# The influence of education in decision making concerning athlete's return to sport following a concussion injury: A systematic review

Waterworth, Victoria; Procyk, Alexander; Canetti, Elisa; Hing, Wayne A; Gough, Suzanne

*Published in:*
Journal of Concussion

*DOI:*
10.1177/2059700220941985

*Original Article*

Journal of Concussion
Volume 4: 1–17
© The Author(s) 2020
DOI: 10.1177/2059700220941985
journals.sagepub.com/home/ccn
SAGE

# The influence of education in decision making concerning athlete's return to sport following a concussion injury: A systematic review

**Victoria Waterworth, Alexander Procyk, Elisa Canetti, Wayne Hing and Suzanne Gough**

## Abstract

**Objectives:** Concussions have emerged as one of the most prevalent and controversial injuries sustained within the sporting context. The objective of this review was to determine the influence that education has on decision making concerning athlete's return to sport following a concussion injury and if the risk is worth it in the eyes of the athletes.
**Study design:** Systematic review.
**Methods:** A rapid literature review was performed in PubMed, CINAHL, SPORTDiscus, Embase and Web of Science looking for articles that discussed concussions and any three of the four following search terms: (a) decision making, (b) education/knowledge, (c) sport/return to sport and (d) risk.
**Results:** Sixteen of 1243 articles were included in this review based on eligibility criteria. Ten were cohort studies, four were cross-sectional studies and two were qualitative research. There was a good agreement between the authors for all studies when determining risk of bias, presenting a Cohen's $\kappa$ of 0.901 (95% CI, 0.834, 0.968), $p < 0.001$.
**Conclusion:** Education can make a difference in athlete's decision making process to return to sport; however, their awareness of the health risks that they put themselves in by returning to sport too soon is clouded by other external and internal factors. What is not fully understood is why do they put themselves at this risk? Further studies should explore athletes' risk aversion behaviour and how it impacts their decision to return to sport following a concussion.

## Keywords

Traumatic brain injury, risk aversion, return to play

Date received: 29 July 2019; accepted: 18 June 2020

## Introduction

Concussions have emerged as one of the most prevalent and controversial injuries sustained within the sporting context, with years of research going into how to manage athletes' post-concussion injury and their return to sport (RTS) journey.[1–3] Many countries around the world have specific procedures, guidelines and laws on how to guide an athlete through this journey, with much of the current research centring around the medical personnel and coaches' perspectives on deciding an athlete's readiness to RTS. However, a large majority of athletes are still finding ways to defy medical advice and deciding when to RTS themselves.[4] Little research has been done regarding the decision making process of the athlete's themselves and how they evaluate their own personal health risks when deciding to RTS. Concern has surfaced around the conflicting education that these athletes have been receiving and how their basic knowledge of concussions impacts their decision making going forward in sporting endeavours, putting themselves at increased risk.

Faculty of Health Sciences and Medicine, Bond University, Gold Coast, Australia

**Corresponding author:**
Victoria Waterworth, Faculty of Health Sciences and Medicine, Bond University, Gold Coast, Queensland 4229, Australia.
Email: vlwaterworth@gmail.com

A concussion is referred to as a traumatic biomechanical force to the head or body that creates a complex pathophysiological process that affects the brain and is often interchangeably referred to as a mild traumatic brain injury (mTBI).[5–7] Different mechanisms of injury occur in sustaining a concussion, including forced blunt trauma to the head or whiplash of the head or neck during incidental or purposeful collisions within the sport.[5,8] Of the approximately 57 million people who experience a mTBI each year, 20% are suggested to be secondary to physical activity and sports.[5] Athletes who do RTS with an undiagnosed or misdiagnosed concussion are at risk of second impact syndrome, which could lead to brain herniation and possible death.[9] Other potential health risks from sustaining numerous concussions include alterations to cognitive functioning and the mental health of athletes later in life, as well as an increased risk for neurodegenerative brain disorders.[9,10]

In sports, a concussion is considered a common and sometimes frequent injury, depending on the nature of the sport itself. Making an initial diagnosis is difficult due to the vast array of concussion symptoms, causing problems for RTS decision for the athletes as there is no standalone gold standard assessment tool and a shortage of objective findings.[5,8,11] As stated in the most recent consensus statement on concussion in sport, which was presented at the 5th International conference on concussion in sport held in Berlin, an individual should be removed from playing field and should not be allowed to return on the day of injury.[7] Different outcome measures have been developed to improve the sideline diagnosis of concussions including the Cantu Grading Scale and the Sport Concussion Assessment Tool-3 (SCAT-3) or more recently the SCAT-5.[5-8,12] These outcome measures assess the symptoms that the athlete might be displaying on the field, but there is an inherent lack of assessments evaluating the risk of putting the athlete back in the field of play after sustaining this type of injury.

The idea of how risk averse the athlete is and how they evaluate the risk of concussions is a topic that is not well researched. Risk aversion within the human decision making model has been studied mostly in the economic field, where it is defined as human behaviour that tries to reduce uncertainty as much as possible when faced with a decision of unknown parameters.[13] Some of the main theories behind explaining risk aversion include the expected utility theory, which describes the decision making process as axioms of the decision making individual being analogous of any other rational person making the same decision.[13] Another theory is the prospect theory, which describes a subjective value placed on options for the individual, and that the decision will be made based on an individual's perception that the probability of loss is steeper than the appropriate gains for the results of the decision.[13,14] Conversely, another coveted theory regarding decision making is the nudge theory which uses the idea of positive reinforcement and indirect influences to elicit a positive decision made by the individual.[15] Nudge theory lacks, though, the subjective response of the athletes themselves and how they evaluate risk which the expected utility theory and prospect theory consider more in their approaches.[15]

The decision making process of an athlete returning to sport post-concussion is two-fold; encompassing the physical effect of the injury and their knowledge of the injury itself. Even with a clear understanding of the symptoms that come with having a concussion, athletes treat them more like a musculoskeletal injury, with both their descriptions and management, affecting the athlete's capacity to take into consideration the long-term effects that follow a concussion injury.[16] The pressure to compete or perform at a specific level takes over, influencing an athlete's understanding of what risk they are putting themselves in by RTS.[2,3,17,18] In a cohort study by Bramley et al., there was a significant difference in high school soccer players reporting a concussion to their coach during a championship game versus a regular game, suggesting that different scenarios might drive different processing of risk within adolescent athletes.[2] The differences in game importance may potentially change how an athlete risks their health, leading to more education required for athletes to understand how their decisions can affect them in not only their current game, but in their everyday lives.

