underpinned by the idea that systems comprise various levels (e.g., government, regulators, company, company management, staff, and work), each of which are co-responsible for safety. With regard

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to injury, the framework argues that safety failures are created by the decisions of all actors, not just the front line participants in isolation, and accidents are caused by multiple contributing factors, not just one bad decision or action. Although the systems approach has typically been used to describe how accidents are caused, rather than how they can be managed, there is no logical reason why the same methods could not be applied to investigating current practices (Salmon et al., 2016; Goode et al., 2015). In the concussion context, this approach would argue that there is a shared responsibility of concussion management across the rugby system, including players, direct supervisors, club management, sporting agencies and government etcetera.

Within contact sport environments (i.e., high risk environments) head impacts and injuries occur frequently, thus are not considered abnormal. This has led to the development of concussion management strategies (e.g., McCrory et al., 2013) that are based on assumptions about the mechanisms of injury rather than the system-wide factors which may influence injury risk. Svedung and Rasmussen (2002) identified the need for incident management in a dynamic system to be based on normal work practice. Although Rasmussen's framework was developed to better understand the mechanisms underpinning large scale, high risk accidents (e.g., "freak" accidents which occur due to the loss of control in an otherwise controlled system), Goode et al. (2015) demonstrated that this framework can also be applied to more frequent accidents which occur in repetitive task settings where the conditions at the time of injury are unlikely to be considered abnormal. This shifts the traditional focus on investigating error mechanisms to an ethnological field analysis of behaviour shaping features occurring in the work place (Svedung and Rasmussen, 2002).

The authors therefore argue that Rasmussen's risk management framework provides a suitable model for examining concussion prevention and identification in rugby. Firstly, given that injury management decisions, actions, and system performance at all levels of a system are interactive (Rasmussen, 1997; Rasmussen and Suedung, 2000; Svedung and Rasmussen, 2002), applying systems thinking to concussion management provides a framework for examining the system of actors and agencies that potentially share the responsibility for concussion identification and treatment. Secondly, it provides a way of representing the various levels of influence within the system and considers concussion identification and treatment as an emergent property arising from the interactions between actors within the system. In turn this will enable identification of the system wide factors influencing concussion identification and treatment. Thirdly, like with many community-based sports, the amateur leagues of rugby are delivered through a network of local clubs. Behind this network, rugby is administered in a hierarchical sociotechnical system with international, national, state/provincial and regional bodies (World Rugby, 2015; see Fig. 1 in which the local Queensland community rugby system were mapped onto Rasmussen's framework). Using Rasmussen's framework, non-linear interactions may be able to be identified, thus better informing the translation and dissemination of influencing factors, concussion knowledge, and management strategies throughout the rugby system. The development of a proactive approach to concussion management requires a consideration of the factors that shape decision-making and behaviour in the sport context, as well as an understanding of the hazards inherent to the activity (Rasmussen and Suedung, 2000; Svedung and Rasmussen, 2002). Therefore Rasmussen's framework provides a means of integrating actor perspectives in order develop an overall picture of the factors influencing the concussion management strategies within the rugby system.

2. Method

2.1. Participants

Participants were 118 members of the community rugby union (69.2% male), who were either presently or previously directly involved with the sport in a community or amateur team. Respondents ranged in ages from 15 to 75 years ($M = 34.8$, $SD = 13.0$), and had been involved with rugby for an average of 15.2 years ($SD = 12.9$). Over half of the sample had either an undergraduate or postgraduate degree (31.5% and 33.3%, respectively); 22% had a high school education (or were still in high school). The majority of respondents (40.2%) identified as being primarily a 'player'; 'coach', 'parent', and 'medic' each comprised ~15% of the sample. The demographics of respondents within different roles are displayed in Table 1.

2.2. Measures

Participants were asked open-ended questions about what their role-specific strategies and responsibilities were in identifying and treating sport-related concussion. Participants were asked six questions about their perceived role-specific responsibilities as well as their actual behaviours and/or concussion identification and treatment strategies (e.g., Are you able to identify a concussion/symptoms of a concussion?; In your role, what are your responsibilities in treating concussion?). In addition to demographic questions (e.g., age, years of involvement, primary and secondary role in rugby), participants were also asked where they had received most of their concussion-related knowledge.

