

# Title Cognitive Symptoms out last Physical Post Cycling Crash

## Summary

**Purpose.** - The aim of this study was to gain off road cyclists self-reported views on the severity of a concussion post-crash from a short-term (24 hours) and a long-term (8 weeks) perspective. The study also aimed to ascertain if the crash had any long-term effects on the rider's quality of life (QOL). **Method.** - The study used two established questionnaires to establish rider perspectives. The Rivermead Post Concussion Symptoms Questionnaire was administered to determine understanding of short-term symptoms, along with the Rivermead Head Injury Follow-Up Questionnaire, to establish long-term and QOL issues. A total of 76 amateur cyclists completed the survey. **Results.** – The survey looked at both physical and cognitive symptoms post-crash. The riders reported cognitive and affective/QOL as having a higher impact on them than any physical injury post-crash. The results of this survey also indicate that cognitive impairment had longer negative impact on their QOL than any physical injuries. **Conclusion.** – The findings from the current study infer that cognitive impairment post cycle crash need a greater focus from both sports bodies and employers.

## Introduction

Sport related concussion (SRC) and traumatic brain injuries (TBI) have received increased attention in the media and academic literature over the last 20 years (1, 2 3, 4, 5). With several high-profile cases, and greater public awareness, researchers have suggested that SRC is a serious public health problem (6, 7) and a silent worldwide epidemic (8). Concussion is commonly described as a transient trauma-induced alteration in mental status that may or may not involve loss of consciousness, with symptoms typically not lasting more than a few weeks, (9, 10, 11), whereas TBI refers to the adverse pathophysiological impact of biomechanical trauma to the head, and is viewed as a more permanent alteration of brain function, even though the individual with TBI may be asymptomatic (12).

Research into SRC and TBI have predominately focused on contact sports such as combat sports (13) rugby union (14, 15) and American football (16). However, more recently, researchers have begun to investigate concussion in non-contact sports, such as football (3), and various cycling disciplines. For example, in road cycling, Rooney et al. (17) and Decock et al. (18) estimated the number of head injuries incurred because of a crash to be between 5-15% annually. In comparison, Clark et al. (19) and Becker et al. (20) reported approximately 5-13% of mountain biking injuries involved the head. However, the actual numbers may be much higher in both disciplines, as many crashes are either not observed or go unreported (21, 22). Although these studies have ascertained that head injuries occur in cycle sport they do not state if the head injuries led to a concussion.

Numerous studies have looked at the effect of concussion in a variety of other sports, such as football, ice hockey, lacrosse, basketball, wrestling and soccer (23, 24). Weinberger and Briskin (23) and McCrory et al. (24) reported that athletes experience rapid short-term cognitive impairment post-injury, with athletes reporting a range of symptoms, from headaches, dizziness, cognitive impairment through to a loss of consciousness (23, 25). However, the most commonly reported symptoms of SRC were headaches and dizziness (26). These signs and symptoms of concussion usually diminished within 7-10 days (26). However, in some cases, recovery has been reported to take longer than would typically be expected (24), due to a condition referred to as 'Post-concussion syndrome'. Willer and Leddy (25) reported that 10% of concussions resulted in persistent long-term symptoms, while research by Woodrow et al. (28) found that almost half (47%) of their 108 patients with TBI showed incomplete recovery 6 months post-injury.

According to Jaffee et al. (29), SRC is also associated with a variety of sleep disturbances, including insomnia and hypersomnia syndromes, increased time falling asleep, difficulty remaining asleep, increased sleep related breathing disorders, and increased feelings of tiredness. Sleep disturbances and sleep disorders have also been shown to impair the recovery process (30), while also negatively impacting the athletes' quality of life (QOL). For example, Chan and Feinstein (31) reported persistent sleep disturbance following a TBI was associated with increased symptoms of depression, anxiety, and apathy (30), as well as reduced engagement with physical activity and reduced academic performance. Furthermore, appropriate sleep during the recovery stage may help decrease experiences of prolonged symptoms or even developing post-concussion syndrome (29).