This study aims to systematically review the current existing literature on the effects of education and knowledge on the decision to RTS following a concussion. Our overarching research question is broken into two aspects: firstly, can education make a difference to athletes' decision making process when returning to sports following a concussion injury and secondly, are they aware of the health risk they face by returning to sport too soon following injury?

## Methods

This study was directed by consideration of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.[19]

A rapid literature review was performed on 22 August 2018 to help determine the final search strategy. A final article search was performed on 24 August 2018. Databases that were used include PubMed, CINAHL, SPORTDiscus, Embase and Web of Science. The key search terms used in each of these databases can be found in Table 1. In addition, articles

**Table 1.** Search strategies and databases.

| Database | Date searched | Key search terms | Results |
|---|---|---|---|
| PubMed | 24 Aug 2018 | (athlete* OR team OR sport* OR competitive OR recreational OR "Athletes"[Mesh]) AND ("Return to sport" OR "return to play" OR "Return to Sport"[Mesh]) AND (Injur* OR Concussion* OR "head trauma" OR "brain injury" OR health OR "quality of life" OR "Brain Concussion"[Mesh]) AND ("risk aversion" OR risk* OR "Health Risk Behaviors"[Mesh]) AND (knowledge OR information OR education OR decision* OR "Health Knowledge, Attitudes, Practice"[Mesh] OR "Clinical Decision-Making"[Mesh]) | 351 |
| CINAHL | 24 Aug 2018 | ((athlete* OR team OR sport* OR competitive OR recreational OR (MH "Athletes+")) AND ("Return to sport" OR "return to play" OR (MH "Return to Sport+")) AND (Injur* OR Concussion* OR "head trauma" OR "brain injury" OR health OR "quality of life" OR (MH "Brain Concussion+")) AND ("risk aversion" OR risk* OR (MH "Health Risk Behaviors+")) AND (knowledge OR information OR education OR decision* OR (MH "Health Knowledge, Attitudes, Practice+") OR (MH "Clinical Decision-Making+")) | 115 |
| SPORTDiscus | 24 Aug 2018 | ((athlete* OR team OR sport* OR competitive OR recreational OR (MH "Athletes+")) AND ("Return to sport" OR "return to play" OR (MH "Return to Sport+")) AND (Injur* OR Concussion* OR "head trauma" OR "brain injury" OR health OR "quality of life" OR (MH "Brain Concussion+")) AND ("risk aversion" OR risk* OR (MH "Health Risk Behaviors+")) AND (knowledge OR information OR education OR decision* OR (MH "Health Knowledge, Attitudes, Practice+") OR (MH "Clinical Decision-Making+")) | 172 |
| Embase | 24 Aug 2018 | ((athlete* OR team OR sport* OR competitive OR recreational OR 'Athletes'/exp) AND ("Return to sport" OR "return to play" OR 'Return to Sport'/exp) AND (Injur* OR Concussion* OR "head trauma" OR "brain injury" OR health OR "quality of life" OR 'Brain Concussion'/exp) AND ("risk aversion" OR risk* OR 'Health Risk Behaviors'/exp) AND (knowledge OR information OR education OR decision* OR 'Health Knowledge, Attitudes, Practice'/exp OR 'Clinical Decision-Making'/exp)) | 376 |
| Web of Science | 24 Aug 2018 | ((athlete* OR team OR sport* OR competitive OR recreational OR Athletes) AND ("Return to sport" OR "return to play" OR "Return to Sport") AND (Injur* OR Concussion* OR "head trauma" OR "brain injury" OR health OR "quality of life" OR "Brain Concussion") AND ("risk aversion" OR risk* OR "Health Risk Behaviors") AND (knowledge OR information OR education OR decision* OR "Health Knowledge, Attitudes, Practice" OR "Clinical Decision-Making")) | 214 |

were also hand selected based on review of included articles' reference lists, identifying additional studies that met inclusion criteria. These articles were subjected to the same eligibility criteria. Two authors (AP and VW) of this study worked collaboratively on the search strategies and the screening process based on the eligibility criteria.

Initial criteria for inclusion of articles were done based on titles and/or abstracts having included concussions as part of its focus, as well as including three out of the four following subjects: (a) decision making, (b) education/knowledge, (c) RTS/sports and (d) risk. The inclusion criteria for the remainder of this review consisted of full-length research articles in English written after the year 2009 which focused on cohort studies, cross-sectional studies, or qualitative research. Studies were included if they explored human subjects only, particularly current or past athletes, either male or female, with no limitation on age range, sport or geographic location.

Exclusion criteria applied during study selections were as follow: articles that were not full-length or had no abstracts, and only available in languages other than English; other publication types that are not cohort, cross-sectional or qualitative research, such as reviews, book chapters, conference abstracts and randomised control trials; studies that identified

RTS for other musculoskeletal injuries only; subjects that were either animal or human subjects who were only coaches, trainers or parents of the athletes; and publication dates before 2009.

Each study was reviewed by two of the authors (AP and VW) of this review and results were cross-matched for consensus. The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Cohort Studies, Analytical Cross-Sectional Studies and Qualitative Research[20,21] were used to critically assess the risk of bias in the studies selected based on the eligibility criteria. Respectively the critical appraisal tools consisted of a series of questions with regards to the study design. Each item was judged based on inclusion within the study being appraised with the following criteria: 'yes', 'no', 'unclear'. All items scored 'yes' received a value of 1, where all items scored 'no' or 'unclear' were scored 0. The raw scores for each appraisal tool are: 11 for cohort studies, 8 for cross-sectional studies and 10 for qualitative research. No modifications were made to any of the JBI appraisal tools. These scores were compared between the two authors (AP and VW) and analysed for inter-rater reliability with Cohen's kappa ($\kappa$) through IBM SPSS Statistics.[22,23] Any discrepancies in agreement were discussed by the two authors (AP and VW) first before a consensus was reached.