Using Rasmussen's framework, the identification and treatment of sport-related concussion in community sport can be considered within a sociotechnical system (see Fig. 1). Using this framework governing bodies (e.g., IRB, ARU); regulatory bodies, such as schools and state clubs; regional clubs (e.g., regional club presidents, club members); immediate supervisory group, including coaches, parents, and referees etc.; activity participants (e.g., players, spectators, match officials); and equipment and surroundings, such as the field conditions and safety equipment were considered as components of the system. To ensure that all levels of the system were included in the study, local rugby union coordinators, management, and coaches contributed and gave feedback on the adaptation of the model (see Fig. 1). It should be noted that role multiplicity (i.e., players may also be parents; coaches may also hold managing roles at the regional level) is common in community sport, and was addressed by asking participants to identify their primary and secondary roles within the rugby.

2.3. Procedure

Ethical approval was obtained from the University of the Sunshine Coast's ethics committee (S/14/662). The questionnaire was developed as an online survey using *SurveyMonkey*, and trialled on a small selection of different actors ($n = 20$) before distribution. The survey was distributed online at the conclusion of the 2014 rugby season (October–November). Invitations to participate were sent via email to regional Australian rugby teams and their associated members (e.g., local referees and team medics). Invitations were also sent to the wider rugby community through social media (e.g., Twitter, Facebook) and local newspaper and televised media. Informed consent was obtained from all respondents before the survey began. Participants under 16 years old were instructed to obtain parental consent before they completed the survey. All participants were informed that participation was voluntary and responses would remain anonymous.

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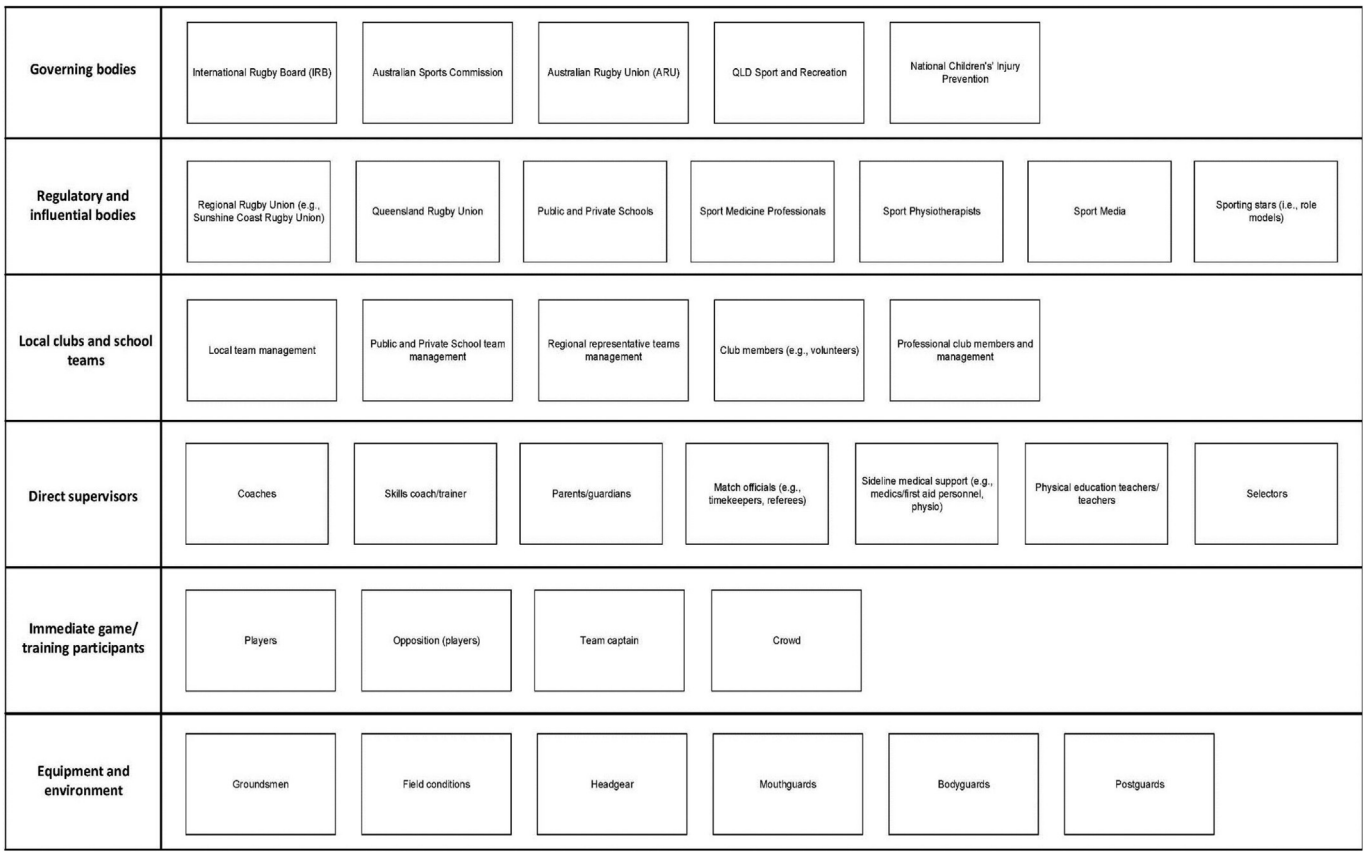