Taken together, the literature highlights that there are a range of short to long-term outcomes from a concussive injury. Furthermore, cycle sports have been highlighted as being under-researched within the SRC field, despite having considerable estimated prevalence rates and unique risk factors. The study aims were to gain participants self-reported views on the severity of a concussion in the short-term (24 hours) and long-term (8 weeks) post-concussive injury. The survey also aimed to determine whether or not any long-term effects had impacted the rider's quality of life (QOL).

## Materials and Methods

### Participants

A cross sectional analysis of amateur off-road cyclists was undertaken with 76 participants agreeing to take part in the study. The cyclists were from mountain biking (MTB), bicycle motocross (BMX), and cyclocross (CX) disciplines. Participants were recruited via the Leeds Urban bike park and through social media platforms. A summary of the study and inclusion criteria was distributed through these portals. The inclusion criteria were: all participants needed to be 18 years of age or over, involved in regular off-road cycling (more than once per week) and had experienced a self-reported concussion within the last 24 months. Written and informed consent was gained from all participants prior to them completing the questionnaire. The study was granted approval from the University of Derby ethics committee (ETH2223-2540) and was conducted in accordance with the ethical standards of the Declaration of Helsinki.

### Study Design

The survey was developed in Qualtrics and participants were given a link to access the online survey. The opening page of the survey consisted of an information sheet outlining the study aims and objectives. The page also included a consent declaration which participants needed to agree to before being allowed to progress to the survey questions.

Two previously validated surveys (23, 32) were used to analyse the participants views: Rivermead Post-Concussion Symptom Questionnaire (RPQ) (see figure 1) and the Rivermead Head Injury Follow-Up Questionnaire (RHFUQ) (see figure 2). Both surveys were integrated into a single survey available via Qualtrics.

## Questionnaire

### Rivermead Post-Concussion Symptom Questionnaire (Short-term effect- 24 hours)

The self-report Rivermead Post Concussion Symptoms Questionnaire (RPQ) (33) was used to report concussion symptoms. The RPQ used a 5-point Likert scale to evaluate commonly reported concussion symptoms (0 = not experienced at all, 1 = no more of a problem/symptom is unchanged; 2 = mild problem; 3 = moderate problem; 4 = severe problem). Concussion symptom severity was determined by calculating the individual responses to each question of the RPQ. A higher score indicated increased post-concussion symptom severity.

### Rivermead Head Injury Follow-Up Questionnaire (8 weeks after the crash)

An adaptation of the Rivermead Head Injury Follow-Up Questionnaire (RHFUQ) was used to measure functional and social QOL factors. Functional and social QOL factors were again measured using a 5-point self-report Likert scale (0=no change; 1=very mild; 2=mild change; 3=marked change; 4= A very marked change) (31). Participants were asked to report if they currently have/had difficulty with any of the quality of life (QOL) factors, including subjective ratings of work outcomes, relationships, social, domestic, and leisure activities. The participants were also given an open-ended question in which they could add any other symptoms they suffered from post-concussion.

The final part of the survey was an opened ended question in which participants were asked: Did you have any long-term symptoms linked to the crash.

## Data analysis

The results from each question were analysed using confidence intervals. The Confidence interval gave the mean of the value and the variation within the value. The Confidence interval was set at 95% in line with other comparative studies that have used the Rivermead questionnaires (34, 35). All data was analysed using IBM Statistical package for social science (SPSS) version 29.

Responses to open-text questions were collated together and coded into key categories using conventional content analysis (36). All researchers coded the data individually which was followed by a team review in which the final categorisations were agreed.

The self-reported results from the questionnaire identified three categories that participants noted which had an impact on them post-crash. These were Physical, Cognitive and Affective/ QOL with cognitive and Affective/ QOL being of greater impact.

