

**Concussion:  
The Hype, the Headlines, and the Hyperbole  
VS.  
The Evidence**

A Team Eye Doctor's Perspective

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Jennifer B. Christy, PT PhD

Graham D. Cochrane, MD, PhD

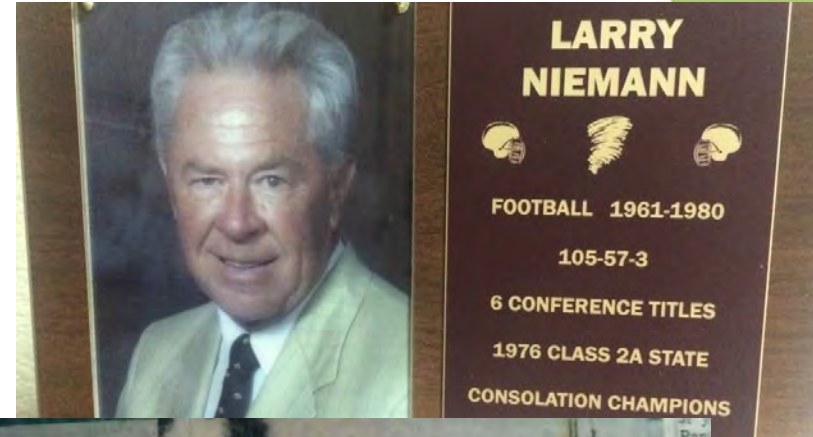
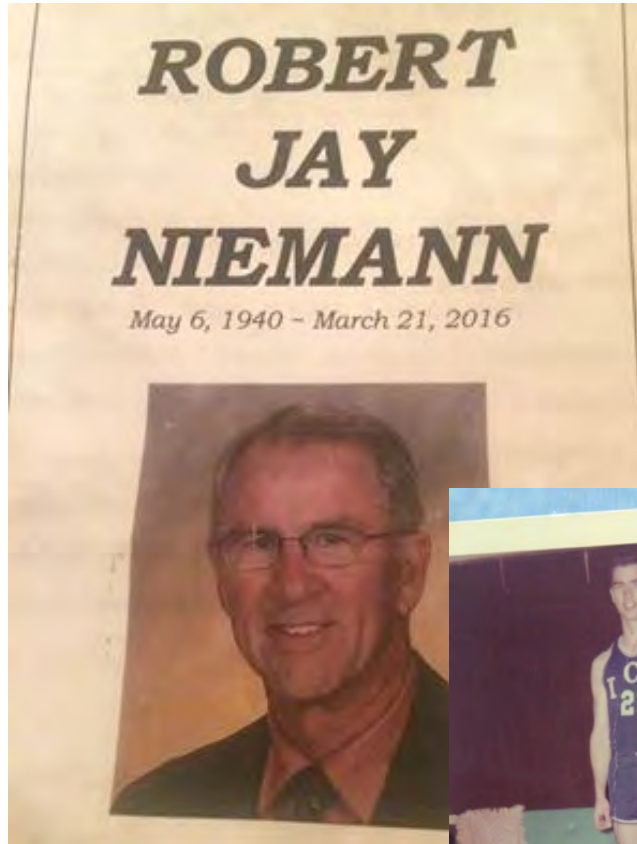
## Financial Disclosures: K. Weise

- None
- Roles – no additional support
  - UAB Team Physician – Eye Care
    - <https://uabsports.com/staff-directory>
    - Wait and hurry up
  - World Games Lead Eye Doctor
  - USFL Lead Eye Doctor
  - Co-Director, BlazerVision
  - Chair, UAB Intercollegiate Athletics Advisory Committee Chair