Fig. 1. Application of Rasmussen's risk management framework illustrating the actors within the community rugby union system (Clacy et al., 2016).

Table 1
Participant demographics.

Primary Role	Distribution			Age (years)			Experience (years)	
	n	%N	%♂	*Range*	*M*	*SD*	*M*	*SD*
Player	50	42.3	74.4	15–44	24.1	6.0	9.9	6.7
Coach	17	14.4	93.8	25–57	39.1	10.8	25.0	11.8
Parent	18	15.2	41.2	42–75	49.9	7.8	15.0	18.1
Management	2	1.7	50	34–42	38.0	5.7	17.5	23.3
Medic	17	15.2	52.9	22–63	40.2	11.8	16.7	13.2
Admin	5	4.2	80	40–52	46.4	5.8	25.6	19.0
Volunteer	3	2.5	100	29–54	41.5	17.7	14.5	13.4
Referee	6	5.1	80	20–37	26.8	6.8	14.2	5.9

Note. %♂ Percentage of the actors in each role that were male.

Complete responses were extracted from *SurveyMonkey* and analysed using the NVivo qualitative data analysis software, version 10 (incomplete responses were excluded from all analysis; n = 2). Qualitative responses were analysed thematically (adapted from Braun and Clarke, 2006) and coded into common themes (nodes), with separate coding for identification and treatment domains of concussion awareness. To ensure responses were coded consistently data were analysed and coded twice by two different researchers. Any inter-rater discrepancies were revisited in the raw dataset to ensure the context was considered in the coding. These discrepancies were discussed until consensus was achieved. Frequency matrices were generated for the number of times each theme was mentioned by actors in each role; both inter- and intra-role discrepancies and trends were then mapped onto Rasmussen's framework (Svedung and Rasmussen, 2002) and discussed.

3. Results

3.1. Concussion identification: ability, roles, and responsibilities

Almost all (93%) respondents from each level of the system indicated that they were able to identify the symptoms of concussion. The respondents who reported that they were unable to identify the symptoms of concussion included 5 players, 1 coach, 1 parent, and 1 referee. A summary of the findings regarding concussion identification is presented in Fig. 2.

3.1.1. Local club management

Club managers (n = 2), administration (n = 3), and volunteers (n = 5) where the actors sampled from the 'Local Club Management' level of the rugby system. The majority (71%; n = 5) of the sample of administrators and club management respondents indicated that although they could identify a concussion, they do *not* have a responsibility to do so within their roles. All of the volunteers (n = 3) in this study however stated that they had a responsibility to identify concussive injuries. The identification responsibilities that were identified within this level of the system were to 'ensure there are properly trained personnel' (n = 3), 'provide education [about concussion]' (n = 2), 'involve the club doctor' (n = 5), and 'make decisions on field as to whether or not concussion has occurred' (n = 2). When asked *how* they do (or

