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Medical Director of Sports Medicine Program



Sports Medicine Physician at Children's Healthcare of Atlanta

- Dr. Marshall served as a General Pediatrician in Camp Lejeune, NC until 1998 when his military commitment was completed. He then practiced General Pediatrics at the University of Michigan in Ann Arbor until 2000 and joined Children's Healthcare of Atlanta in 2001.
- Member of the American Academy of Pediatrics and a member of the AAP section on Sports Medicine and Fitness. He serves on the Medical Advisory Committee for the Georgia High School Association, and is team physician for many Atlanta area high schools, clubs, and gyms.

Overview and Pathophysiology of Pediatric Concussion

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The Law

- **HB 284 “The Return to Play Act of 2013”**
 - In effect 1/1/14
- **All public and private schools must create a concussion policy with a minimum:**
 - Information sheet given to parents on the risk, recognition and management of concussion.
 - Youth athletes that show s/s of concussion must be removed from play and evaluated by a healthcare provider.
No same day RTP.
 - Before RTP, must be cleared by a HCP trained in management of concussions, (orthopedic surgeons, ATCs **are** included)

1970s: Nobody got Concussions

2018: “Everyone” gets Concussions

What happened?



Questions Raised

- What is a concussion?
- How common are they?
- What happens inside the brain with concussion?
 - Structural injury? Inflammation? Bleeding?
- How do I know? What do I / we do?
- When can he/she return to school?
- What about headaches at school?

Questions Raised

- When is it safe to return to play?
- Can we predict who? Genetics? Biomarkers?
- How many is too many?
- Do subclinical blows matter?
- Can concussions be prevented?
- Helmets, mouthguards, headbands, neck strengthening, rule changes, etc?



Concussion Stats

- **1.1-1.9 million kids concussions occur annually in kids 18 years and younger**
- **Number rising rapidly in the past 10 years**
 - Increased awareness, education, media, more kids playing sports, bigger, faster kids

But...

Concussion Stats

Real number is probably much higher:

- ED vs pediatrician office (75%) or not at all? (45%)
- Underreporting
- Not educated
- Don't want to be held out (30-66%)

What HS Sports have the highest rate?

- Football (NCAA gih) 0.54-0.94 per 1000 exposures
- Girls soccer 0.30-0.73
- Boys lacrosse 0.30-0.67
- Boys hockey 0.54-0.62
- Boys wrestling 0.17-0.58
- Girls lacrosse 0.20-0.55
- Girls field hockey
- Girls basketball
- Boys soccer
- Girls softball
- Boys basketball
- Girls VB
- Cheerleading
- Baseball
- Girls gymnastics 0.07

What is a Concussion?

- Knocked out?
- Headache?
- Dizziness?
- Vomit 3x in 30 min?
- At least 5 symptoms?
- Symptoms last > 15 min?



No universally accepted definition

- Transient alteration in cognitive functioning after a blow to the head or around the head causing an acceleration force to be delivered to the brain
- Trauma induced alteration in mental status that may or may not involve loss of consciousness
 - NATA
 - mTBI?

Mechanics of Concussion: How does the head move?

- Many different outside forces can be applied to the **head**, with or without helmets
- 2 forces can be applied to the **brain**:
 - Contact (direct blow)
 - Inertial (acceleration)



Contact Force

Direct blow to head

- Skull fracture, depressed
- Epidural bleed, subdural, intracerebral, subarachnoid
- May occur at site of impact or remote from impact
- Common in moderate or severe brain injuries but uncommon in concussion (mTBI)

Inertial (acceleration) Force

- Most evidence shows acceleration loading to the brain at the moment of impact is the major cause of concussion (mTBI)