A reference management software (EndNote)[24] was used to import search results. Two reviewers (AP and VW) screened the results separately, before collaborating after the final stage of screening. Duplicate records were removed before screening titles and abstracts for inclusion and exclusion of the relevant studies. After initial screening, full-texts were then obtained for further analysis. Based on the remaining items in the eligibility criteria, the final selection process of screening for study types, participants and year was completed. Disagreements regarding eligibility were discussed between the two reviewers (AP and VW) and resolved by consensus or with assistance from additional authors support (WH and SG), documenting reasons for the studies exclusion.

The data from the selected articles were extracted and tabulated based on the following information: author/year, study design, purpose, demographics, interventions used and results. Two reviewers (AP and VW) individually reviewed each included article based on eligibility criteria before combining extracted results.

## Results

The results of the search strategy and screening process are shown as a PRISMA flow diagram in Figure 1. The electronic database search produced a total of 1228 records, with an additional 15 articles identified searching references of already eligible articles. Table 1 shows the databases used with the search strategies listed and the results obtained from each database.

From these articles, 597 were identified as duplicates, leaving 646 articles left for the screening process. Ninety-eight articles met the initial inclusion criteria for title or abstract of the search term concussion plus three out of the four other search terms: (a) decision making, (b) education/knowledge, (c) RTS/sports, or (d) risk. Full article eligibility produced 71 results, in which 16 articles met the final eligibility criteria.

Of the 16 articles included, 10 were cohort studies,[1,2,25–32] 4 were cross-sectional studies[3,17,33,34] and 2 were qualitative research studies.[16,18] Seven studies were based on the United States of America,[1–3,16,26,29,32] two in Australia[28,30] and Canada,[25,34] and one in Ireland[17] and Italy[33] respectively. High school aged students[1–3,17,28,29] and University aged students[16,27,28,31,32,34] were both represented in six studies each, while athletes older than 25 years of age[26,28,30,32,33] were in five articles and one article looked at adolescents.[25] Six articles considered male and female athletes or participants,[2,3,16,25,29,31] while five examined males only[1,26,27,30,33] and one looked at females only.[32] A wide variety of sports were examined, including rugby,[17,28,30,33] ice hockey[25–27,32] and multi-sports[3,29,31,34] with four articles each, and American football[1] and soccer[2] with one each. Seven studies focused on the athletes' knowledge and attitude towards concussions;[1,3,16–18,25,33] four looked at the side effects that come with concussions and how the athletes deal with them;[26,27,31,34] three looked at an athlete's RTS following a concussion injury,[28,30,32] and two articles explored how education can affect athletes' decision making process.[2,29]

The Cohen's $\kappa$ analysis was run to determine if there was agreement between the two authors' judgement on the risk of bias for all cohort studies, cross-sectional studies, and qualitative reviews based on their individual appraising through the JBI tools.[20,21,23] There was a good agreement between the two authors for all studies, $x = 0.901$ (95% CI, 0.834, 0.968), $p < 0.001$. A consensus was met between the two authors following initial analysis and clarification of criteria where discretions were found. Table 2 represents the consensus and final results reached by the authors during appraisal. The final JBI raw scores are presented in Table 3.

Common weaknesses in the cohort and cross-sectional JBI checklist included questions dealing with confounding factors. Often the articles did not clearly state the strategies used for factors that were limiting their studies, leading to a score of "0" being given 92% of the time, based on the results in question 5 of cohort and question 6 of cross-sectional studies.[20]

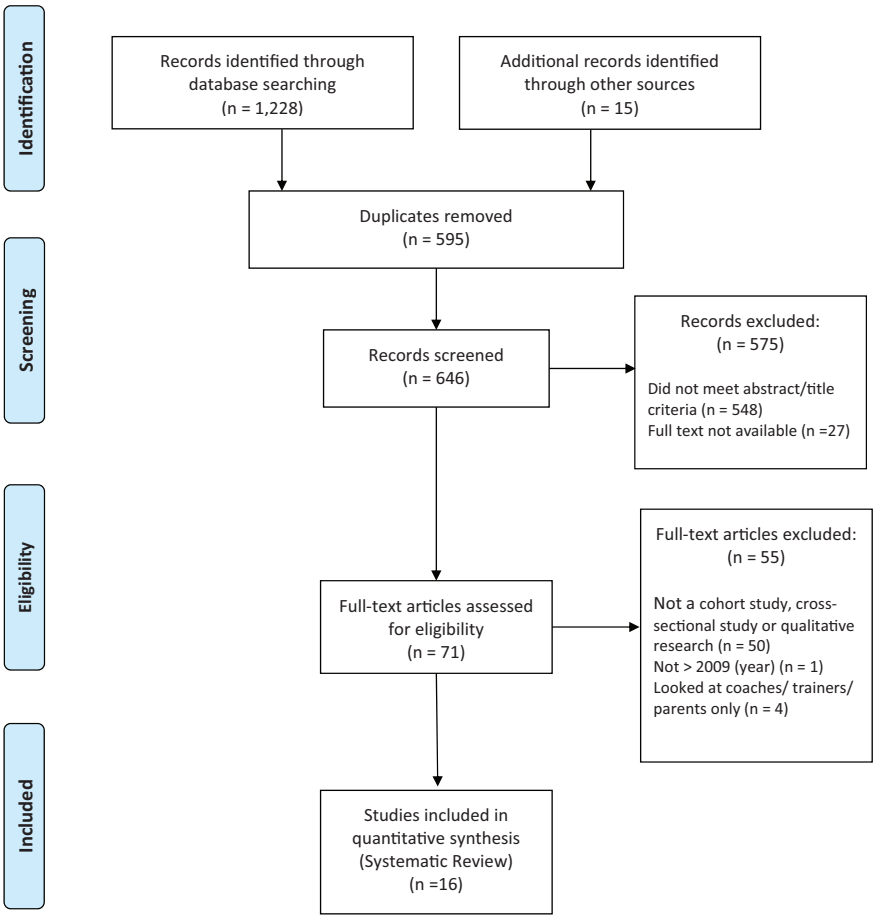


**Figure 1.** PRISMA flow diagram. Adopted from: Moher et al.[19]

**Table 2.** JBI critical appraisal checklist for cohort studies, cross-sectional studies and qualitative research.[20,21]