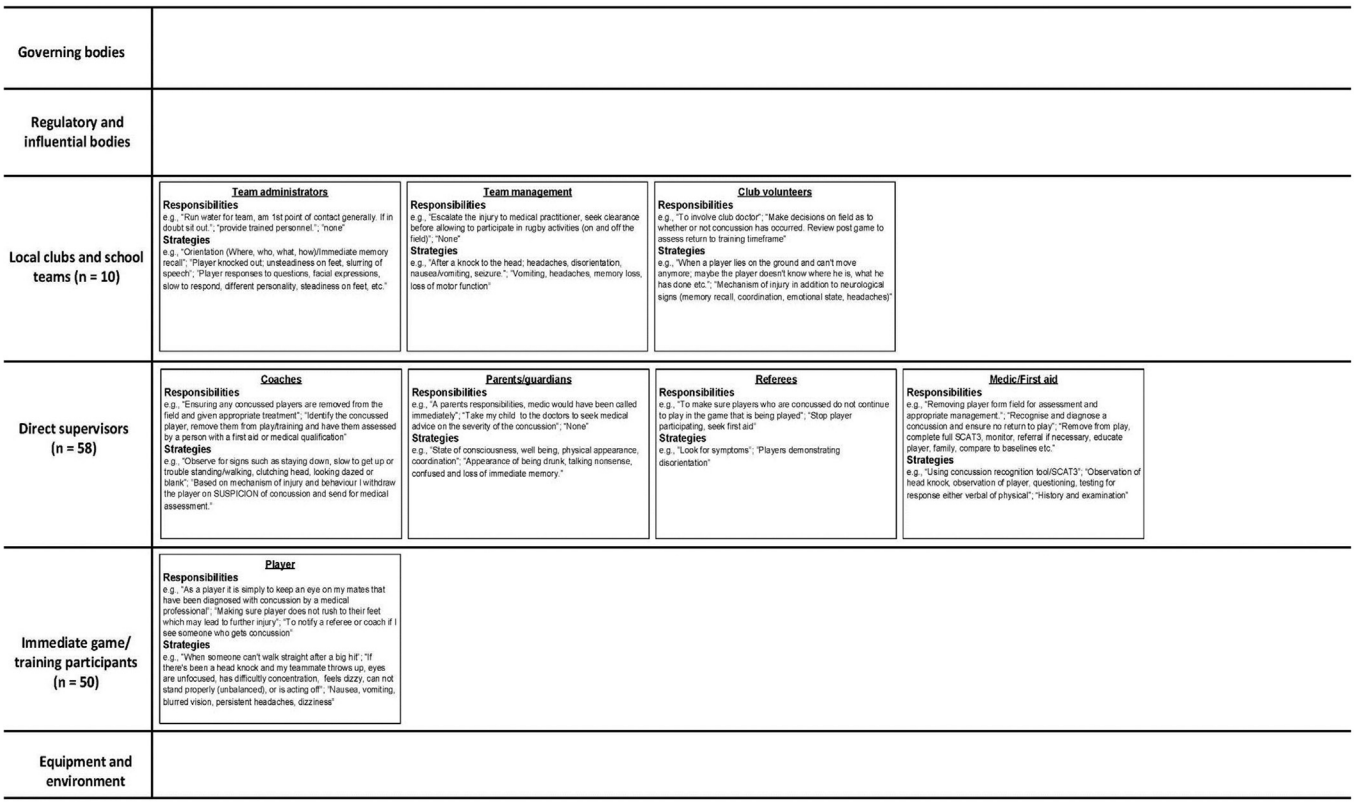

Fig. 2. Adapted actor map of the concussion identification roles and responsibilities within the community rugby system.

would) identify a concussion, volunteers reported being able to identify a median of 3 symptoms of concussion (range 1–6) while club managers and administrators could identify a median of only 2 symptoms of concussion (range 0–5). 'Disorientation' was noted as an identifying symptom of concussion by all volunteers whereas management and administration suggested that they would watch for a "knock to the head" and 'look for changes in the characteristics and behaviours of the players'.

