Sports-related concussion (SRC) assessment in road cycling: a systematic review and call to action

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ABSTRACT

Background Sports-related concussion (SRC) is a recognised risk in road cycling and can have serious health consequences. Recent high-profile cases of professional road cyclists continuing to participate in races despite suffering obvious SRC have highlighted the difficulties in assessing SRC within road cycling.

Purpose To undertake a systematic review of the literature on SRC assessment in road cycling.

Study design Systematic review.

Methods Literature describing SRC assessment in road cycling was identified by searching MEDLINE, EMBASE, PsycINFO and Web of Science. Two reviewers independently screened titles and abstracts for eligibility and a qualitative analysis was undertaken of included studies.

Results From 94 studies identified, two were included for review. Gordon et al describe the presentation of a single case of paediatric concussion following a cycling crash. They highlight the utility of SRC evaluation using the Sport Concussion Assessment Tool (SCAT) as well as the importance of a stepwise return-to-play protocol. Greve and Modabber discuss a number of traumatic brain injuries that occurred during the 2011 road cycling season and, as a minimum, call for riders to be withdrawn from competition following loss of consciousness or amnesia. Both studies are at high risk of bias and of low quality.

Conclusion Road cycling poses unique challenges for the assessment of SRC. This review illustrates the lack of published evidence to advise effective means of SRC assessment within road cycling. The Union Cycliste Internationale (UCI) regulations advise the use of SCAT-5 for concussion assessment but this tool is impractical, requiring modification for use in road cycling. We would like to call on the UCI to hold a consensus meeting to establish an evidence-based SRC assessment protocol and return-to-riding protocol for road cycling.

INTRODUCTION

Sports-related concussion (SRC) is a common sports-related injury and a growing global public health concern. In recent years, great advances have been made globally in the diagnosis and management of the condition in contact sports. However, some sports, particularly road cycling, do not have sport-specific SRC diagnosis and management protocols.
reported to cycle at least once a week and 3.4% cycling five times a week.\textsuperscript{9}

The fifth Concussion Consensus Conference in Berlin (2017) defined SRC as ‘a complex pathophysiolog-
ical process affecting the brain, induced by traumatic biomechanical forces\textsuperscript{40} and highlighted several clinical
features that can be used to suspect SRC in any athlete. Indeed understanding the impact of SRC on athletes
is ever increasing. Guidelines regarding graduated return-
to-play have been well developed in contact sports such as
soccer, rugby and Australian Football League (AFL) and
adapted for use in cycling but these are not evidenced
based and often do not take into account the unique
demands of a sport such as road cycling. Returning
to sport too soon after SRC can expose the athlete to
increased risk of repeat injury or sustaining a new muscu-
loskeletal injury and prolonged physiological symptoms
that may become more severe\textsuperscript{11–14} as well as exposing
the other race participants to an increased risk of injury
from, for example, the concussed athlete causing an acci-
dent due to impaired balance, which is commonly found
following SRC.\textsuperscript{10}

There are also potential long-term consequences for
athletes suffering SRC and there are ongoing studies in
this area. Several studies of retired contact and combat
sport athletes show increased incidence of depression and
cognitive deficit later in life, with an association
between cognitive deficit and the number of concus-
sions suffered. Posthumous neuroimaging studies show
moderate evidence of changes at both a microscopic
and macroscopic level, as well as some evidence of
neurochemical and functional changes.\textsuperscript{15,16} In recent
years, a number of studies have been conducted with
former National Football League (NFL) players,
studying the link between concussion and long-term
development of Chronic Traumatic Encephalopathy.
It is, therefore, important to be able to diagnosis SRC
in road cyclists via an agreed road cycling specific SRC
assessment procedure and therefore reduce both the
potential short-term and long-term consequences to
the athlete and their colleagues.

There have recently been some high-profile cases
of professional road cyclists with suspected SRC
continuing to participate in the race\textsuperscript{17} and road cycling
team staff have highlighted the difficulty in managing
suspected SRC in fast-paced sports such as road cycling\textsuperscript{18} as well as the often remote nature of medical
monitoring for elite road cyclists—with the athlete
often being in one country and the medical team in
another. These cases and medical issues unique to the
professional sport of road cycling have highlighted the
lack of a sport-specific SRC assessment protocol in road
cycling. Thus, the aim of this study was to undertake a
systematic review of the literature on SRC assessment
in road cycling. This knowledge base could then help
in the development of a specific road cycling SRC
protocol, including a return-to-play protocol following
an SRC diagnosis.

\section*{METHODS}

This systematic review is reported in line with the
Preferred Reporting Items for Systematic Reviews and
Meta-analyses guidance.\textsuperscript{19} This review focused on any
peer-reviewed published articles which described SRC
assessment in road cycling. We searched the appro-
priate medical databases including MEDLINE, EMBASE,
PsycINFO and Web of Science. Studies were excluded if
they were not relevant to road cycling. Two reviewers
independently screened titles and abstracts for eligibility.
Figure 1 demonstrates the flow diagram of reviewed and
included studies. Due to the lack of available studies
in this area, a qualitative analysis was undertaken of
included studies.

