What kind of injury is most detrimental to athletes at onset and later in their lives? What kind of sports does this injury occur in most frequently? How does this injury affect the athlete’s body from the onset to years down the line? In this chapter we will investigate the answers to all these questions and more as we investigate brain injuries, and more specifically concussions.

 **What sports have the most concussions?** 1.7 million to upwards of 5 million concussions occur annually. About 70 percent of all concussions reported are from individuals of high school age, with increasing numbers in younger age groups. 33% of all sports related concussions happen at practice. Girls are also more likely to get a concussion versus boys. There are many different types of sports available for participation across the globe, some are more detrimental to the brain than others. These sports would be those that involve repeated trauma, many impacts, a lot of bodily contact, etc. In other words, contact and collision sports are the worst ones to participate from a concussion standpoint, and even these have their own outliers that are very hard on the brain. Some of these include: football, girls’ volleyball, girls’ basketball, girls’ soccer, hockey, wrestling, lacrosse, softball, baseball, and rodeo. All of these sports have one thing in common: impacts to the head. These impacts occur from other athletes, balls, equipment, the ground/ court, nearly anything can cause injury. Of all these sports, football (specifically high school football) accounts for nearly 47% of all concussions! On top of that, 1 of every 2 concussions goes undiagnosed and untreated. Lastly, nearly 40% of concussions are related to a permanent neurological disability. But, for us to truly understand how concussions work, we have to investigate the mechanisms that cause them and what structures are involved.

 **So what is a concussion?** A concussion is a brain injury caused by a blow to the head or a violent shaking of the head and body. Even small hits, such as those the lineman suffer play after play are damaging to the brain according to recent studies. This is because of the constant sharp and violent movement of the brain and head, that these small hits are labeled as sub-concussive. To imagine what happens to the brain causing a concussion, picture this: a plate that has jello on it and the plate is moved quickly and sporadically in a different direction. The jello lags behind the movement of the plate, i.e. the jello moves slower than the movement of the plate. However, you’ll notice that the jello continues to move after the plate is stopped, snapping into the other direction because it moved too far. This point is where one of a couple things happen in the brain. This snapping back action is causes damage due to the movement, similar to whiplash, or the brain impacts the skull. This hard surface contact obviously causes injury. Now this impact or sharp movement causes axon shearing or tearing. Axons help to make up neurons, which send signals to one another in the brain and nervous system. These axons are partially made up structurally by a protein called tau. When injury occurs, the axon breaks off into little pieces, which then begins to build up in the axon. This building up causes the axon to swell and eventually cuts off the signaling pathway. The axon eventually can not swell anymore and explodes releasing tau protein. Buildup of this protein can be found in individuals with Alzheimer’s, Dementia, and stroke patients. But these patients of these other diseases do not have near as high concentrations as do those diagnosed with Chronic Traumatic Encephalopathy (CTE). This disease is caused by those sub-concussive hits and concussions.

 **What are some symptoms to look for in concussions?**  Symptoms of concussion can vary but in the medical field, if a patient loses consciousness due to an impact to the head, the patient has sustained a concussion. The same thing goes for if a patient has ever seen stars, elephants, or even pink elephants after they have hit their head on something. Some other symptoms that are common with concussion patients are: nausea, vomiting, dizziness, loss of coordination, sensitivity to light, headache, balance issues, confusion, memory loss, mood changes, feeling sluggish, sleep issues, blurry vision, and many more. If an athlete sustains a concussion and has a good relationship with the on-site medical professional, they can be usually be spotted quickly and will have issues hiding the injury if the medical professional knows the athlete well. You might wonder how the athlete can hide the injury or why they would try to hide it, knowing the information that was previously mentioned. Currently, treatment and diagnosis of concussions is mostly subjective. In other words, the treatment and diagnosis is based on symptoms strictly reported by the patient that can not accurately be measured. These symptoms may also not be able to be seen by the observer, such as a headache. Therefore, the only option currently available is to treat the symptoms of the concussion until symptoms subside. At that point, the patient is cleared to go back to regular activity. This subjective diagnosis and treatment allows competitive individuals to play the system and “stay in the game” to keep playing and not lose time, even though it is an inconvenience, it is better for the body. These patients will also try to end treatment sooner than they should as well, but at this point in their recovery process, it is more difficult to do. This is because they may be impaired which will be noticeable to the medical professional treating them. However, if these individuals succeed in avoiding diagnosis and/ or treatment they put themselves in grave danger.

 **Post-Concussion Issues** Second Impact Syndrome occurs when an individual sustains a concussion before a previously sustained one has healed. This can lead to death, and most often does. This occurs due to the fact that the brain swells at this point and can also start to have a bleed on the brain. This increased swelling and fluid causes excess pressure on the brain because of the presence of the skull. The brain is put under so much pressure that it end up causing it to lose/ cease function. Even if the patient gets to a hospital fast enough and part of their skull is removed to relieve the pressure, the patient may still be disabled because of the pressure. Even if the patient is diagnosed and treated, they still are at risk for problems later in life. After a concussion is sustained, it is much easier for the brain to be concussed again. Also, after repeated impact the patient may be diagnosed with CTE later in life. CTE is characterized by: memory loss, change in demeanor, suicidal thoughts and actions.

**Diagnosis, Treatment, and Research** There are not very many methods for treatment and diagnosis currently in practice for use with concussions. Currently the main focus is finding out if a patient has symptoms and then treating those symptoms. These treatments tend to be pain medication to alleviate the pain associated with a concussion. Diagnosis has improved some recently using imaging techniques to see changed brain activity. Pre-participation testing has also been implemented. These test are performed by each athlete before the athlete participates in sport activities. These tests use software to get a baseline for neurological performance of the patient. If a concussion has occurred, the results of the test will be much lower and slower than those of the baseline. This test has to be performed before participation due to the difference in people’s abilities. One person’s base line could be another’s concussed results. Some of the treatment methods have involved limiting the exposure to stimulus and lowering the amount of brain activity the patient has to do. This amount is slowly increased back to normal capacity through a period of time. There are many proposed and researched diagnosis methods. These include: detectors, imaging, and biomarkers, among others. The detectors involve inserting tracers into the patient’s bloodstream that specifically look for tau protein in abundance. As afore mentioned, this protein will only be present in high quantities if an injury has occurred. Some of the imaging techniques involve the use of dyes or clearer imaging techniques. These propose an issue in requiring these large pieces of equipment to be present. The biomarker aspect somewhat coincides with the detector/ tracer model. However, the approach uses proteins, enzymes, cytoskeleton components, and many other molecule levels in the blood to assist in diagnosis. This is achieved through drawing the blood and testing it for high levels of proteins, enzymes, and cytoskeleton components that are unique to neurons only. If these are present elsewhere, then obviously injury has occurred. One of these proteins happens to be tau protein. But, these new methods are still require a lot of research before they are put into practical application.

Concussions are a very difficult injury, in both having one and attempting to treat the patient. This injury poses a lot of risk to the patient for later disability. However, since the occurrence of this injury is so high and is such a prevalent problem, research on the topic is being performed at a fast pace. What was the correct and relevant knowledge just five years ago is now viewed as mostly obsolete and this trend shows no signs in slowing down. This injury may change how sports are played, but most agree that it will not end these high collision and impact sports.

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