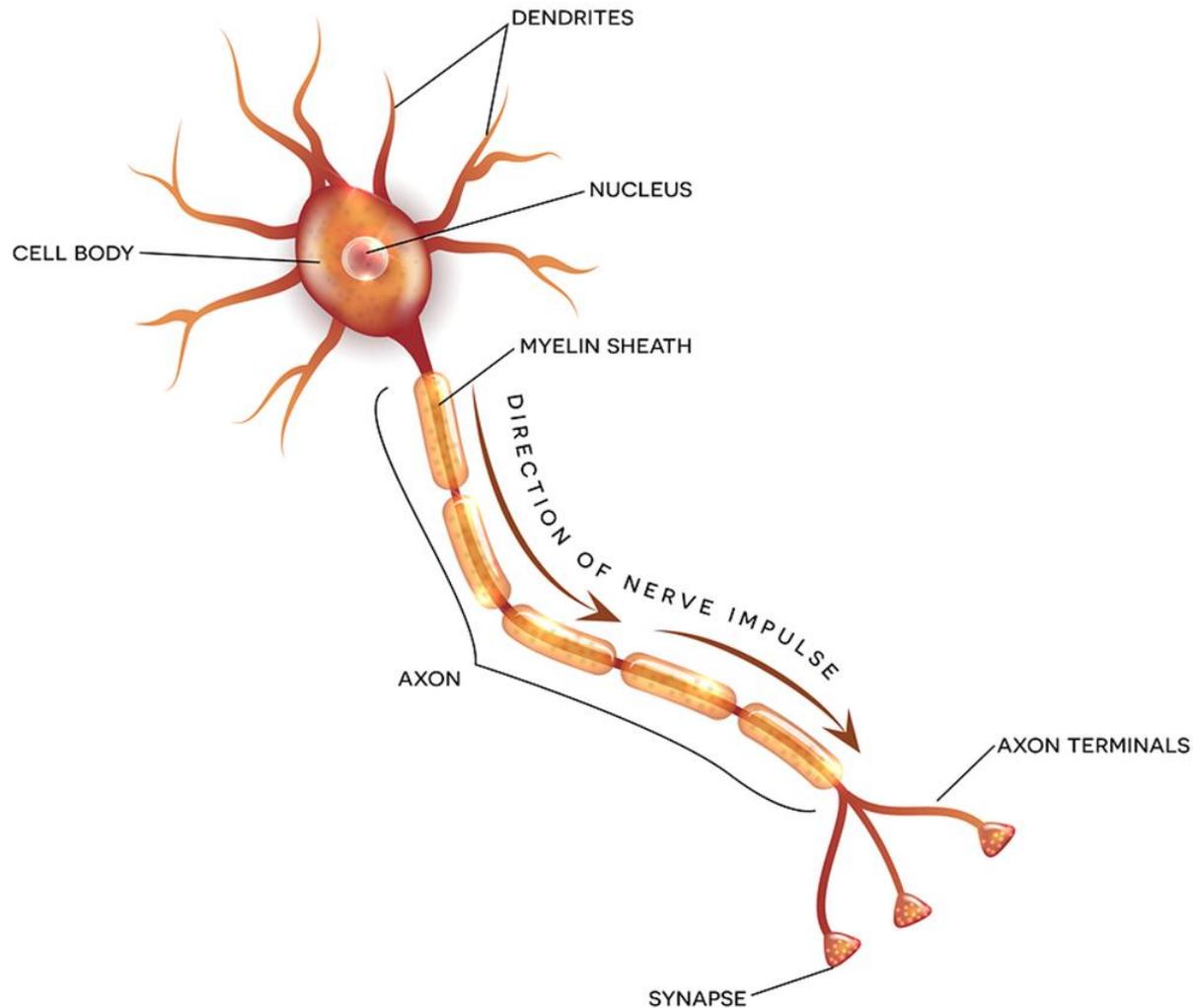
Early Research

- Most early researched focused on brains response to **linear** forces:
 - Thresholds in animal models
 - Peak pressure to the brain correlated to peak acceleration
- Drop tests
- Tolerance to skull fracture measured
- Begin to understand the skull response to linear acceleration
- Protective equipment and automotive safety systems determining injury risk are based on this research