## Results

The results from the Rivermead Post-Concussion Symptoms questionnaire found that cognitive impairment was the highest scoring self-reported symptom. The symptoms 'Poor concentration' and 'taking longer to think' both recorded a mean score of 3.5 on the Likert score out of 5. Whilst, the lowest score was physical with 'double vision' at 1.68.

The result from the Rivermead Post-Concussion Symptoms Follow up questionnaire found that the symptoms related to cognitive function and Affective/ QOL were not short term. As 33% of the participants noted symptoms persisted for over 6 months and 14 % stated they lasted longer than 12 Months, post-crash. Participants stated that 'Ability to maintain previous work load or quality of work' (2.67 mean score) and 'Finding work more tiring' (2.82) were main reported symptoms.

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## Discussion

The aim of the study was to evaluate off-road cyclists self-reported concussion symptoms and severity post-crash from a short-term (24 hours) and a long-term (8 weeks) perspective. Three main themes were established from the data: 1) Physical 2) Cognitive, and 3) Affective/QOL. The riders reported Cognitive and Affective/QOL as having a higher impact on them than any physical injury post-crash. However, it is important to consider, some respondents may have been reporting on an incident that occurred over 12 months post-crash (see table 3) and one rider stating they over 18 months; 'Still suffer from tinnitus daily over 18 months on from the crash' (see table 4), therefore, accurate recollection of events and symptoms could be questioned.

### Physical

Many physical symptoms are used to confirm if a concussion has occurred in a person. For example, the centre for disease control and prevention (37) states headaches, nausea, vomiting, dizziness, and double or blurry vision are symptoms of concussion. The riders in the present survey reported all these symptoms as mild to moderate problem 24 hours post-concussion (see table 1). The duration of physical symptoms was also reported as being short-term rather than long-term. Riders noted that headaches and feeling dizzy were the main symptoms within the 24 hours post-crash and vision issues as being the lowest (see table 1). When asked about long-term symptoms, only 3 riders from the 76 respondents reported experiencing any of the above symptoms of concussion over a longer period, thus suggesting, that in this cohort at least, post-concussion syndrome appears to be a low occurrence.

In summary, the results from the current study infer that the physical aspects associated with crashing are generally short-term, which could be interpreted as similar to the findings of Iverson et al. (27), who noted that physical symptoms diminished withing 7-10 days.

### Cognitive

Webbe et al. (38) conducted a study on neurocognitive performance after a head impact in female soccer players. The authors found that an impact to the head can have both short- and long-term effects on cognitive ability. The results from the current study, like Webbe et al. (38), found that riders reported both short- and long-term cognitive impairment as a result of their concussion.

From a short-term perspective riders noted a moderate problem related to concentration, memory, and fatigue. However, the results also show that the reduced cognitive function was noted as being much longer. For, example, 33% of the participants stated that they had a reduced cognitive function lasting longer than 7 months (see table 3). Sixteen percent of the riders reported them lasting between 7-9 months and 14% reported them lasting over 12 months. Riders reported two main cognitive symptoms: memory loss and inability to concentrate.

A study by Moore et al (39) concurs with the finding from this study. Moore et al (39) looked at bicycling-related concussions leading to a syndrome called post-concussion syndrome. The authors found that 80–90% of concussions were short term, but long-term symptoms included cognitive

difficulty, depression, anxiety and/or sleep disturbance did exist. The authors found the reduced cognitive function lasted between 3-85 months with a mean of 24 months.

In summary, it would appear that SRC as a result of off-road cycling crashes results in lasting cognitive impairment, impacting upon rider wellbeing post-concussion more so than any physical trauma induced from a crash. As can be seen from several of the comments in Table 4, many riders reported lasting effects on memory, the capacity to work as effectively as pre-accident, struggles with anxiety and depression, while several respondents reported struggling to find the right words to use during conversations. However, too often these lasting cognitive consequences of traumatic brain injury are ignored or not treated effectively, with a priority being placed on treatment of visible symptoms. Therefore, we argue further research and the development of more effective treatments and support services needs to be developed going forward.