\section*{Search methods for identification of studies}

Detailed search strategies were developed for each elec-
tronic database searched with input from a medical
librarian to allow identification of studies for inclusion
in this review. The terms searched for across the different
databases included:

\begin{itemize}
  \item Concussion.
  \item Cycling.
  \item Road cycling.
\end{itemize}

Searches were carried out using the following data-
bases: MEDLINE, EMBASE, PsycINFO and Web of
Science until January 2018. The titles and abstracts of
publications from the search strategy were independently
screened by two authors. Additional studies were identi-
fied from reviewing the reference lists of the retrieved
papers through a handsearch. Articles not meeting the
inclusion criteria were discarded. A record was kept of all
articles excluded at this stage and the reasons for their
exclusion. No language restrictions were made although
all papers were written in the English language. Data on
methodological issues, eligibility criteria, interventions
and study design were extracted independently by two
review authors. There was no blinding to study author,
institution or journal, and a record was kept of each study
included in the review.

\section*{Assessment of quality and risk of bias}

The Physiotherapy Eddidence Database (PEDro) scale\textsuperscript{20}
was used to assess the quality of included papers in the
review.

\section*{RESULTS}

From 94 studies identified, 65 studies were excluded
after screening the titles and abstracts. The full texts of
29 articles were reviewed and two studies were included
in the review, with two full-text articles being unable to
be traced and reviewed. The most common reasons for
studies being excluded were that they were not specific
to road cycling or to SRC assessment.

The first paper included in the systematic review was by
Gordon et al\textsuperscript{21} and is a single case report. They describe
the presentation of a single case of paediatric concus-
sion following a cycling crash and highlight the utility of
evaluation for SRC using the Sport Concussion Assessment Tool (SCAT-222 in the case report) as well as the importance of a stepwise return-to-play protocol.21 22

The second paper included in the review was by Greve and Modabber23 who present an opinion piece discussing the treatment of TBIs using the 2011 road cycling season as an example. As a minimum they call for riders to be withdrawn from competition following loss of consciousness or amnesia.24 They argue that sufficient time and adequate facilities for assessment are simply not possible in professional road cycling because time taken to assess for SRC at the side of the road penalises the rider’s position and therefore performance in the race. Both these studies are at high risk of bias and generally of low methodological quality.

**DISCUSSION**

**Overview**

This is the first systematic review of the literature on SRC assessment in road cycling and 94 studies were identified from our search criteria, with two meeting the inclusion criteria and being included in the review. One study was a case report and the other was an opinion piece, with both being at high risk of bias and of low methodological quality. Both studies highlight the importance of a SCAT assessment for managing concussion in cycling and indeed the stepwise return-to-play protocol that it contains. However, there is a lack of available literature regarding SRC assessment and management in road cycling. We, therefore, call on interested clinicians to address this lack of literature and develop a specific road cycling SRC protocol. The first step to address this issue would be a consensus meeting with all relevant parties, including the Union Cycliste Internationale (UCI) and the medical staff of road cycling teams.

**Comparison with previous literature**

Athlete safety should be at the core of professional, and indeed recreational sport. ‘If in doubt, sit them out’—the mantra of Sport Scotland’s Concussion Guidance25—has become a widely adopted phrase in collision sports and cycling should seek to be an early adopter of promoting this culture at elite and community levels. The fifth Concussion Consensus Conference in Berlin (2017)10 culminated in the development of an updated version of the SCAT-5.26 The tool incorporates elements designed to effectively and efficiently assess an injured athlete’s concussion status. It is designed to be used as a sideline assessment. The elements included in SCAT-5 are:

- Symptom score.
- Physical signs score.
- Glasgow Coma Score.
- Balance examination score.
- Coordination score.
- Standardised assessment of concussion (SAC).
  - Orientation.
  - Immediate memory.
  - Concentration.
- Delayed recall.
- Maddock’s questions.

The importance of baseline measurements is also being investigated, however, there are obvious benefits to knowing an individual athlete’s preinjury performance on certain tasks such as balance examination and elements of the SAC. Additionally, it is advised that an SRC history should form part of their medical record. While the tool is comprehensive, it has a completion time of around 10–15 min, which is impractical for a number of sports, including road cycling. The Berlin Consensus Statement on Concussion in Sport states that ‘Adequate facilities should be provided for the appropriate medical assessment both on and off the field for all injured athletes. In some sports, this may require rule changes to allow an appropriate off-field medical assessment to occur without affecting the flow of the game or unduly penalising the injured player’s team.’20 Action must be taken to increase adherence to the Berlin Consensus Statement within road cycling, particularly in facilitating a ‘pitch-side’ SRC assessment within competition, which may require rule changes to accommodate this.