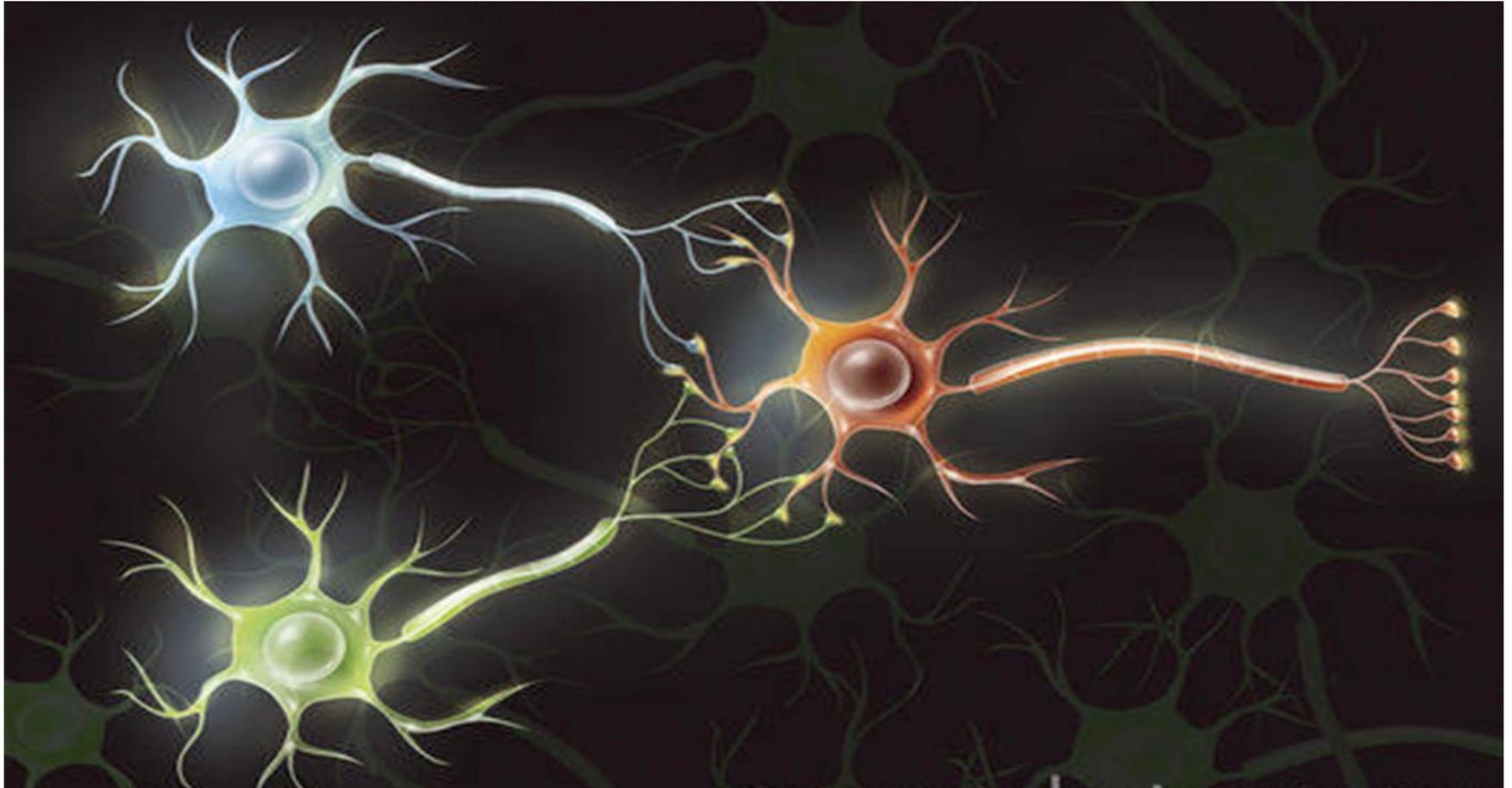
But...What about Rotational Acceleration?

- Highly organized brain tissue deforms more readily in response to shear forces when compared to other tissues
- More widespread damage than with linear acceleration or contact
- Research has proven this

What happens in the brain?

