

Identifying Brain-based Biomarkers of Youth Concussion



Stacy Suskauer, M.D.
Pediatric Rehabilitation Medicine
Director, Brain Injury Rehabilitation Programs
Director, Brain Injury Clinical Research Center



Kennedy Krieger Institute



Concussion = mild Traumatic Brain Injury

Concussion

- is a brain injury
- results in a graded set of clinical symptoms
- symptoms reflect physiological (not structural) changes in the brain



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A public health problem for children



- Millions of concussions are estimated to occur in the U.S. annually.
- For every 1 concussion in the NFL, it is estimated that there are 50,000 concussions in student-athletes. (Gerry Gioia)
- The number of children receiving care for concussion is increasing. (Bakhos et al., *Pediatrics*, 2010)





Common symptoms of concussion

Physical Symptoms

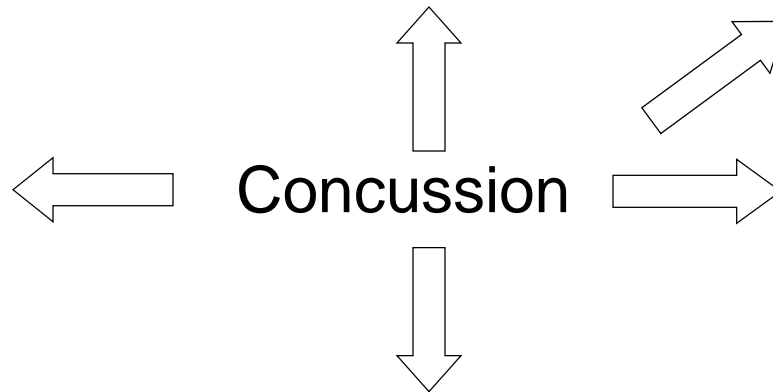
Headaches
Nausea
Fatigue
Visual problems
Balance problems
Sensitivity to light
Sensitivity to noise
Numbness/tingling
Vomiting
Dizziness

Thinking Symptoms

Feeling mentally foggy
Problems concentrating
Problems remembering
Feeling more slowed down

*Pre-school aged children *

Regression in potty training
Behavioral changes
Nightmares
Stomachaches



Concussion

Sleep Symptoms

Drowsiness
Sleeping more than usual
Sleeping less than usual
Trouble falling asleep