3.1.2. Direct supervisors

Team coaches (n = 17), parents (n = 18), referees (n = 6), and medical aids (medics; n = 17) were the actors sampled from the 'Direct Supervisor' level of the system. There was some overlap between the direct supervisors' responses. The majority of coaches felt their main responsibilities were to 'remove the injured from play' (53%) and 'recognise a concussed player' (35%). Similarly, 80% of referees also saw it as their responsibility to remove concussed athletes from play, however only two referees saw it was their responsibility to identify a concussion. Seventy-one percent of coaches and 41% of parents stated they had a responsibility to seek medical assistance in *suspected* cases of concussion. The responses from medics were unanimous in that their role was to identify concussion. Almost all respondents (94%) saw themselves as being responsible for 'on and off field decision making', 'medical assessment', and 'return to play'. Most medics stated they had overlapping responsibilities to 'identify a concussion' (29%), 'remove the injured player from the field' (53%), and 'provide primary care' (41%). Only 18% of medics stated their responsibility to use formal measures (e.g., Sport Concussion Assessment Tool [SCAT]; McCrory et al., 2013) to identify concussion, although one respondent mentioned this would only be done at "national level competition".

When asked how they identified concussion, medics were able to identify a median of 4 symptoms (range 1–10). Coaches, parents, and referees each reported a median of 3 symptoms of concussion (range 1–9, 0 to 6, and 0 to 8, respectively). 'Confusion' was the most frequently identified symptom of concussion by all direct supervisors. Other commonly identified symptoms were 'changed cognition/personality', 'loss of balance', 'memory loss', 'nausea/vomiting', and 'loss of consciousness'. Medics were the only actors who said they would use formal guidelines and/or measures to identify concussion, however only 18% of the sample stated they would need a player history to conduct this assessment.

3.1.3. Immediate game environment

Players (n = 50) were the only actors sampled from this level of the amateur rugby system. Although 32% (n = 16) of community rugby players saw they had a responsibility to check on their teammates, only 16% (n = 8) of the players in this study said they would have a responsibility to identify their own concussion (e.g., "Admit to myself I have a concussion"). Further, almost a quarter of players (24%, n = 12) who said they could identify concussion did not believe they had a responsibility to do so, typically seeing it as the role of the medical staff. Contradicting this, zero players stated that they required the advice/assistance of a medic to be able to identify concussion. Players identified a median of 3 symptoms (range 1–9), most frequently noting 'memory loss', 'confusion', and 'nausea/vomiting'.

3.2. Concussion treatment: roles and responsibilities

A summary of the findings regarding concussion treatment from each level of the rugby system are presented in Fig. 3. This figure gives an indication of the differences in perceptions across the rugby system regarding roles and responsibilities around

