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Concussion Myths: Confronted Head-On

Most often, when we think of concussions, we think of a person hitting their head. But in fact, a concussion can result from a hit to the face, neck, or anywhere on the body if the force of the impact is strong enough to be transmitted to the head. By definition, force, F is the magnitude of acceleration, a, times the mass (m) of the object.

$$F = ma \tag{1}$$

Throughout this paper, the term "force" is sometimes used in place of "acceleration" in an effort to convey the relationship between the magnitude of impact and concussive effects. Note that force is proportional to acceleration. Thus, the *faster* the acceleration, the *larger* the force.

What does that mean for the brain?

The brain is lightly anchored to the skull by the meninges – specifically, the pia - and sits in a body of protective cerebrospinal fluid. When a force is large enough to move the body or head, the brain accelerates as well, hitting the skull, and potentially leading to a concussion.

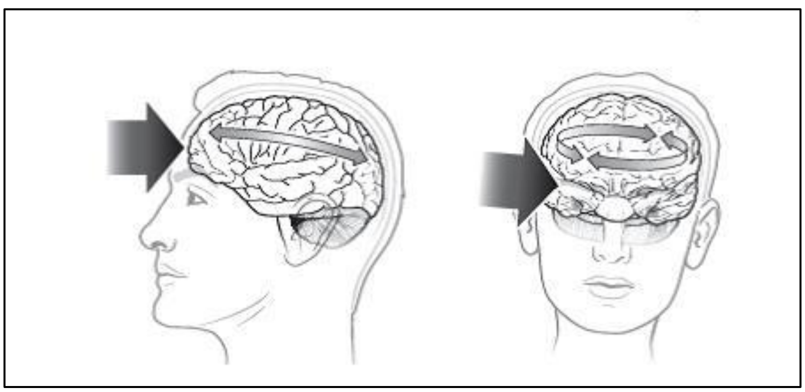

Figure 1. Linear (left) and rotational (right) acceleration. (Cantu and Hyman, 2012)

There are two types of forces that lead to concussions: linear and rotational (Fig. 1). In a linear force of impact, the brain moves straight forward and hits the front of the skull. This can cause bruising and/or tearing of the brain. If the impact is of rotational force, the hit is off-center, causing the brain to spin within the skull. Because the inside of the skull is not a smooth surface, this rotation can cause the brain and blood vessels to be stretched, sheared, and torn (Cantu, 2012). Rotational force is oftentimes the worse of the two kinds of forces leading to a concussion – although in virtually every hit to the head, both types of forces occur. The magnitude of each type of incident force impacts the level of damage that occurs when an individual suffers a concussion. When the impact of a hit is strong enough to disturb the spine and the brain, a force anywhere on the body has the ability to damage the brain, and impact its function.

It is important to note that every individual is susceptible to concussions and brain injuries. However, we tend to only think about the dangers of concussions when it comes to sports. While concussions were previously thought to be a minor brain injury, the last two decades have seen research indicating long term, severe brain damage from repeated concussions among the NFL player population. The research suggesting chronic brain deficits from continuous hits to the head has drawn a lot of attention, particularly because of the NFL's large fan base. And while the increased concern for athlete-sustained concussions is a good thing, it is important to recognize a growing public misconception that concussions are only caused by head-on collisions.

What does the NFL – and other professional leagues – have to do with this misconception?
Before explaining the effects of this misconception, and why it is necessary to inform the public of the truths behind concussions, we must first understand how the misconception arose in the first place. When former NFL player, Mike Webster, began to suffer from severe personality changes, depression, and early on-set dementia, he brought about a law suit against the NFL. Several doctors confirmed that Webster's dementia was a result of playing professional football, but it wasn't until Webster passed away that scientists really began to question the extent of the brain damage. In a Frontline report, *League of Denial*, neuropathologist, Dr. Bennet Omalu states that he found deposits of tau protein in the frontal lobe during Webster's autopsy. While the brain looked normal on the outside, the microscopic damage was indicative of chronic traumatic encephalopathy (CTE), a progressive neurodegenerative disease found in people who have suffered repeated blows to the head (Omalu et. al., 2010) After publishing a paper on his findings, the NFL concussion committee refuted Dr. Omalu, asking him to retract his paper.

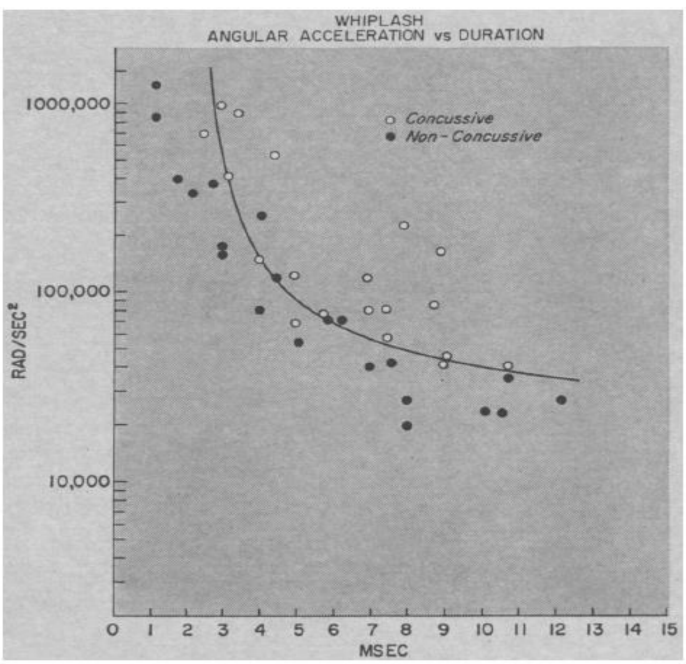

Figure 2. The relation of amplitude (rad/s^2) to duration (milliseconds) of rotational accelerations of the head recorded in experimental whiplash injury. (Ommaya et. al, 1968)