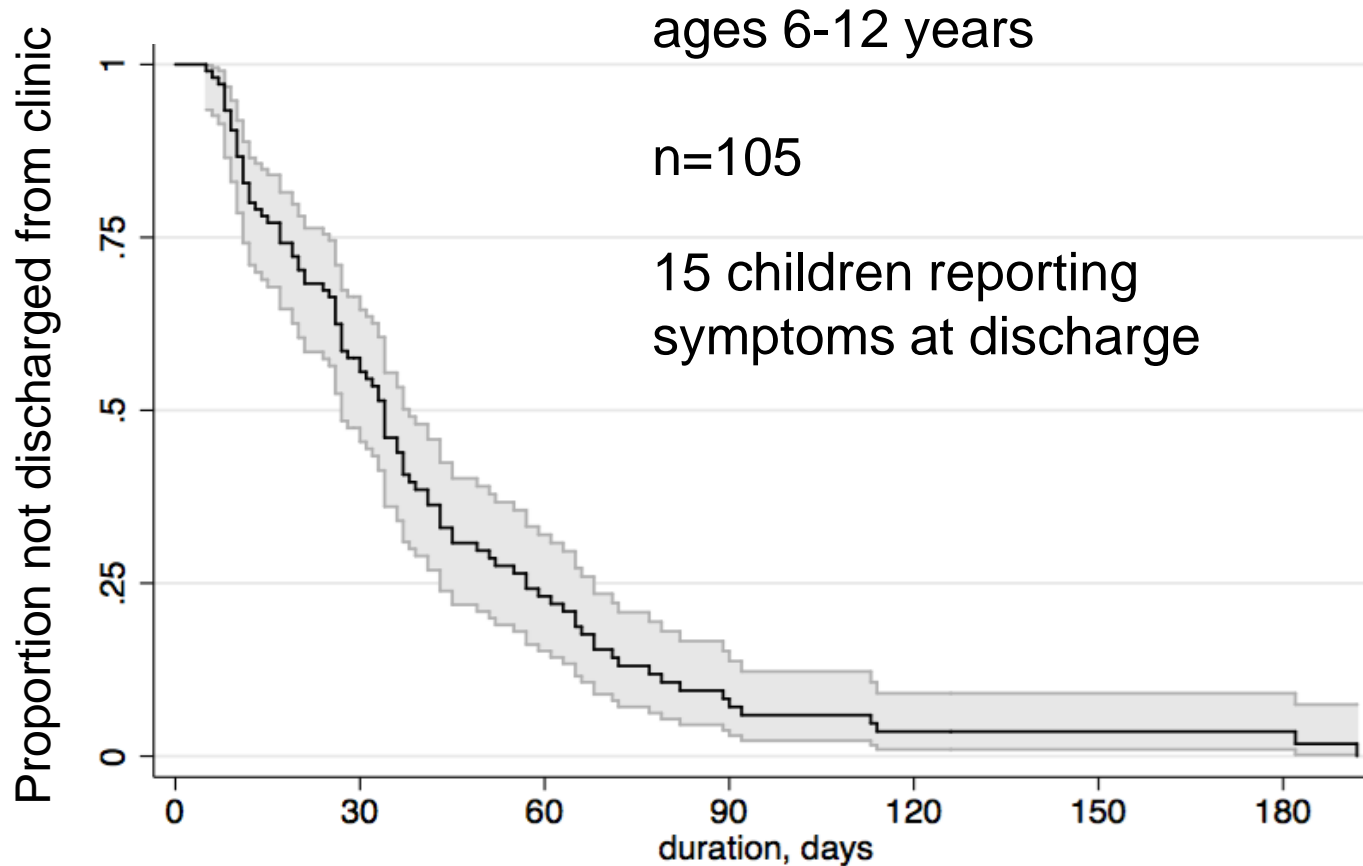
Emotional Symptoms

Irritability
Sadness
Feeling more emotional
Nervousness





Days from injury to discharge from Neurorehabilitation Concussion Clinic





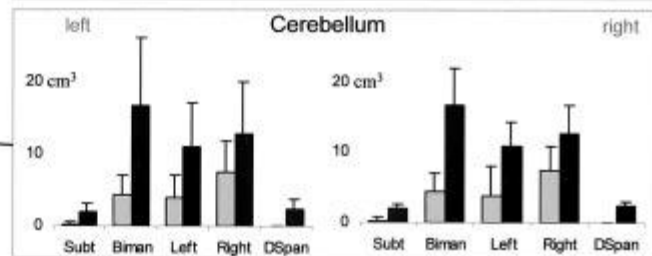
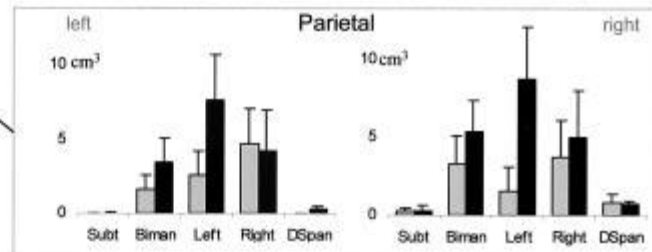
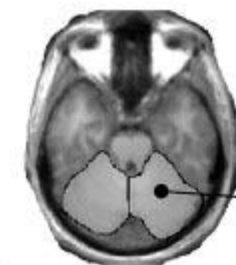
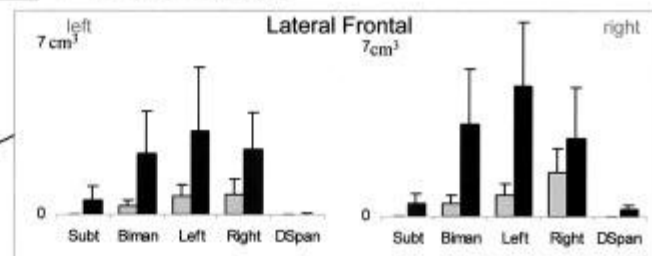
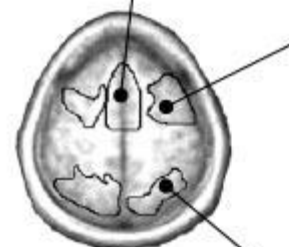
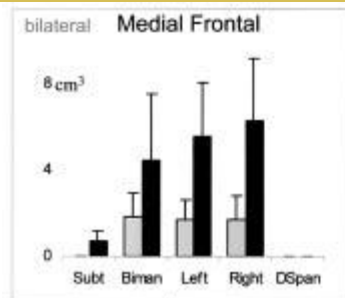
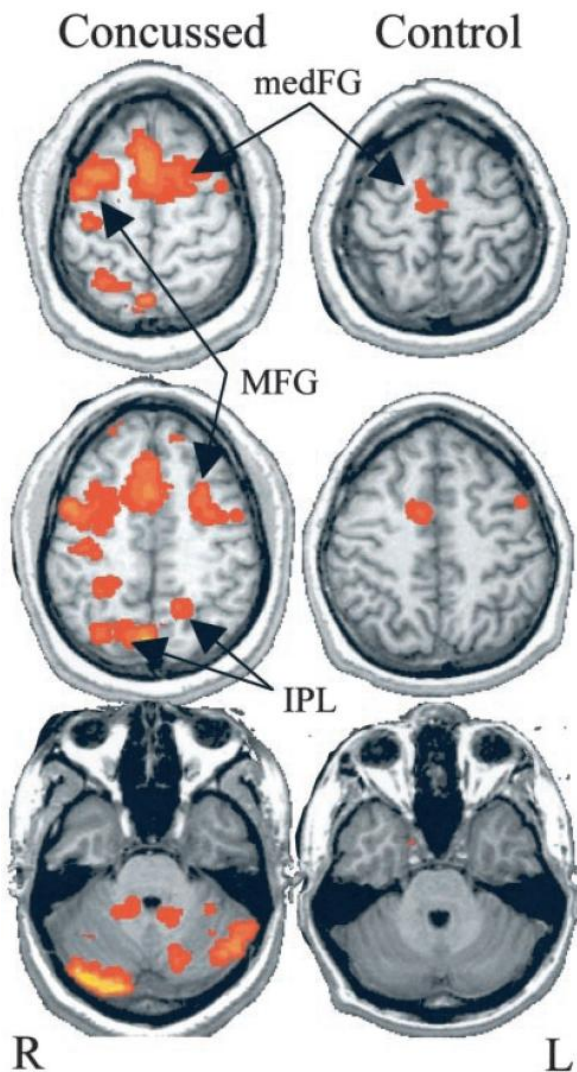