| JBI critical appraisal checklist for cohort studies | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Anderson et al.[1] | N | N | UC | Y | N | Y | UC | N | N | N | Y |
| Bramley et al.[2] | Y | Y | UC | Y | N | Y | UC | N | N | N | Y |
| Cusimano[25] | N | N | UC | UC | UC | Y | UC | N | N | N | Y |
| Echemendia et al.[26] | Y | UC | Y | Y | UC | Y | Y | Y | Y | UC | Y |
| Echlin et al.[27] | Y | Y | Y | UC | UC | UC | Y | Y | Y | UC | N |
| Hollis et al.[28] | N | N | Y | Y | Y | UC | UC | Y | Y | UC | Y |
| Kurowski et al.[29] | Y | Y | Y | UC | UC | UC | Y | Y | Y | UC | Y |
| Makdissi et al.[30] | Y | Y | Y | Y | UC | Y | Y | Y | UC | UC | Y |
| Merritt et al.[31] | Y | Y | Y | Y | UC | Y | UC | N | N | N | Y |
| Tuominen et al.[32] | N | N | UC | UC | UC | Y | Y | Y | UC | UC | Y |

| JBI critical appraisal checklist for cross-sectional studies | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 |
|---|---|---|---|---|---|---|---|---|
| Boffano et al.[33] | UC | Y | UC | Y | UC | UC | Y | Y |
| Brown et al.[34] | Y | Y | Y | Y | UC | UC | Y | Y |
| Delahunty et al.[17] | UC | Y | Y | UC | UC | UC | Y | Y |
| Miyashita et al.[3] | UC | Y | UC | UC | UC | UC | UC | Y |

| JBI critical appraisal checklist for qualitative research | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Roiger et al.[18] | Y | UC | Y | Y | Y | N | N | Y | UC | Y |
| Torres Colon et al.[16] | Y | Y | Y | UC | Y | Y | Y | Y | UC | Y |

Y: yes; N: no; UC: unclear; JBI: Joanna Briggs Institute.

**Table 3.** Data extraction.

| Author, year | Study design | JBI CAS[14,23] | Purpose | Demographic | Intervention | Results |
|---|---|---|---|---|---|---|
| Anderson et al., 2016[1] | Cohort study | 3/11 | Assess high school football player's knowledge of concussions and determine whether increased knowledge is correlated with better attitudes toward reporting concussion symptoms and abstaining from play. | 120 male participants (Grades 9–12) 3 competitive football teams Cincinnati, USA. | Two surveys anonymously given, no formal concussion education prior.<br>Examined concussion knowledge and attitudes about reporting (e.g. importance of reporting symptoms, abstaining from play). Scores calculated for both. | *Knowledge:* 93% correctly responded that LOC is not a requirement and 92% believe there is a risk or re-injury or death if a second concussion occurs.<br>*Attitude*: 53% would always or sometimes continue to play if experiencing a headache after injury. 22% agree or strongly agree that an athlete should play in an important game if they have a concussion. 75% of players would play through an injury to win the game. |
| Boffano et al., 2011[33] | Cross-sectional study | 4/8 | Examine the knowledge and beliefs regarding concussion. | 60 male participants (age 13–39). Four amateur rugby teams. Turin, Italy. | Questionnaire about player's knowledge on the S&S of concussion and RTS strategies, protocols, and their beliefs regarding sport participation after a concussion. | Thirty-eight per cent of athletes had no knowledge of concussion symptoms. Ten players believed they could RTS immediately after sustaining a concussion injury (both with and without knowledge of S&S for concussions). |
| Bramley et al., 2011[2] | Cohort study | 5/11 | Determine concussion education and how it relates to concussion decision-making during a game. | 183 (60) male and female. Participants (Grades 9–12). Soccer players, Ohio Valley Athletic Conference, USA. | Surveys were mailed during the winter of 2009 and 2010.<br>Players were asked if they had ever received concussion education and were presented three scenarios regarding concussion and potential RTS decisions during a game. | Seventy-two per cent of players with a Hx of concussion training indicated that they would always notify their coach or trainer, 36% of players with no Hx of concussion training would notify their coach or trainer. A lower percentage of athletes would inform their coach in a championship game compared to a regular game (88% cf. 97%). |

(continued)

**Table 3.** Continued.

| Author, year | Study design | JBI CAS[14,23] | Purpose | Demographic | Intervention | Results |
|---|---|---|---|---|---|---|
| Brown et al., 2015[34] | Cross-sectional study | 6/8 | Address the gap in knowledge by studying the performance of university varsity athletes both with a history of concussion and health age matched controls without concussion history on a movement coordination task requiring rule integration. | 35 male and female aged 18–26. 18 athletes with Hx of concussion, 17 control. Varsity athletes from multiple sports (football, hockey, rugby, basketball, volleyball, track and field, and field hockey teams) York University, Canada. | Participants approached during routine pre-season baseline medical testing.<br>Participants were instructed to move a cursor on a computer programme, displacing the indicator as quickly and accurately as possible from the centre circle to one of four peripheral targets.<br>Different experimental conditions with different levels of decoupling of vision and action were used. | Significant effects were seen in timing and accuracy measures of people with histories of concussion and healthy controls.t<br>Discriminant analysis showed athletes with concussion history had a performance of 94% accuracy, even though they were asymptomatic by current standards. |
| Cusimano, 2009[25] | Cohort study | 2/11 | Describe what minor league hockey players, coaches, parents and trainers know about concussion, its recognition, implications and management. | 409 male and female participants including players, coaches, trainers and parents from Atom (10 years old) and Bantam (14 years old) age divisions.<br>Ice Hockey AA (highly competitive) and recreational competitive levels<br>Toronto, Ontario, Canada. | Questionnaire to assess concussion knowledge, mechanism of concussion, signs and symptoms of a concussion and RTS guidelines. | About 1/4 of children and adults were not aware of any symptoms of a concussion or could name only one symptom<br>*RTS guidelines*: 26% of Atom players and 23.9% of Bantam players did not know or thought it was acceptable for an athlete experiencing symptoms of concussion to play if the athlete is 'careful' for important games. 40% of Atom players, 33.8% of Bantam players and 12.7% of adults incorrectly stated that a concussed athlete can RTS when feeling '90% better', or 'while still experiencing a mild headache for the next game as long as it's at least two days later.'[6] (p. 318) |

(continued)