### Affective/QOL

The survey in this study noted that aspects of both personal and professional life were impacted by the concussion. Riders commented that they had suffered 'Depression, etc mental problems ' post-crash and were 'Unable to perform high performance tasks (under pressure) to the same standard as before crash'. The participants also noted they suffered from depression and anxiety and one participant stated they were suffering from post-traumatic stress disorder (PTSD), though it is unclear from their response whether this had been clinically diagnosed. Other studies (29) have noted that concussion can have an impact on an athlete's QOL through poor sleep patterns, tiredness, and poor cognitive function. However, the severity of this in the current study appears to be much greater than that reported by Jaffee et al. (29). If the impact on QOL is so profound it could be assumed that guidance and support are available for riders. However, much of the guidance is based on short term physical rather than long term cognitive and QOL. For example, in 2018 British cycling published a concussion protocol (40) which gives definition of concussion, symptoms to look for and what to do if you suspect you have concussion. The guidelines refer to 24-48 hours post-concussion and there is limited guidance on long term symptoms. Similarly, the UCI guidelines (41) focus on the same factors and does not give any detailed guidance on what long-term issue may occur and how to deal with them.

Another factor that links QOL and concussion are the responsibilities of the rider outside cycling. As noted in the method section the riders were all amateur riders with family and work responsibilities. It was unclear in the findings from this study if the participants who reported severe long term symptoms were given support as the comments infer they were in need of support. Participant noted they were suffering from a variety of cognitive issues affecting their QOL such as 'Emotional regulation linked to work pressure' and 'big confidence issue and been struggling with depression, finding joy and motivation'. In order for riders to cope with the long-term symptoms of concussion the implementation of guidance and education of employers, Sports national governing bodies and riders may be long overdue.

### Limitations

The methodological approach undertaken in this study utilises self-reported reflection using a questionnaire. Self-reflection is a method commonly used in research and has been extensively used in medical studies and diagnosis (42). However, self-reported reflection is by nature reliant on personal subjective discourse. As a result, participants responses have the potential to have validity/reliability issues, this should be taken into account when analysing the findings of the current study. The validity/ reliability can be as a result of several factors such as recall biased in which participants

recall of an incident is altered due to the passing of time. Social acceptance in which participants report a view based on what they believe a peer or colleague may want to hear (43) and inaccurate introspection in which complex thoughts and feelings can distort the original experience, leading to inaccurate recall of an experience (44). Despite the possible biased issues self-reported research is still a commonly used methodologically approach in health and medicine. The British Medical Council have noted that self-reported reflection and feedback is a method for aiding in developing practices (45).

## Implications of the Study

A key finding from this study is that riders reported cognitive impairment as being a greater issue than physical injury post-crash. Current regulations of at least one national governing body (British cycling) and the world governing body (UCI) focus on the short-term physical aspect of post-crash injuries and include limited guidance on long term cognitive issues. The addition of guidance on cognitive impairment in their regulations and possible training for coaches and race officials and are a change to be considered by these official bodies.

When looking at the implication of studies the real-world aspect should never be overlooked. This study was aimed at amateur riders with families and work careers. Riders in the study noted that the cognitive impairment had an impact on their work life. It is unclear from this study if the riders reported the impairment to their employers. Or if any integrated care had been implemented to aid the riders back into work. Many employers are responsible and have policies aimed at returning employees back to work when they have had a physical injury/ illness. However, cognitive impairment is more difficult to quantify and ascertain if recovery has occurred. Therefore, devising guidelines for this is complex. A future area of study may be to look at the post-crash cognitive recover and support in the work place.

## Disclosure of interest

The authors declare that they have no competing interest

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