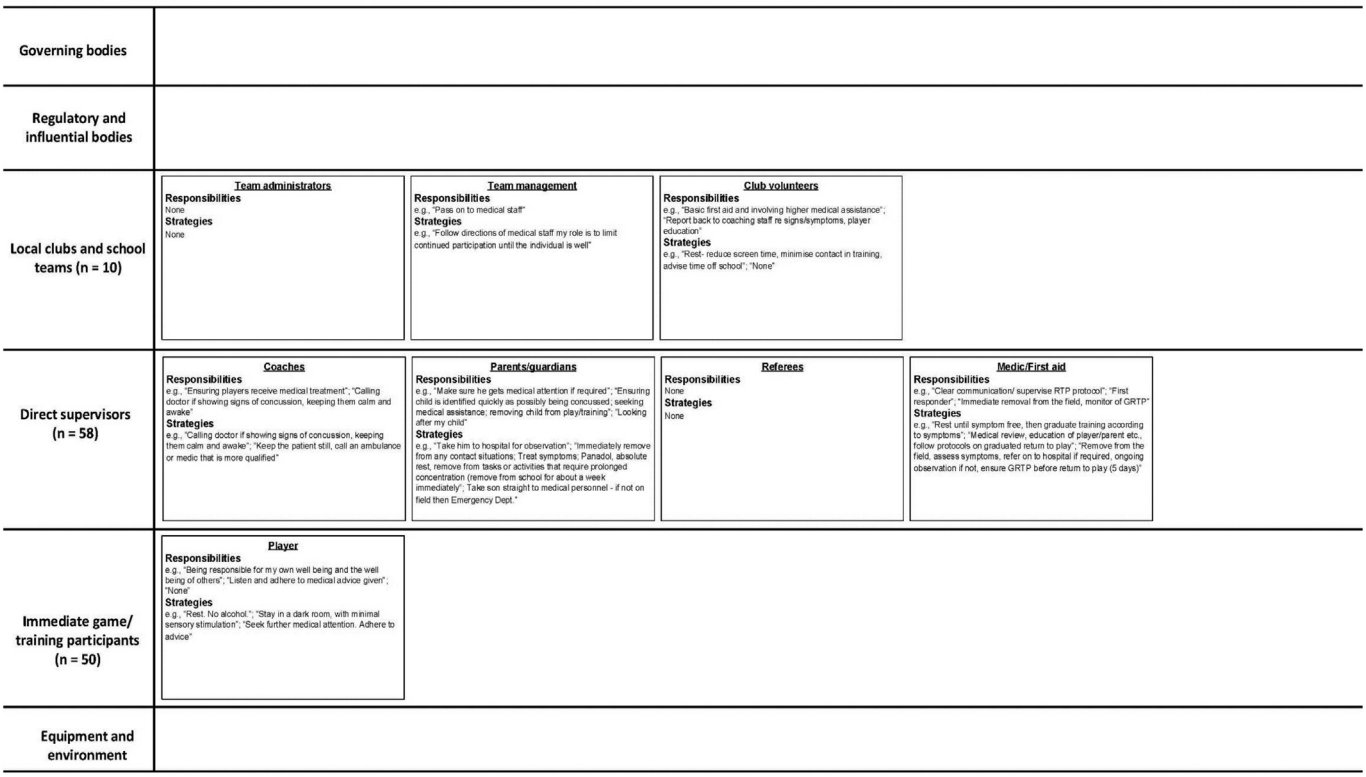

Fig. 3. Roles and responsibilities in treating concussion in community amateur rugby on an adapted actor map.

concussion treatment. These differences are described in more detail below using a top down progression through the system (i.e., from club management to players).

Thirty-two respondents (29%) indicated that, within their role, they were involved in treating concussion. This sample was mostly made up of medics (47%), parents (19%), players (16%), and coaches (13%). None of the local club management actors or referees identified as being involved in treating concussion.

3.2.1. Direct supervisors

From this system level, medics' responses were the most consistent; with 88% of medics indicating their responsibility to provide primary care and immediate injury assessment following a concussion. Parallel to this, coaches and parents both identified that their main responsibility was to 'ensure players/children receive appropriate medical treatment'. Additionally coaches stated they would "keep the patient calm and responsive while medical attention was being sought", "use the SCAT", and "ensure an appropriate recovery period." Medics presented similar treatment strategies, namely 'providing on field medical assessment', 'utilising concussion assessment tools', and 'supervising gradual/safe return to play'. Medics also stated that they would "refer injured players for further medical assessment".

3.2.2. Immediate game environment

Only 1% of players in the study indicated they had a role in treating concussion (n = 5; 4 of which were female). Treatment responsibilities held by players included "listening and adhering to medical advice", "helping out where I can as directed by medical staff, "being responsible for my own wellbeing and the wellbeing of others". The two common themes in *how* players treated concussion were 'seeking medical attention' (and adhering to it; n = 3), and 'rest' (which was specified as, "no thinking, no visual stimulus, and using a hyperbaric chamber"; and "no alcohol").

4. Discussion

The aim of this study was to apply a systems approach to describing how people in community amateur rugby currently identify and treat rugby-related concussion. To do this, Rasmussen and Suedung, 2000 risk management framework was used to represent the rugby system and organise actor responses by system level. The application of this framework provided a means of integrating actor perspectives in order develop an overall picture of the factors influencing the concussion management strategies within the rugby system. The adaptation of this framework to the community amateur rugby system revealed both similarities and discrepancies between the perceived responsibilities and management behaviours of actors at each level of the system.