**Table 3.** Continued.

| Author, year | Study design | JBI CAS[14,23] | Purpose | Demographic | Intervention | Results |
|---|---|---|---|---|---|---|
| Delahunty et al., 2015[17] | Cross-sectional study | 4/8 | Investigate both lifetime and 1-year prevalence of concussion.<br>Evaluate the players' knowledge and attitudes toward concussion. | 304 male participants (<18 years old)<br>Youth rugby union players in Ireland | Self-administered anonymous questionnaire designed to gather player attitudes and perceptions. Questionnaire sought information on (1) player demographics; (2) self-reported concussion history; and (3) perceptions about concussion. Players were asked about suspected concussion events and both diagnosed and suspected concussion injuries were cross-referenced with symptoms experienced to ensure that each concussion event was accompanied by concussion symptoms. | *Attitudes and education*: Concussion was reported to be a serious risk to rugby players' welfare by 82.2%. 2.3% perceived that concussion was an insignificant injury. Even if recovering from a concussion injury, 72.5% said that they would play an important match. 16.1% of players said they would play as they felt the match was more important than a concussion. 7.9% felt that they "could not let their team down" by not playing[7] (p. 20)<br>Of the 59 players who had a diagnosed concussion, 83.1% ($N = 49$) reported that they would play an important match even if they believed they were concussed, compared with 70.2% of those who had never experienced a concussion. Almost one-third of those with diagnosed ($N = 19/59$, 32.2%) concussion expressed that they had previously felt pressurised to play when recovering from a concussive injury. Pressure came more from the athlete personally with pressure from coaches and teammates less so. |

(continued)

**Table 3.** Continued.

| Author, year | Study design | JBI CAS[14,23] | Purpose | Demographic | Intervention | Results |
|---|---|---|---|---|---|---|
| Echemendia et al., 2016[26] | Cohort study | 8/11 | Expand the findings of prior article to include multi-year (2-, 3-, and 4-year) ImPACT test–retest intervals with National Hockey League (NHL) athletes using a two-factor (speed/memory) model of the ImPACT. | 423 male athletes<br>2-year retest: 187 NHL players<br>3-year retest: 118 NHL players<br>4-year retest: 118 NHL players. | Two-factor model combines 'verbal and visual memory composites into a single memory factor and the visual motor speed and reaction time composites were combined into a single speed factor'[8] (p. 3). All athletes received baseline cognitive testing with the two-factor model of ImPACT and then were retested as per their assigned year retesting group. | The two-factor model is promising for the Speed index across multiple language version of ImPACT at the one-year interval.<br>Improvement in the memory composite was also evident, although the two-factor composite remained below the traditional cutoff of .70 for use in clinical decision-making. Increased one-year reliability of the two-factor ImPACT approach compared to traditional composite. The test's ability to detect cognitive changes following injury is improved with increased stability, allowing better RTS decisions. |
| Echlin et al., 2010[27] | Cohort study | 6/11 | Prospectively measure the direct physician-observed incidence of concussion and recurrent concussion within 2 teams of junior ice hockey players during 1 regular season (36 games), utilising the concussion definition and RTS protocol. | 67 male participants (age range: 16–21).<br>Junior ice hockey players from 2 teams (Team A and Team B). | Team A was observed during 34/36 regular season games where Team B was observed during 21 of 36 regular season games. Concussion was clinically diagnosed utilising an observed or self-reported mechanism, immediate or delayed neurological signs, or symptoms and abnormal SCAT2 or ImPACT test results.<br>Concussion surveillance was conducted at each regular season game of the participating teams by 1 independent physician and 1 to 3 independent, nonphysician observers. | Twenty-one concussions were physician observed or self-reported and subsequently physician diagnosed in 52 physician-observed regular season games, yielding an incidence of 21.52 concussions per 1000 athlete exposures. A concussion was diagnosed in 19 (36.5%) of 52 observed games. |

(continued)

**Table 3.** Continued.

| Author, year | Study design | JBI CAS[14,23] | Purpose | Demographic | Intervention | Results |
|---|---|---|---|---|---|---|
| Hollis et al., 2012[28] | Cohort study | 6/11 | Reports the proportion of community rugby union players complying with post-concussion RTS regulations and the self-reported level of RTS advice provided to them | 1958 male participants (age range: 15–48).<br>Community Rugby Union Players. Sydney, Australia. | At baseline, each player completed a self-administered questionnaire on age, competition level and a 19-item sensation-seeking scale assessing impulsive behaviour, player characteristics (i.e., rugby experience, playing position, training volume and protective equipment use), and the number of concussions in the previous 12 months. Injury report forms relating to each player's concussion were completed and forwarded to the researchers after the game.<br>The main outcome of measure was the number of days accrued (post-concussion) until the player returned to play (either competition game play or a regular team training session), and this estimate was calculated from the date the concussion was sustained until the first regular team training session or competition game the player was next actively involved in. | Ten per cent of the cohort sustained one or more concussions (range 1–4) during the observational period of the study, with a total of 215 concussions sustained overall. Median number of days until players returned to either competition game play or a regular team training session following their first concussion was 3; 87% of concussed players returned to either competition game play or a regular team training session within 1 week, 91% by the second week and 95% by the third week. According to the players who received advice, over three-quarters received advice that did not comply with the regulation 3-week stand-down period, and of the remaining athletes who received advice compliant with the regulation, all went against what was advised and were non-compliant in returning to play prematurely. |
| Kurowski et al., 2015[29] | Cohort study | 7/11 | Preseason education would lead to better knowledge and self-reported attitudes, and better reporting of concussion symptoms during the season compared to a control group. | 496 male and female participants (Grades 9–12, education group: $n = 234$, control group: $n = 262$).<br>Multiple sports: football, soccer, basketball and wrestling, Cincinnati, OH, USA. | Questionnaire administered during the preseason of all respective sports to assess an athlete's knowledge of concussion and attitudes/ behaviours about their willingness to report or stop activity after sustaining a concussion and other injuries during play. In the education group, a 20-min educational lecture to participants was given immediately after they completed the preseason survey. The lecture included content on the definition of concussion, S&S, current concussion guidelines and RTS recommendations. | Of the individuals reporting symptoms, there were fewer athletes in the education school 31/43 (72%) than the control school 68/77 (88%) that reported they continued playing. Of the individuals diagnosed with a concussion, a similar number in the education 3/11 (27%) and control schools 3/13 (23%) reported returning to play before their symptoms had resolved. |

(continued)