Evaluating Concussion and Recovery from Concussion

- The gold standard for evaluating recovery from concussion:
 - Presence of symptoms
 - Neurological examination, including balance
 - Cognitive testing, compared to baseline, when available
- There is currently no objective measure of brain physiology in clinical use for evaluating presence of and recovery from concussion.





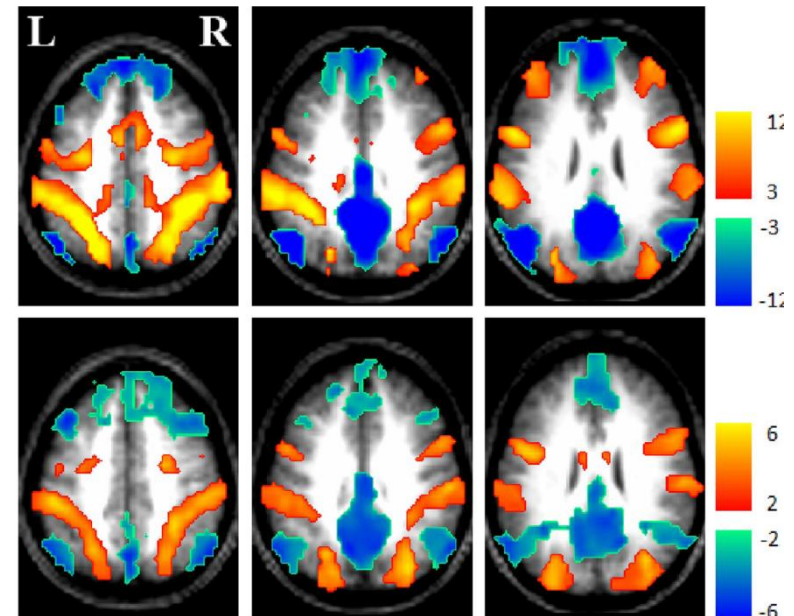
Behavior isn't sufficient for assessing recovery