**What are the Maddock’s questions?**

A primary component of the SCAT-5 immediate assessment is a list of five questions to test the memory of the injured player, known as the Maddock’s questions. These questions are:

- ‘What venue are we at today?’
- ‘Which half is it now?’
- ‘Who scored last in this match?’
- ‘Which team did you play in your last game?’
- ‘Did you team win the last game?’

Despite being described as a ‘critical’ element of the SCAT-5 assessment, these questions only apply in a team sport setting (eg, football, rugby, basketball). They are not applicable to individual sports such as road cycling. There is a brief note in the SCAT-5 document saying that ‘appropriate sport-specific questions may be substituted’, but different questions from different doctors in these individual sports may remove the uniformity and efficiency of the assessment in accurately detecting concussion. A suggested alternative for road cycling specific Maddock’s questions could be:

1. What is the name of this race?
2. How many kilometres are there still to go in today’s stage?
3. Who is the road captain today for the race?
4. What was your last race?
5. What is your coach’s name?

These questions could be asked through the radio by the team doctor but road cycling specific questions should be further developed with the UCI and medical staff of the road cycling teams.

**Previous SRC guidelines in road cycling**

The American Cycling Association27 SRC guidelines were ‘intended for education of cycling team managers,
coaches and athletes of the symptoms and management of concussion in athletes but are not a surrogate for evaluations by appropriately trained medical professionals. They aim to provide a framework for the administrative arm of the team to put in place systems and processes that establish a bottom line of best practice, on which team medical staff can build on. This is largely based on the outdated SCAT-2, which was developed following the third International Conference on Concussion in Sport in Zurich in 2008. The guidelines provide recommendations for immediate evaluation of a cyclist with suspected SRC and could help provide guidance for road cycling medical teams to adapt with the UCI for use in road cycling events.

**SRC guidelines in other sports**

Sports like rugby are played in comparatively closed environments to road cycling, where a multitude of camera angles can be used to follow general play and individual players. These television images can be followed in real time and replayed using innovative approaches like the myplayXplay concussion spotting system used by the Rugby Football Union. Another issue unique to road cycling compared with other sports is that athletes cannot be easily removed from play without penalising their position within the race and thus their potential result and performance. A solution to this could perhaps be a concussion assessment at the side of the road, akin to the Head Injury Assessment protocol used in rugby, with the cyclist then ‘moto-paced’ back into his position within the race if they pass this assessment. Such an approach could be supported by rule changes and technological support provided and enforced by the UCI to allow for a safe space for thorough identification and management at the roadside. Furthermore, central injury databases, as promoted by other authors, particularly during the three grand tours in professional cycling, would allow road cycling medical teams to better understand the patterns of SRC injuries and therefore to develop methods of reducing SRC within road cycling.

While the UCI cycling regulations discuss multimodal assessment in suspected SRC and the need for immediate withdrawal from competition if SRC is suspected, no internationally agreed assessment protocol for concussion in road cycling has been published. The UCI regulations advise the use of SCAT-5 for concussion assessment but this tool requires modifications for use in road cycling, including adapting the return-to-play programme. The UCI along with individual national cycling federations should seize the opportunity to have a consensus meeting to establish an SRC protocol for road cycling, in line with the precedent set in other sports, helping to ensure safe cycling, from elite road races to recreational cycling. This should lead to the establishment of a cycling specific SCAT that is valid, effective and multilingual to facilitate the global nature of road cycling and the acute nature of SRC assessment. The tool should also consider the role of both medical and non-medical personnel, for example, neutral mechanics, who may be the first responder following a crash and the need for appropriate rule changes and use of technology to facilitate SRC assessment as well as independent evaluation of the fidelity to the programme.

**Strengths and limitations**

This is the first systematic review of the literature on SRC in road cycling. This review attempted to identify all studies of potential relevance by developing a comprehensive search strategy and then supporting this through handsearching reference lists of all articles examined in the review. The authors sought to include all eligible studies regardless of publication language, although all studies were in English.

This systematic review is limited by the few studies available in this expanding and novel area of research: only two met the inclusion criteria. As mentioned previously, some authors have previously grouped SRC into mTBI and we did not search the literature for mTBI. Thus, some articles relevant to SRC in road cycling may have been missed.

**CONCLUSION**

This is the first review of its kind to bring together the available evidence of SRC assessment in road cycling, illustrating the lack of studies in this area. Further work, particularly an SRC cycling specific consensus meeting, is required to build on the existing protocols for managing SRC generally in sport and to adapt these to the unique sporting demands of road cycling, facilitating safer participation in road cycling for all.

**Contributors** All authors contributed to the systematic review, writing drafts of the manuscript and reviewing the final version of the manuscript for publication.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** NH is a team physician within the World Tour of professional cycling and has received research grants from the National Institute of Health Research (NIHR) and British Association of Sport and Exercise Medicine (BASEM).

**Patient consent for publication** Not required.

**Provenance and peer review** Not commissioned; externally peer reviewed.

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