**Table 3.** Continued.

| Author, year | Study design | JBI CAS[14,23] | Purpose | Demographic | Intervention | Results |
|---|---|---|---|---|---|---|
| Makdissi et al., 2009[30] | Cohort study | 8/11 | Determine whether a concussed player returned to play using an individual clinical management strategy is at risk of impaired performance or increased risk of injury or concussion on their return to competition | 158 male participants<br>All elite professional players participating in the AFL in Australia. | Players were referred into the study when they had experienced a concussive injury while playing football in an AFL competition between 2000 and 2003 (4 seasons).<br>Once a player was identified as having sustained a concussive injury, data on all outcome measures were collected for 3 AFL games preceding injury and the player's first 3 consecutive AFL games after injury.<br>For each concussed player, control players were selected from the non-injured playing population of the same team playing in the same games. Controls were matched for playing position, age and size. | Analysis of the performance statistics and injury rates demonstrated no differences between using 1 game or 3 games pre- and post-injury. When only a single game was used, a larger proportion of the concussed player group could be included in the analysis, thereby reducing any potential for selection bias. Ten players were injured in their first game back after concussion. |
| Merritt et al., 2014[31] | Cohort study | 6/11 | Characterise the symptoms that athletes' sanction at baseline by determining the factor structure of the PCSS at baseline.<br>Identify premorbid/preinjury characteristics that are predictive of post-concussion symptom reporting. | 757 male and female participants (College athletes; baseline: $n = 702$, post-concussion: $n = 55$).<br>Enrolled in an ongoing concussion management programme between 2004 and 2013. | All athletes were administered baseline neuropsychological tests, consisting of both neurocognitive and neuro-behavioural measures (PCSS), prior to their participation in varsity athletics. The main outcome measure was the PCSS – a 22-item self-report measure that assessed severity of concussion-related symptoms. Broken into four symptom clusters: cognitive, physical, affective and sleep.<br>Athletes were referred for post-concussion testing if they sustained a mTBI/concussion, defined by experiencing posttraumatic amnesia (lasting less than 24 h), loss of consciousness (lasting 30 min or less), or any alteration in mental status and/or post-concussion signs or symptoms at the time of injury. | Preliminary correlation analyses revealed non-significant relationships between any of the baseline PCSS-related predictor variables and the dichotomised post-concussion total symptoms score. Baseline symptoms clusters, as a set, reliably distinguished between athletes with low and high post-concussion total symptom scores. Classification results indicated that 29.4% of the athletes with low total post-concussion symptom scores and 94.7% of the athletes with high total symptom scores were correctly classified, with the model correctly predicting 74.5% of the cases. |

(continued)

**Table 3.** Continued.

| Author, year | Study design | JBI CAS[14,23] | Purpose | Demographic | Intervention | Results |
|---|---|---|---|---|---|---|
| Miyashita et al., 2014[3] | Cross-sectional study | 2/8 | Determine: High school athletes' current attitudes and beliefs regarding sport-related concussions; understanding of the critical nature of this injury, and; whether receiving correct information regarding concussive injuries will alter their reporting behaviour. | 454 male and female participants (212 females, 242 males; mean age, 15.7 ± 1.15 years).<br>Multiple sports: football, cheerleading, soccer, basketball, wrestling, volleyball and lacrosse.<br>Colorado, USA. | Questionnaire to gain background information, PMHx, and examine the athlete's personal perceptions and knowledge of concussions.<br>Following the questions regarding concussion perception, a brief educational summary regarding specific aspects of concussions was provided, covering: mechanism of injury, S&S, long-term side effects, impact on education/learning, baseline testing, and RTS protocols. | Majority of athletes believed that the importance of the game should have an impact on the RTS decision, whereas a smaller percentage indicated a game is not an important factor in making RTS decisions. After the education session, there was a significant difference of realising an undiagnosed concussion as opposed to prior the education session in all sports. Found to be significantly different for RTS decisions depending on the importance of game in football, girls' and boys' soccer, and boys' basketball. |
| Roiger et al., 2018[18] | Qualitative research | 6/10 | Evaluate the lived experiences of retired collegiate athletes with a history of 1 or more concussions; guided by 3 aims to gain a more thorough understanding of participants': (1) concussion histories, (2) knowledge and perceptions of concussive injuries, and (3) post-concussion quality of life. | 14 male and female participants (age range: 21–25) with a history of 1 or more concussions and retired from 1 to 5 years.<br>Former National Collegiate Athletic Association Division I athletes | Conducted semi-structured interviews based on flexible questions aimed to assess participants' knowledge and perceptions of concussive injuries, and post-concussive quality of life. | Early onset and discrepancies in post-concussion sport and academic engagement were two common themes among the participants' concussion Hx. Participants' knowledge and perception of concussions were captured within 1 emergent theme: judgement of injury severity. Further analysis revealed that participants' perceptions of concussion severity were deeply connected to a sense of indifference, change in perspective over time, and athletic identity. |

(continued)

**Table 3.** Continued.

| Author, year | Study design | JBI CAS[14,23] | Purpose | Demographic | Intervention | Results |
|---|---|---|---|---|---|---|
| Torres Colon et al., 2017[16] | Qualitative research and cross-sectional study[a] | 8/10 | Examine student's cultural understanding of concussion could explain their reluctance to modify their risky behaviour. Evaluate cultural factors that could affect student's decision to play sports and risk a concussion. | 46 male and female participants (College students)<br>Students who participated in recreational (organised youth and high school-level) sports (non-student athletes)<br>Notre Dame University, USA. | Mixed-methods approach<br>Participant observations and informal interviews, noting students' intensity of play, handling of injuries during play, informal talk about injuries (including concussions), question how injuries were handled<br>Used CDA to examine student's cognitive understanding of the effects and consequences of concussions. Conducted structured interviews to better appreciate how students understand and experience concussions. | *CDA results*: Main terms of agreement across all informants were dizziness, memory loss and headaches for the cultural domain; found no difference between the cultural domain between the concussed and non-concussed students.<br>Interviews revealed a more complicated process between knowledge of concussions, risk assessment, and the significance of sports. Even though definitions of concussions were consistent, they are still heavily influenced by the more prevalent cultural understanding of sport injuries as skeletomuscular injuries. No students stopped playing after being concussed, but if asked if younger siblings could play after receiving a concussion, the answer was the opposite. |

(continued)