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Resting state functional MRI

- **Dorsal Attention Network (DAN)** – supports voluntary attentional control
- **Default Mode Network (DMN)** – supports integration of cognitive and emotional processing, monitoring the world around us
- Within-network changes reported in concussion

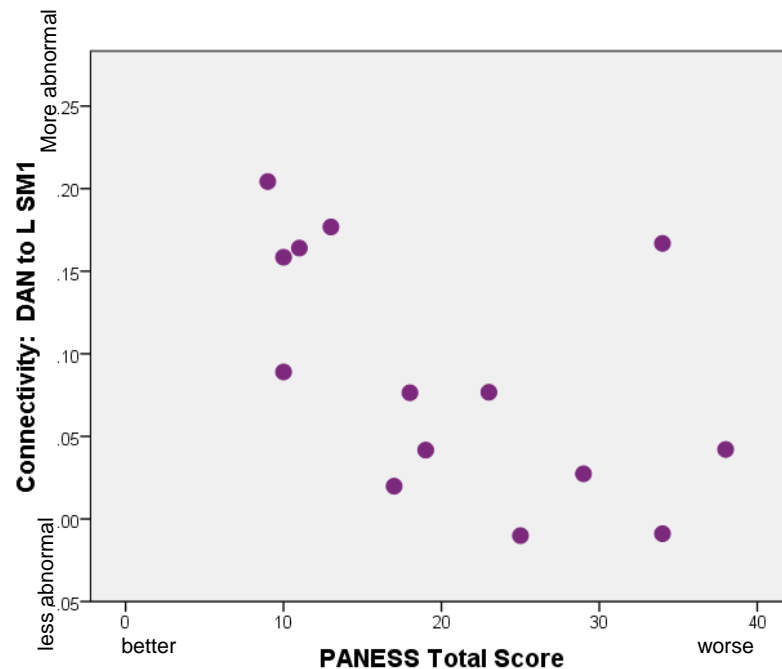
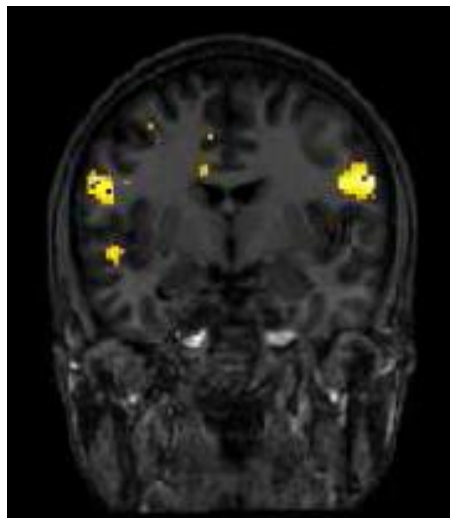
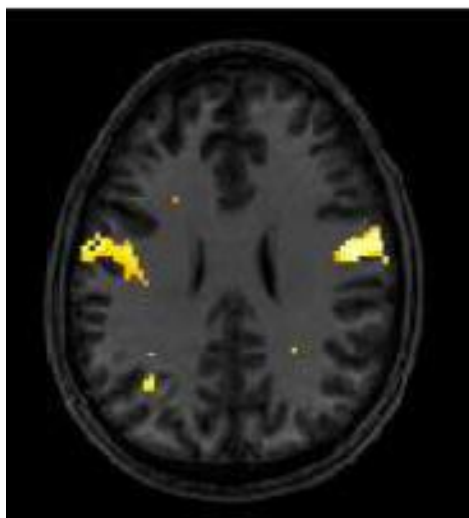




Recovery or Compensation?

- 14 adolescents ~2 months after injury
- Many were clinically recovered and back to play at the time of research participation

Recently injured children show more connectivity between the brain's attention and motor networks



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Functional brain changes after concussion

Do these eventually resolve over time?

