

# Persistent Post-Concussive Symptoms in Sports-Related Concussions

Subjects: Sport Sciences

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Formerly referred to as “post-concussion syndrome”, the term persistent post-concussion symptoms (PPCS) was forwarded in the Berlin Consensus Statement on Concussion in Sport (2016), in part due to the stigma surrounding the term “syndrome”. This was loosely defined as concussion symptoms lasting longer than 2 weeks in children and 4 weeks in adults, a definition later adopted by the American Medical Society for Sports Medicine (AMSSM) in 2019. In the latest Amsterdam consensus statement, the PPCS definition was updated to denote symptoms lasting for >4 weeks in all age groups.

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## 1. The Epidemiology of PCSS

Epidemiological studies on the prevalence of PPCS are conflicting due to shifting definitions of the condition itself. A typical estimate of the prevalence of PPCS repeated in the literature is 15–30% <sup>[1]</sup>, but this number can change dramatically depending on the criteria and timing used. For instance, one study showed that 64% of mTBIs were positive for PPCS at the three month mark by ICD-10 criteria vs. 11% when using the old DSM-IV criteria <sup>[2]</sup>. Furthermore, several large prospective studies now show that mTBI symptoms can persist for over a year in around 50% of cases <sup>[3][4]</sup>.

## 2. The Epidemiology of Prolonged Symptoms

In sports medicine, the prevalence of prolonged single symptoms is arguably of more importance than the prevalence of PPCS. This is because return-to-play (RTP) criteria, by consensus (and in some cases by law), calls for the complete resolution of concussion-related symptoms <sup>[5]</sup>. Importantly, the relatively low PPCS prevalence reported in numerous publications may distort expectations on how long it should take for athletes to return to sports.

For high-quality evidence on single prolonged symptoms, the Transforming Research and Clinical Knowledge in TBI (TRACK-TBI), a multi-center prospective cohort study, is an excellent resource. In this research, participants were evaluated at the 2-week mark, and then 3-, 6-, and 12-months post-injury. In this cohort of over 2000 patients, the percentage of participants who reported at least one new or worsened symptom after mTBI was 90% at 2 weeks, 78% at 3 months, 74% at 6 months, and 71% at 12 months. If the ICD-10 criteria of 3 or more symptoms was applied to this data set, 53% would be diagnostically positive at the one-year mark <sup>[6]</sup>. One problem with these numbers is that the TRACK-TBI cohort includes roughly 15% moderate to severe TBI cases, the 85% balance being mTBI cases.

Another source of data is the prospective, multicenter Predicting and Preventing Post-concussive Problems in Pediatrics (5P) cohort study of 3063 children 5–17 years of age, presenting within 48 h of a concussion injury. In this research, 50% of participants still had at least one symptom at the 28-day mark. Fatigue and headaches were the most common complaints. Notably, 68% of the concussions in this research were sports-related <sup>[7]</sup>.

## 3. Controversies in the Prevalence of Prolonged Symptoms in Athletes vs. Non-Athletes

The above findings conflict with the clinical literature on collegiate sports-related concussions (SRCs), which reports a much faster recovery rate. For instance, in one cohort study of 1974 SRCs in college and club sport members, only 11.7% had symptoms lasting beyond 35 days <sup>[8]</sup>. Another source of data, the Concussion Assessment, Research, and Education (CARE) Consortium, is a 30-site study with 1751 collegiate athlete participants with SRCs. In this research, 80% of athletes were asymptomatic within 14 days of recovery, with a median time to recovery of 6.4 days and median RTP time

of 12.8 days. Only 22.8% experienced “slow recovery”, which was defined in the study as symptoms lasting beyond 14 days or a RTP longer than 24 days <sup>[9]</sup>.

There are several possible explanations for this conflicting data. When considering SRCs, it must be recognized that athletes form a unique population with distinct characteristics, such as the following:

- Age: Athletes tend to be younger than the general population.
- Health: The physical and mental health of athletes tends to be better than the general population.
- Access to care: Most athletes have access to athletic professionals who have basic training in concussion treatment.
- Supplements: Many athletes take supplements that may be neuroprotective, such as creatine.
- Severity of injury: SRCs tend to be less severe than injuries that involve polytrauma, such as in motor vehicle accidents.

On the other hand, non-sports concussions may take longer to recover than SRCs due to factors like age or mechanism of injury <sup>[10]</sup>. Further, litigation intent in non-SRCs may influence the rate of concussion symptom resolution, and studies have documented attenuated symptom improvement in those involved in litigation vs. controls <sup>[11]</sup>.

In addition, SRCs in competitive sports are known to be subject to significant underreporting, with one study showing that 68% of college football players had at least one concussion they did not disclose <sup>[12]</sup>. The high rate of misreporting and underreporting in competitive-level sports most certainly distorts the data on symptom recovery time. Researchers argue that this controversy deserves more attention in future research.

## **4. Risk Factors of Prolonged Recovery**

Understanding risk factors for PPCS can alert practitioners to be particularly vigilant and proactive in the acute period for at-risk athletes. A variety of risk factors have been identified in the clinical literature, some of which are not always consistent. The most commonly reported preinjury risk factors are having prior concussions, female gender, mood disorders, learning disorders, attention deficit hyperactivity disorder (ADHD), and a personal or family history of migraines <sup>[13][14][15][16]</sup>. When looking at post-injury risk factors, the commonly cited factors include injury severity, retrograde amnesia, a high symptom score, “feeling in a fog”, delayed reporting, and the presence of sleep disturbances <sup>[4][12][17][18]</sup>.

The issue of multiple concussions as a risk factor warrants further discussion. While several studies have documented that prior concussions are both a risk factor for future concussions and for prolonged recovery, others have failed to substantiate this connection <sup>[19]</sup>. While neuroprotective strategies for concussion (such as certain supplements like creatine or omega oils) are outside of the scope of this article, researchers generally recommend them for athletes after their first concussion.

## **5. The Time-Course Pattern of Symptom Recovery**

The time-course of mTBI symptom resolution underscores the importance of early intervention. There is a definitive “hockey-stick” pattern in the resolution of symptoms, with rapid resolution happening in the first weeks after concussion, followed by very little resolution after this period.

In a prospective study of PPCS, it was found that being symptomatic at one month was significantly predictive of being symptomatic at one year <sup>[20]</sup>. This is in line with the findings of the TRACK-TBI study, where there was only a 7% drop in those with one symptom from the 3-month to 12-month mark. Expressed another way, symptoms decreased steadily at ~1.7 symptom score points per month in the first 3 months but then only 0.2 points per month for the rest of the year <sup>[6]</sup>.

This distinctive time-course pattern correlates with the development of nociplastic pain and the phenomenon of central sensitization. When symptoms linger, central neuroplastic changes occur, and the symptoms become chronic. This underscores the notion that a therapeutic window for conservative interventions exists in the early period, but this closes once the deleterious neuroplastic changes in central sensitization become established.

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