**Table 3.** Continued.

| Author, year | Study design | JBI CAS[14,23] | Purpose | Demographic | Intervention | Results |
|---|---|---|---|---|---|---|
| Tuominen et al., 2016[32] | Cohort study | 4/11 | Report the incidence, nature, causes, severity and time trend of injuries in women's international hockey tournaments/games using standardised epidemiological methods | 5344 female participants (<18 years old and >18 years old)<br>Women's international hockey players (WWC, WWC U18) during 8 ice hockey seasons from 2006–2007 to 2013–2014. | Team physician followed all players on the team and filled in an IRS form when an athlete sustained an injury based on the criteria for the form. The IRS form was filled only once for each injury and included detailed information on the period, location on ice, mechanism, anatomic location, severity and specific injury diagnosis. | *Specific injury diagnosis*: Concussions accounted for a small yet clinically important number (15.5%) of injuries in the championships. The two most common causes for concussion were unintended collision (34.6%) and body check (30.8%)<br>A penalty was called in only 25.0% of the events when a concussion was caused by body check. For those players diagnosed with a concussion, 11.5% returned to play in the same game, but no indication of which players returned to play or why. Most concussions occurred before the 2012 Zurich Consensus Guidelines, which do not allow RTS in the same game. *Injury severity*: Majority of players RTS within 1-week of injury (58.1%). *Anatomic location*: Most common head and face injuries were concussions (74.3%). *Causes of injuries*: Injuries were caused by unintended collision (26.3%), body checking (24.6%) and puck contact (12.0%). Much of the injuries caused by stick were lower body injuries (70.0%). Player position, period and zone. Number of concussions sustained by a centre was 4 times higher than any other position. During a game, the second (35.3%) and third (37.1%) periods had the highest injured players. |

AFL: Australian Football League; CDA: cultural domain analysis; cf: confer; Hx: history; IRS: injury report system; JBI-CAS: Joanna Briggs Institute – Critical Appraisal Score; LOC: loss of consciousness; mTBI: mild traumatic brain injury; NHL: National Hockey League; PCSS: Post-Concussion Symptoms Scale; PMHx: past medical history; RTS: return to sport; S&S: signs and symptoms; SD: standard deviation; USA: United States of America; WWC: World Women Championships; WWC U18: World Women Championships Under 18.

[a]For the purpose of this review, this article was analysed as a qualitative research study.

Questions dealing with follow-up and strategies to address incomplete follow-ups also were given a score of "0" for the overwhelming lack of acknowledgement within the cohort study articles. The qualitative research presented some areas requiring more clarification within the articles, specifically when it came to ethical approval.

All 16 articles were reviewed and information extracted included: author/year, study design, purpose, demographics (including number of participants, male/female, age, sports played, and region), interventions used in the study, and the relevant results. Table 3 provides a summary of all the extracted data, as well as the JBI critical appraisal scores.

## Discussion

The difference that education can make to an athlete's decision making process when returning to sport is complex. This review determined only two previous studies that focused on the difference that education can make with athletes' decision making process with regards to a concussion injury. The cross-sectional study by Miyashita et al.,[3] evaluated how education can help athletes understand what a concussion is, finding a significant difference in the education group when it came to realising what an undiagnosed concussion can look like. This finding supports that education can make a difference in the decision to RTS; however, it is limited to the understanding of the condition itself, and the extent to which athletes understand how it will impact their future health. There is a strong consensus that athletes who played either ice hockey or rugby understood that symptoms of a concussion may include dizziness, memory loss and headaches, and does not always involve a loss of consciousness.[1,16] However, some studies still reported that up to 40% of the sporting populations tend to be unaware of any concussion symptoms or only have knowledge of one symptom.[25,33] This lack of knowledge represents a weakness still present in athletes understanding of this injury and questions the type of education athletes are receiving to inform them of all the signs and symptoms that they should be aware of following this injury. Of the six studies that explored athletes' knowledge, only one recognised that athletes understand the risk of re-injury or death if a second concussion occurs.[1] With this small representation of knowledge confounded to one article, it suggests that further research should be conducted to look at the content that is included in athletes' education of concussion injuries and their awareness of what this injury can mean to their health.

Kurowski et al.[29] also focused on preseason education and how it can impact knowledge and self-reporting of concussion injuries in their cohort study from 2015. They found that despite the education, fewer athletes who received the education would report their symptoms and continue playing compared to the control group, returning to play before their symptoms had resolved regardless of receiving education.[29] This demonstrates that there is more at play than just athletes' understanding of concussion injuries that can affect their decision making process. Athletes have many factors to focus on including current symptoms, game situations, external pressures and personal drive, to name a few. It needs to be understood that making these decisions is complicated, as the knowledge of concussions needs to be weighed against the risk of returning and the significance of the sport itself.[16] Perceived importance of a game plays an important role in RTS decisions, which could outweigh the decision to stop playing if faced with a concussion injury.[3] Athletes report that they would play through an injury to win a game or participate in an important match, where a small percentage of athletes indicate that the game importance should not be a driving factor to RTS.[1,3,17] This demonstrates that even with education, athletes drive to play and athletic identity could override their decisions, putting themselves in risky situations that could lead to further complications later in their athletic career. If this drive to keep playing overshadows education provided to athletes about concussions, then what needs to be examined further is why do they put their health at risk and continue playing?

There is a lack of clarity as to why athletes take this kind of health risks. From the two studies that did look at risk, it was recognised that concussions did pose a serious risk to the athletes;[1,17] however, neither explored the influential factors affecting the athlete's decisions to take such risk. There is a paucity of studies that have investigated risk aversion in athletes, which is important for medical practitioners and team support personnel to understand to help guide these athletes in their RTS decision making process. This limitation in the research is imperative as it does not allow us to fully understand why athletes take these kinds of risks in sports following a concussion.

## Conclusions

The decision making process associated with RTS following a concussion injury is inherently complex. The impact of education provided to athletes in order to inform decisions to RTS and the athletes' knowledge of associated health risks is currently limited. This systematic review highlights that athletes may benefit from the provision of education regarding immediate health risks and the potential of developing post-concussion

related conditions. This review also emphasises a gap in the research when understanding the risks that athletes take by RTS prematurely following a concussion injury. The concept of risk aversion is an area that has a paucity of research within the sports and injury rehabilitation field. Future studies are warranted to explore the complexity of athletes' decision making processes and influential factors relating to RTS following a concussion injury.