- If so, should return to high-risk activities be based on resolution of brain findings?
- If not, is this a risk factor for
 - repeat injury
 - prolonged symptoms after next injury
 - problems later in life





A need

- Assessment tool which is:
 - Anchored to brain physiology
 - Sensitive to injury and recovery
 - Practical
 - Portable

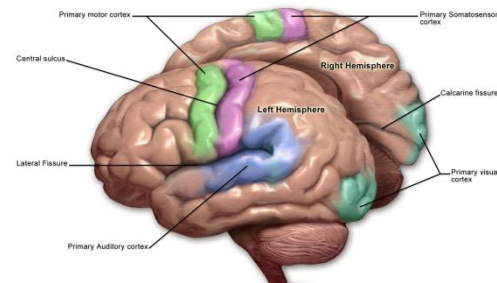
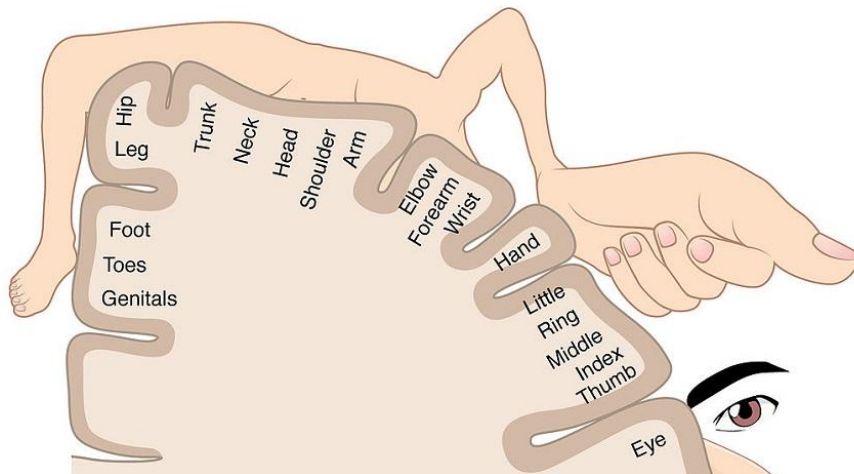




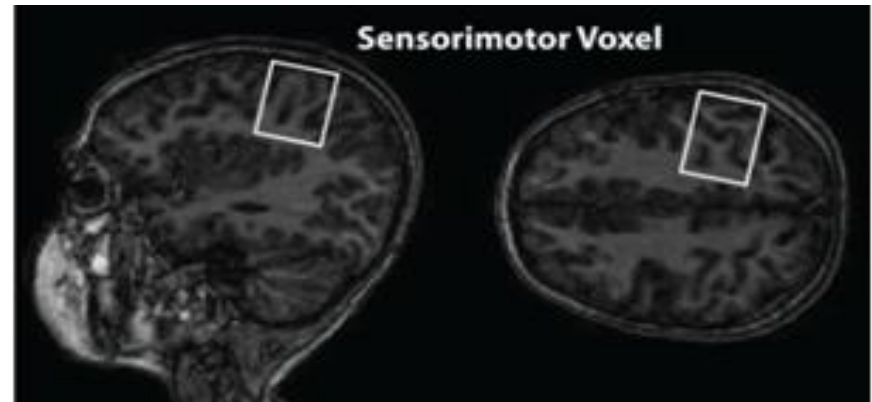
A portable means of evaluating functional connectivity?

Sensory protocols:

- based on perception of vibrations applied to finger tips
- designed to evaluate interactions between neighboring brain regions



Understanding the brain basis of sensory findings





Recruiting for Research:

- Right-handed teenaged athletes
 - With no history of concussion
 - Within 1 week of sports-related concussion
 - 443-923-7987





A black and white photograph showing several hands of different skin tones stacked on top of each other, symbolizing support and teamwork.

Neurorehabilitation Concussion Clinic at Kennedy Krieger Institute

- **Interdisciplinary Care**
 - Every child sees a brain injury physician and a neuropsychologist at every visit
 - Support as needed from Kennedy Krieger Institute's other brain injury programs (>30+ years experience)
- **Commitment to access within 1-2 weeks from parent call**
 - Adding more availability as needed over time
 - East Baltimore and Columbia sites



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