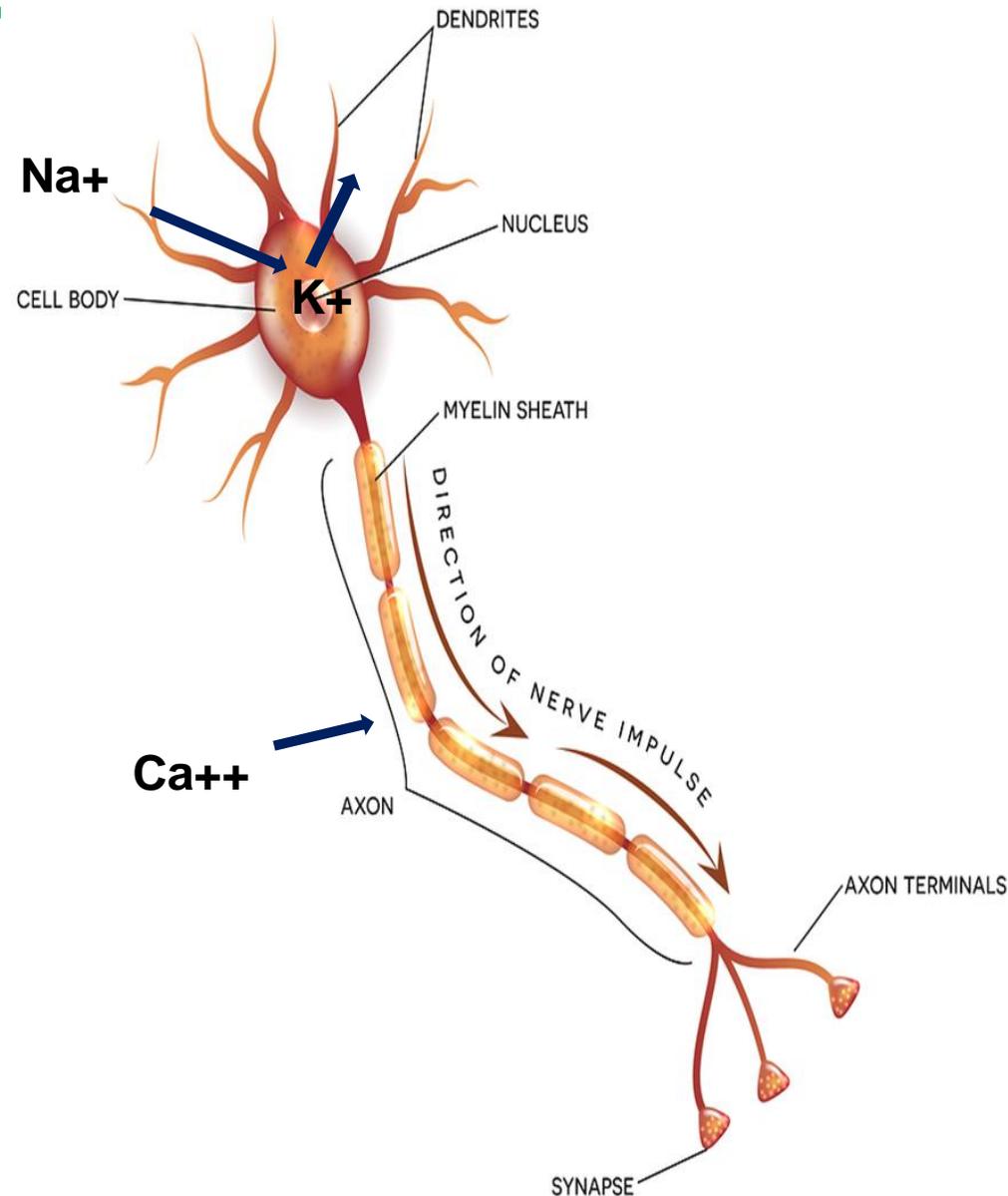


Neurons



Neurophysiology

- K efflux, Na influx
- **↑** glutamate
- Further K efflux, Na, Ca influx
- Brain cannot function properly until ions are “pumped” back to their normal position.
- **This is when the brain is concussed.**



Questions Answered

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What Next?

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