## Practical implications

- Understanding the complexity of factors influencing athletes' decisions to RTS post-concussion injury is central to the development of educational resources for athletes to minimise long-term health risks.
- Gaining a greater awareness of risk aversion and risk seeking tendencies of athletes will help healthcare professionals understand the potential impact these have on an athletes' decision to RTS following a concussion injury.
- The provision of the education pertaining to the health-related impact concussion injury may influence an athletes' decision to RTS.

### Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

### ORCID iD

Victoria Waterworth https://orcid.org/0000-0002-3241-166X

### References

1. Anderson BL, Gittelman MA, Mann JK, et al. High school football players' knowledge and attitudes about concussions. *Clin J Sport Med* 2016; 26: 206–209.
2. Bramley H, Patrick K, Lehman E, et al. High school soccer players with concussion education are more likely to notify their coach of a suspected concussion. *Clin Pediatr* 2012; 51: 332–336.
3. Miyashita TL, Diakongeorgiou E, Hellstrom B, et al. High school athletes' perceptions of concussion. *Orthop J Sports Med* 2014; 2: 2325967114554549.
4. Sye G, Sullivan SJ and McCrory P. High school rugby players' understanding of concussion and return to play guidelines. *Br J Sports Med* 2006; 40: 1003–1005.
5. McCrea HJ, Perrine K, Niogi S, et al. Concussion in sports. *Sports Health* 2013; 5: 160–164.
6. Jennett B and Teasdale G. *Management of head injuries*. Philadelphia, PA: F. A. Davis Company, 1981.
7. McCrory P, Meeuwisse W, Dvorak J, et al. Consensus statement on concussion in sport – the 5th international conference on concussion in sport held in Berlin, October 2016. *Br J Sports Med* 2017; 51: 838–847.
8. McLeod TCV, Lewis JH, Whelihan K, et al. Rest and return to activity after sport-related concussion: a systematic review of the literature. *J Athl Train* 2017; 52: 262–287.
9. Bey T and Ostick B. Second impact syndrome. *West J Emerg Med* 2009; 10: 6.
10. Manley G, Gardner AJ, Schneider KJ, et al. A systematic review of potential long-term effects of sport-related concussion. *Br J Sports Med* 2017; 51: 969–977.
11. Makdissi M, Davis G and McCrory P. Clinical challenges in the diagnosis and assessment of sports-related concussion. *Neurol Clin Pract* 2015; 5: 2–5.
12. Patel DR, Shivdasani V and Baker RJ. Management of sport-related concussion in young athletes. *Sports Med* 2005; 35: 671–684.
13. Zhang R, Brennan TJ and Lo AW. The origin of risk aversion. *Proc Natl Acad Sci USA* 2014; 111: 17777–17782.
14. Trepel C, Fox CR and Poldrack RA. Prospect theory on the brain? Toward a cognitive neuroscience of decision under risk. *Brain Res Cogn Brain Res* 2005; 23: 34–50.
15. Thaler R and Sunstein C. *Nudge: improving decisions about health, wealth and happiness*. New Haven, CT: Yale University Press, 2008.
16. Torres Colon GA, Smith S and Fucillo J. Concussions and risk within cultural contexts of play. *Qual Health Res* 2017; 27: 1077–1089.
17. Delahunty SE, Delahunt E, Condon B, et al. Prevalence of and attitudes about concussion in Irish schools' rugby union players. *J School Health* 2015; 85: 17–26.
18. Roiger T, Cover R and Zwart MB. The lived experiences of retired college athletes with a history of 1 or more concussions. *J Athl Train* 2018; 53: 646–656.
19. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med* 2009; 151: 264–269.
20. Moola S, Munn Z, Tofanaro C, et al. *Systematic reviews of etiology and risk. Joanna Briggs Institute reviewer's manual*. Adelaide: The Joanna Briggs Institute, 2017.
21. Lockwood C, Munn Z and Porritt K. Qualitative research synthesis: methodological guidance for systematic reviewers utilizing meta-aggregation. *Int J Evid based Healthc* 2015; 13: 179–187.
22. IBM. *IBM SPSS statistics for macintosh*. Armonk, NY: IBM Corp, 2010.
23. Laerd Statistics. *Cohen's kappa using SPSS statistics. Statistical tutorials and software guides*. https://statistics.laerd.com/ (2015, accessed September 2019).
24. Reuters T. *Endnote [computer program]*. New York, NY: Thomson Reuters, 2018.
25. Cusimano MD. Canadian minor hockey participants' knowledge about concussion. *Can J Neurol Sci* 2009; 36: 315–320.

26. Echemendia RJ, Bruce JM, Meeuwisse W, et al. Long-term reliability of ImPACT in professional ice hockey. *Clin Neuropsychol* 2016; 30: 328–337.
27. Echlin PS, Tator CH, Cusimano MD, et al. A prospective study of physician-observed concussions during junior ice hockey: implications for incidence rates. *Neurosurg Focus* 2010; 29: E4.
28. Hollis SJ, Stevenson MR, McIntosh AS, et al. Compliance with return-to-play regulations following concussion in Australian schoolboy and community rugby union players. *Br J Sports Med* 2012; 46: 735–740.
29. Kurowski BG, Pomerantz WJ, Schaiper C, et al. Impact of preseason concussion education on knowledge, attitudes, and behaviors of high school athletes. *J Trauma Acute Care Surg* 2015; 79: S21–S28.
30. Makdissi M, McCrory P, Ugoni A, et al. A prospective study of postconcussive outcomes after return to play in Australian football. *Am J Sports Med* 2009; 37: 877–883.
31. Merritt VC and Arnett PA. Premorbid predictors of post-concussion symptoms in collegiate athletes. *J Clin Exp Neuropsychol* 2014; 36: 1098–1111.
32. Tuominen M, Stuart MJ, Aubry M, et al. Injuries in women's international ice hockey: an 8-year study of the World Championship tournaments and Olympic Winter Games. *Br J Sports Med* 2016; 50: 1406–1412.
33. Boffano P, Boffano M, Galiesio C, et al. Rugby players' awareness of concussion. *J Craniofac Surg* 2011; 22: 2053–2056.
34. Brown JA, Dalecki M, Hughes C, et al. Cognitive-motor integration deficits in young adult athletes following concussion. *BMC Sports Sci, Med Rehabil* 2015; 7: 25.