

Go to Bed, Sleepy Head: The Relationship Between Head Injuries and Sleep Problems

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"It's raining, it's pouring,
The old man is snoring,
He bumped his head and went to bed,
And couldn't get up in the morning."

—The Little Mother Goose

Reflecting on this nursery rhyme taught to me by my parents at age two, I now see how apt it is, almost four decades later. Head injuries have been a huge focus in the sports world since at least 2009 when numerous studies showed that repeated head trauma in athletes in the National Football League (NFL) could have serious consequences and downstream effects in players, including the increased risk of violence, mental health problems, spinal cord injuries and even dementia (chronic traumatic encephalopathy [CTE]).

In this article, I will not discuss the immediate assessment and treatment of concussions or the decisions determining when an athlete can return to play. I will instead discuss the bi-directional relationship between head injuries and sleep problems so that sleep professionals are aware of the right questions to ask and the associated sleep disorders to look for.

Equipped with this understanding, sleep professionals can better serve their patients, and anybody they know who is dealing with post-concussional syndrome (PCS).

What Is a Concussion?

The Centers for Disease Control and Prevention (CDC) defines a concussion as "a type of traumatic brain injury — or TBI — caused by a bump, blow or jolt to the head or by a hit to the body that causes the head and brain to move rapidly back and forth.

This sudden movement can cause the brain to bounce around or twist in the skull, creating chemical changes in the brain and sometimes stretching and damaging brain cells."

TBI is considered mild, moderate or severe depending on the scoring of the symptoms using the Glasgow Coma Scale. The damage can range from light blows to the head with local bruising to hematomas (small blood clots), cerebral edema (brain swelling) and even as significant as shearing/tearing injuries of white matter to specific areas of damage (frontal, temporal, occipital lobes).

Even minor hits to the head that are brushed off as bumps or not even considered as hits can cause "fraying" of the brain and add up in terms of overall damage with severe long-term consequences.

Thus, an umbrella term like "concussion" is woefully inadequate. We have to take into account the severity of an injury, number of injuries, areas affected, loss of consciousness (or not), specific symptoms (indicating areas of the brain affected), duration of complete recovery from those symptoms and other factors impacting brain health (medications, substance use, sleep, inflammation, genetics, hormones, neurotransmitters, mental health, diet and others).

MRIs and CT scans may be normal in many cases. Thus, more sensitive testing such as single-photon emission computerized tomography (SPECT) imaging (functional brain imaging, that can tell us about blood flow and activity levels) is important to establish baseline measurements, quantify the degree of damage and create specific plans to help the brain heal.

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The initial and direct injury is only the beginning of the story. Soon after the initial damage, a waterfall of metabolic events sets in, which causes subsequent brain damage that may result from the generation of free radicals (substances that damage tissues), flooding of neurotransmitters, inflammatory responses, mitochondrial (the powerhouses of the cells) dysfunction and abnormal gene activation, among others.

Thus, based on the degree of damage and the regions affected, different symptoms may manifest and warrant an individualized treatment protocol for each patient. Unless we know what we are treating, we will not know how to treat it.

"I think in a couple [of] years, [sleep deprivation] will be an issue that's talked about, like the NFL with concussions." —Tobias Harris (professional American basketball player)

What Can Concussions Do to Your Sleep?

It is estimated that a college (American) football player has already sustained thousands of hits to the head. In a 2019 study of just one season of college football, 38 players from the University of Rochester's Division III team sustained a collective 19,128 hits to the head. Only two of these encounters resulted in formal concussions, but a majority of the hits were not serious enough to warrant clinical diagnosis.¹

A review of sleep disorder studies and surveys suggest that sleep disorders are three times more common in TBI patients than in the general population. Nearly 60% of people with TBI experience long-term difficulties with sleep.