It was only within the last decade – after the death of Junior Seau – that the NFL began to really accept and recognize the hazards of repeated hitting and concussions received in the game of football. The research performed by Dr. Omalu and other neuropathologists has lead other sports – such as boxing, soccer, and volleyball – to recognize the serious effects of head injury among athletes. But because the NFL is such a large influence in American culture, it's impact on the general public's knowledge of concussions has seemed to have a widespread effect. As a result, many people have begun to categorize concussions as only sports related injuries after direct hits to the head. This misconception is due, in part, to the fact that audience members are generally only witnessing players escorted off the field after a head-on hit. While it is true that most concussions do occur from direct blows to the head, a portion of sports concussions arise from bodily impact that might not *seem* like it damaged the brain.

How do we know that concussions can occur from indirect hits to the head? Good question. In the 1968 experiments performed by Ommaya et. al., it was determined that forceful impacts to the shoulders and neck had the ability to create concussive damage. The experiment, delivered impacts of varying force to the back of a wheeled cart carrying a rhesus monkey. The data (Fig. 2) suggests that despite lack of direct hits to the head, rotational force at high magnitudes lead to concussive damage.

How does this data relate to sports?

As previously mentioned, concussions have become a growing source of concern within the NFL, and other professional sports. The problem with sports being the main platform for concussion awareness is that speculators are only aware of concussive damage if a hit *looks* like it hurt the brain. Despite the manufacturing of "concussion-proof" football helmets, concussions are still rampant among athletes. The reason for this is due to the inability of a football helmet to stop the brain from hitting the skull internally. While a significant amount of research has been done to find ways to protect the brain from the inside, there is currently not a known solution.

Table 5 Sport-specific comparison of mean neck strength measurements between athletes who sustained a concussion and those who did not

	No concussion		Concussion		*p* value[b]
	n[a]	mean (*SD*)	*n*[a]	mean (*SD*)	
Basketball					
Overall neck strength (lbs)	2,559	9.39 (5.12)	58	7.72 (4.80)	**0.011**
Extension (lbs)	2,553	9.71 (5.30)	58	7.97 (4.87)	**0.010**
Flexion (lbs)	2,554	10.21 (5.77)	58	8.20 (5.45)	**0.007**
Right lateral (lbs)	2,537	8.78 (5.13)	58	7.25 (4.66)	**0.017**
Left lateral (lbs)	2,536	8.79 (5.04)	58	7.47 (4.87)	**0.046**
Total	2,563		58		
Soccer					
Overall neck strength (lbs)	2,660	9.15 (5.06)	95	8.15 (4.83)	0.051
Extension (lbs)	2,656	9.49 (5.26)	95	8.50 (4.88)	0.055
Flexion (lbs)	2,659	9.81 (5.64)	95	8.76 (5.20)	0.056
Right lateral (lbs)	2,658	8.61 (5.04)	95	7.63 (4.86)	0.056
Left lateral (lbs)	2,656	8.68 (4.99)	95	7.71 (4.92)	0.064
Total	2,674		95		
Lacrosse					
Overall neck strength (lbs)	1,239	10.69 (5.28)	26	8.37 (4.99)	**0.027**
Extension (lbs)	1,239	10.95 (5.51)	26	8.70 (5.14)	**0.037**
Flexion (lbs)	1,239	11.72 (5.86)	26	9.06 (5.49)	**0.022**
Right lateral (lbs)	1,239	10.00 (5.23)	26	7.82 (4.94)	**0.035**
Left lateral (lbs)	1,239	10.08 (5.15)	26	7.89 (4.86)	**0.032**
Total	1,246		26		

Figure 3. Neck strength comparisons between high school sports players who suffered a concussion versus those that did not (Collins et. al., 2014).

Research by Collins et. al., suggests that neck strengthening may be one way to reduce the risk of concussion in sports. The experiment followed 6,642 high school athletes across a variety of sports, and related size, length, and muscular strength of the neck to the ability of the neck and brain to withstand concussive forces. The data (Fig. 3) suggested that athletes with stronger necks suffered less concussions than those with weaker necks. This information may provide one way to lower the prevalence of indirect concussions. If neck strengh measurements indicate that a player has weaker neck muscles, neck strengthening therapy tailored to their specific risk factors may decrease their risk of concussion (Collins et. al., 2014)

I don't play sports. Why do I care?

While sports related concussions are a common injury, it is important for the general public to understand the risks of concussions outside of a sports setting. A common misconception largely attached to sporting events is that concussions do not occur without a direct hit to the head. However, research has proved that any jolt to the body causing rapid head movement can cause brain injury in the form of a concussion. This means *anyone* is susceptible to a concussion. It is therefore vital that the general public be informed that indirect hits can lead to concussions so that they are better able to protect themselves, and those around them.

Myth: Only hits to the head cause concussions
Audience: General Public

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