4.1. Roles and responsibilities in identifying rugby-related concussion

The sideline identification of concussion is consistently noted in literature as being the most challenging aspect of sport-related concussion management, arising out of inconsistencies in sideline protocol, such as use of screening tools, and unclear role responsibilities (Cohen et al., 2009; McKeever and Schatz, 2003). This was illustrated in this study by between- and within-role discrepancies in perceived identification responsibilities. Although actors at all responding levels of the system (i.e., no actors from the regulatory or government bodies participated in this study) were able to recognise some of the salient indicators of concussive injury (e.g., loss of balance, memory, and/or consciousness), there appears to be a system-wide reliance on medical staff to diagnose concussion. Furthermore, medics and first aid personnel were the only actors in

this study who saw it as their responsibility to utilise standardised concussion assessment measures (e.g., SCAT2). Although medical personnel are often the most qualified actors within the system to make decisions regarding concussion management (Clacy et al., 2013), the multiplicity of their roles and inconsistent presence community amateur sport (Borich et al., 2013; Makdissi et al., 2013) creates a potential gap in concussion identification and management. This was illustrated in the present study as only 18% of medics identified the need to utilise field-side assessment tools, with one medic even stating that these measures would only be used in the "professional levels of competition". This may be due to the absence of medical support staff available at community and amateur training and games (Borich et al., 2013; Cohen et al., 2009; Makdissi et al., 2013). An important conclusion then is that, in community rugby, appropriate diagnoses of player concussion may not be occurring.

This finding offers new insight into how several of the context-specific challenges identified in amateur rugby union may interact and complicate concussion management. Amateur sport often relies on volunteer or trainee medical staff, consequently medics are not always present at both training and game events (Borich et al., 2013; Cohen et al., 2009; Makdissi et al., 2013). Furthermore, standardised identification measures for recording baseline functioning, field-side assessment, and diagnosis are not consistently applied (indeed only 18% of the medics in this study used these measures). This impedes the efficient identification and accurate diagnosis of concussion, which would have a flow on effect to the enforcement of justified removal from play and subsequent gradual return to play recommendations. For this discrepancy to be addressed, future research should examine why standardised measures are not consistently used at all levels of competition, and how implementation can be improved. Developing strategies to ameliorate this discrepancy in the rugby system may have substantial implication to the efficacy and successful implementation of future concussion management guidelines.

From a systems approach, safety is seen as the responsibility of all actors within the system. As such, the reliance on medical staff to diagnose concussion from every level of the rugby system (including management, administration, and referees) needs to be addressed. That is, strategies should be implemented at the organizational (i.e., club) level to ensure that properly trained medical personnel are both (a) available at all rugby training and game events, irrespective of competition grade; and (b) consistently utilise standardised assessment tools to record every athlete's baseline functioning as well as to assess and diagnose concussion as soon as possible (i.e., field-side). Alternatively, identification responsibilities may need to be formally delegated more evenly across the rugby system. For example, assigning the task of collecting regular baseline measures of functioning to club administrators; and encouraging parents to adopt a more active role in educating their children on the seriousness of concussion recognition and management.

A positive finding from this study was the strong sense of 'mateship' in the responses from players, who saw it as their responsibility to identify concussion in their teammates and other players. This finding highlights some important considerations for the interpersonal level of the rugby system, in regards to possible reporting behaviours and the impact of social desirability. In rugby underreporting is often motivated by players not thinking concussion was a serious injury, and/or not wanting to be withheld from participation (Hollis et al., 2012; Gardner et al., 2014). The hyper-masculine subculture often present in contact football has been credited with creating an environment of increased injury risk, consequent of the shared ethos of "putting the team first" and "giving 110%" (Tibbert et al., 2015). While this may encourage some players to feel they have to 'play through the pain' and downplay their injuries; the responses in the present study demonstrated that players feel responsible for 'looking out for their mates', even more so than themselves. This finding has significant implications for possible future interventions to improve the dissemination of sport-related concussion awareness. Some of the noted challenges in identifying concussion (e.g., underreporting, delayed diagnoses) may be ameliorated by developing targeted knowledge transfer strategies which advocate the role of mateship in identifying concussion and promote a cultural shift which normalises the recognition and unbiased reporting of concussive injuries.