Patients suffering from TBI of any severity in both the acute and chronic phases commonly report excessive daytime sleepiness, increased sleep need, insomnia, and sleep fragmentation or disruption.²⁻⁴ In a meta-analysis of 1,706 TBI survivors across 21 studies, the most common sleep disturbances were:⁵

1. Insomnia – Present in 50% of survivors.
2. Difficulty maintaining sleep – Present in 50% of survivors.
3. Poor sleep efficiency – Present in 49% of survivors.
4. Early morning awakenings – Present in 38% of survivors.
5. Nightmares – Present in 27% of survivors.
6. Sleep apnea – Present in 23-36% of TBI patients, compared with 2-15% of middle-aged adults; central sleep apnea (CSA) may occur with increased frequency after TBI.^{3,6,7} The prevalence of obstructive sleep apnea (OSA) varies widely across studies ranging from 11-77%.^{5,8-10}
7. Restless legs syndrome (RLS) – Present in 13% of TBI patients (compared to 2-7% of the general population).
8. Excessive daytime sleepiness (hypersomnia or narcolepsy) – Ranges from approximately 50-80% in patients with TBI (compared with the rate in the general population of 10-25%).¹¹⁻¹⁴

9. Increased sleep need (pleiosomnia) – To differentiate from excessive daytime sleepiness, the term pleiosomnia has been proposed to indicate an increased need compared with the patient's pre-TBI baseline.¹⁵ Studies show that patients with TBI deal with both excessive daytime sleepiness and pleiosomnia (needing one to two hours of sleep more per 24-hour period).^{8,16}
10. Circadian rhythm disturbances – These occur more frequently in patients with TBI. In one study, 36% of people who complained of insomnia after mild TBI met criteria for a circadian rhythm disorder.^{17,18}
11. Abnormal movements or behaviors during sleep – Small studies have suggested that parasomnias and sleep-related movement disorders may occur with increased frequency after TBI in both the acute and chronic phases. These can include acting out dreams (rapid eye movement [REM] sleep behavior disorder), sleep talking, sleep walking and others.

How Concussions Cause Sleep Problems

The mechanism of post-concussive sleep disorders is unclear but may be related to faulty signaling in neurons involved in normal sleep-wake control and circadian rhythm maintenance.¹⁹

One of the mechanisms is lowered orexin (hypocretin) levels in people who have suffered a TBI. Orexins are neuropeptides which are deficient in human narcolepsy type 1 (narcolepsy with cataplexy). Measured orexin levels in the cerebrospinal fluid (CSF) were low in 95% of 44 patients within the first four days of moderate to severe TBI.²⁰ These deficiencies are associated with sleep fragmentation and excessive sleepiness.

Severe TBI was also associated with a 17% loss of dorsal raphe nuclei neurons (which produce serotonin) and a 29% loss of locus coeruleus neurons (which produce noradrenaline). Both of these neurotransmitters are involved in mediating sleep and wakefulness.

Melatonin is the major mediator of the sleep-wake cycle (circadian pattern) and is produced by the pineal gland. Melatonin release may be disrupted following TBI.²¹ Despite this data, melatonin supplementation is not very helpful after TBI. One still may need extra sleep while their brain is trying to heal from the brain injury.

Medications taken after a brain injury may cause problems going to sleep or staying asleep, or can make people sleepy during the day and make them unable to participate in activities. Medications that may cause problems include anti-seizure drugs, opioid pain medications, benzodiazepines (used for relaxation, anxiety and sleep), anti-psychotic medications and certain antidepressants. Medications that may cause or aggravate



insomnia include steroids, bronchodilators (asthma) and stimulants (used to treat attention deficit hyperactivity disorder [ADHD]). Alcohol use and other licit and illicit substance use are also relevant.

How Sleep Problems Influence Concussions

Data pooled from Project REST (Recovery Enhancement and Sleep Training), the National Collegiate Athletic Association (NCAA), the NCAA Inter-Association Task Force on Sleep and Wellness, the NCAA Growth, Opportunities, Aspirations and Learning of Students (GOALS) survey, Pacific-12 Conference (Pac-12) and the American College Health Association (ACHA) show that:²²⁻²⁵

- Sixty-eight percent of collegiate athletes had “poor sleep” on the Pittsburgh Sleep Quality Index (PSQI).
- Sleep is the number one thing athletes’ athletic time commitments keep them from doing.
- Nearly three-quarters of athletes report receiving no education about managing sleep difficulties.
- On average, athletes received 6.27 hours of sleep while in season (8-12 hours is ideal).

College athletes may face greater risk for sport-related concussions if they have insomnia or are even just chronically sleepy. In a survey of 190 NCAA Division 1 athletes, the risk of getting a sports-related concussion during the next year was 14.6 times higher for those with both insomnia and excessive daytime sleepiness than for

those who were well rested. On its own, moderate to severe insomnia more than tripled the risk of concussion and excessive sleepiness (even two or more times a month) more than doubled the risk of concussion.

Studies estimate the prevalence of sleep disturbances in professional athletes ranges from 13-70%. Findings from the Concussion Assessment, Research and Education (CARE) study, which was a study of more than 30,000 student athletes and cadets, found that those who were sleep deprived had symptoms similar to a concussion (18,548 students and 12,039 cadets from four military academies).²⁶ Between 11-28% of these participants had a cluster of symptoms that would meet the definition of PCS despite no recent head injury.

As we already know, sleep deprivation can reduce reaction times and increase the risk of injury, including head injury. Additionally, being chronically sleep deprived can result in more severe symptoms following a concussion, as well as a delayed recovery from the concussion. Succinctly put, post-injury sleep declines may be associated with symptom severity and worsened reaction time during initial stages of recovery or may be the result of the concussion itself.²⁶

On top of that, we already know all the possible sleep disorders that concussions can contribute to. All of them can not only cause distress, but also prevent one’s brain from healing after a concussion. We must also remember that a concussion may be accompanied by neck pain, headaches, other injuries and musculoskeletal pain, all of which can further impact sleep. Thus, sleep optimization is important before an athlete has a concussion to reduce the risk of a concussion, and then to improve the prognosis if one does occur.

Improving Sleep in the Concussed Athlete

Many of the sleep-wake disturbances persist long term after the TBI, as shown by a study in which 31 out of 60 patients with TBI were evaluated at 18 months after injury.²⁷ With such a range of sleep disorders possible falling into every major category, it is absolutely essential to screen athletes periodically for these issues, so that we can direct them to appropriate care. For example, narcolepsy is treated with stimulants or wakefulness agents. These medications are banned by the World Anti-Doping Agency (WADA) unless there is a medical necessity, which requires extensive documentation and the completion of an application for a therapeutic use exemption.

The detection and treatment of such conditions can make or break an athletes’ career. Take insomnia for example. We need a sleep expert to make sure that a serious problem like central sleep apnea is not missed. Therefore, establishing a diagnosis is crucial. Before initiating medications for sleep, we need to screen for underlying factors and diagnose and treat any issues individually. Simultaneously, strategies such as sleep hygiene and cognitive-behavioral therapy for insomnia (CBT-I) can be started.

One’s brain knows it needs more sleep after a head injury. One of the quickest ways to heal the brain after a head injury is to get more recovery sleep. However, we must remember that an athlete may be sleep-deprived at baseline (prior to the concussion), and so when screening them post-concussion, it is very important to use a baseline of optimal sleep rather than a possibly sleep-deprived baseline when tracking their recovery from a concussion.

Medications should be used with caution because of potential adverse effects and drug interactions. Medications such as benzodiazepines, antidepressants, antipsychotics and antihistamines may increase the risk of seizures or interfere with brain healing (neuronal plasticity). In addition, benzodiazepines can cause (paradoxical) agitation, memory problems, addiction and rebound insomnia.

I strongly recommend avoiding benzodiazepines in TBI patients. In all patients who have sustained a TBI, I recommend a referral to a sleep specialist, whether or not there are sleep disturbances, because optimizing sleep post TBI can give an athlete the best chance of recovery from the injury. Other sleep disorders associated with TBI require specific testing and treatments that can be done by a competent sleep medicine physician.

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Conclusion

Sleep problems and concussions have a bi-directional relationship. Sleep strategies and education to optimize athletes' sleep is necessary and possibly a preventative strategy for concussions. Post-concussion, it is recommended to train the concussed athlete on sleep improvement strategies (CBT-I), as well as periodically screen the athlete for ongoing sleep problems or ones that may develop later with validated screening tools. Treating a concussed athlete is a multi-disciplinary effort, and a qualified sleep physician needs to be an integral part of the team. 🌙



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