4.2. Role specific rugby-related concussion treatment responsibilities and strategies

This system-wide reliance on medical personnel to manage rugby-related concussion was found to extend further into perceived treatment responsibilities. Less than one third (29%) of the respondents in this study indicated that they were involved in treating concussion within their role, however there were consistent similarities in the responses that were offered. Medical personnel were the most frequent respondents who acknowledged their role-specific responsibilities in treating concussion; with their responses consistently reflecting the concussion management guidelines proposed by the IRB (World Rugby, 2015) and ARU (2015). The common treatment themes presented by first aid and medical personnel reflected the IRB's 6Rs (i.e., recognise, remove, refer, rest, recover, return). Although there were other levels of the rugby system involved in treating concussion (specifically, parents, coaches, and players); the most common themes presented by these actors were 'refer the injured for further medical assessment' and 'adequate rest' (i.e., two of the six management guidelines). Interestingly, none of the respondents offered a specific amount of rest time that they would prescribe to a concussed athlete, rather it was proposed that the injured should be monitored until symptom free. This cause of this lack of treatment specificity needs to be explored further.

It is concerning that only 1% of players in the rugby system indicated their role in treating sport-related concussion; in concurrence with only 25% of both parents and coaches. Weakness in this aspect of concussion management could have considerable implication on reporting and return to play behaviour. That is, if actors in closest proximity to concussion do not hold any intention or perceived responsibilities in treating concussion, this may likely precede an absence of reasoned or planned action in the event of injury (Godin and Kok, 1996). Previous research has demonstrated that inconsistencies in concussion treatment knowledge and advice may impact the implementation of- and compliance with graded return to play protocol (Finch et al., 2013; Hollis et al., 2012). For example, Hollis et al. (2012) found that 78% of rugby players who sustained or suspected a concussion failed to receive return-to-play advice; and those how did receive the correct advice failed to comply with regulations. The findings of the present study therefore provide further support the need for a system-wide revision to address this gap in the role-specific responsibilities of different actors in treating concussion, with consideration for the specific system structure and context of community rugby. Future research should aim to apply a systems approach to investigating how information is translated throughout the rugby system, as well as which factors control the successful implementation of concussion management strategies across the community rugby system.

4.3. Limitations

As the first study of its kind there were a number of limitations

worth noting. Firstly, there was a limited distribution of actors across the system; namely, there was an absence of participants from the upper levels of the system (e.g., Australian Rugby Union spokespersons, sports medicine professionals; professional athletes etc.). The similarities and differences in concussion management responsibilities and strategies identified in this study may not be a representative of the entire rugby union sample. Although the focus of this study was on community and amateur sport rather than professional levels of competition, with consideration for Rasmussen's risk management framework and systems thinking, future research should assess concussion management across the entire system to ensure the perceptions and actions of all rugby actors are appropriately considered. A second limitation of this study was the sample size, specifically the unequal distribution of actors within different roles (e.g., 50 players compared to two club managers). Future research should aim to recruit equal numbers of participants within each level of the rugby system to ensure each group is accurately represented in the data. Equipment and environmental factors should also be considered in more detail.

5. Conclusions

In this study, the application of Rasmussen's risk management framework to the community rugby system provided insight to the broader contextual and systemic factors that influence how concussion is identified and treated within the multiple levels of the rugby union system. It was proposed that by taking a system-wide perspective on the attitudes and actions of key stakeholders towards concussion management, role-specific themes could be identified with consideration for the specific ecological structure and context of community rugby. Findings illustrated that current challenges noted in the identification and treatment of rugby-relayed concussion in community sport may be due to general role/responsibility confusion and possibly an overreliance on field-side medical aides to diagnose and treat concussive injuries, rather than a lack of system-wide education or actors' inability to identify the symptoms of a concussion. The focus of actors' responses on features within the immediate environment, rather than the whole system (e.g., formal guidelines, government responsibilities), may suggest that the vertical integration of information in the community rugby system may be disrupted. By taking a systems approach these trends offer insight into the specific junctures within the rugby system which may be dislocating the effective communication, internalisation, implementation, and enforcement of effective concussion management.

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