# Robert J. Niemann, OD (ICO '63) Coach Larry W. Niemann



# Katherine K. Weise, OD, MBA, FAAO



# UAB: Who we Are/Who We Are not



# UAB: Who we Are/Who We Are not



# NIH Support - UAB Clinical Pediatric Optometry: 1997-present

- **UG1** – Drs. Katherine Weise (PI), Sarah Lee, M. Heath Hale
  - Convergence Insufficiency Treatment Trial – Concussion (**January 2016 to present**)
- **U10**– Drs. Kristine Hopkins (PI), Marcela Frazier, Sarah Lee, Wendy Marsh-Tootle, Katherine Weise
  - Convergence Insufficiency Treatment Trial – Attention and Reading Trial (CITT-ART) (**August 2014-present**)
- **U10** - Pediatric Eye Disease Investigator Group (PEDIG) – Drs. Marcela Frazier (PI), Sarah Lee, Katherine Weise (formerly Dr. Robert Rutstein, Dr. Wendy Marsh-Tootle)
  - >100 Pediatric OMD and OD
  - Executive Committee: Mayo, Duke, Johns Hopkins, SCCO, UABSO
  - EY011751 (**1997-present**)
- **U10** – Dr. Wendy Marsh-Tootle (PI), Drs. Katherine Weise, Marcela Frazier, Lei Liu
  - Correction of Myopia Evaluation Trial+ (COMET): 118/133 (89%) retention at year 14
  - Multi-center Ocular Observations in Non-myopic Subjects (MOONS)
  - EY11756, EY11754, EY11805, EY11752, EY11740, EY11755 (**1998-2013**)
- **RO1** – Dr. Wendy Marsh-Tootle (with T. Walls, MD)
  - Multi-modal physician intervention to detect amblyopia
  - R01 EY015893 (**2005 to 2011**)
- **U10** – Dr. Kristine Hopkins (PI), Drs. Marcela Frazier, Katherine Weise
  - Convergence Insufficiency Treatment Trial
  - EY014659-02 (**2005-2011**)
- **NIH Loan Repayment Program** (mentor-sponsored research X 0.50 FTE)
  - Dr. Wendy Marsh-Tootle, mentor
    - Dr. Marcela Frazier (2005-2009)
    - Dr. Katherine Weise (2003-2007)
    - Dr. Sarah Lee (2013-present)



# Concussion and Vision – Literature

## 2012-2013

- **Slowed, variable, and delayed dynamic vergence system**
- **Photophobia (light sensitivity)**
- **Reduced near-point of convergence**
  - [Szymanowicz D](#), [Ciuffreda KJ](#), [Thiagaraian P](#), [Ludlam DP](#), [Green W](#), [Kapoor N](#). **Vergence in mild traumatic brain injury: a pilot study.** [J Rehabil Res Dev](#). 2012;49(7):1083-100.
- **Consistent accommodative fatigue effects**
  - [Thiagaraian P](#), [Ciuffreda KJ](#). **Visual fatigue and accommodative dynamics in asymptomatic individuals.** [Optom Vis Sci](#). 2013 Jan;90(1):57-65.
- **Perceived limited depth perception**
  - [Ciuffreda KJ](#), [Yadav NK](#), [Han E](#), [Ludlam DP](#), [Peddle A](#), [Hulse P](#), [Walter S](#), [Han J](#). **Distance perception in mild traumatic brain injury (mTBI).** [Optometry](#). 2012 Apr 30;83(4):127-36.
- **Photosensitivity**
  - [Capó-Aponte JE](#), [Urosevich TG](#), [Temme LA](#), [Tarbett AK](#), [Sanghera NK](#). **Visual dysfunctions and symptoms during the subacute stage of blast-induced mild traumatic brain injury.** [Mil Med](#). 2012 Jul;177(7):804-13.

# Concussion Clinical Research Facility

## Dream Team – July 2013

### Children's of Alabama

**Marshall Crowther, MD** – orthopedics  
**Drew Davis, MD** - Pediatric Rehab Medicine  
**Leon S. Dure, MD** – Pediatrics Neurology,  
**Drew Ferguson, MEd, ATC** - UAB Sports Medicine  
Director  
**James M. Johnston, MD** - Pediatric Neurosurgery

### Eye and Vestibular

**Claudio Busetini, PhD, Dr. Eng.** – Vestibulo- ocular  
reflex science  
**Jennifer Christy, PT, PhD** - Vestibular science

**Chris Girkin, MD** – Dept Chair, Ophthalmology  
**Mark Swanson, OD, MS** – Director, UAB Eye Care  
Ocular Disease Service  
**Katherine K. Weise, OD, MBA** – Director, UAB Eye Care  
Pediatric and Binocular Vision Service

### Neuroscience

**Lori L. McMahon, PhD** – Comprehensive Neuroscience  
Center

### Athletics

**Joseph Ackerson, PhD** - Neuropsych, Chair for Alabama  
Statewide Sports Concussion Taskforce  
**Frank Messina, PhD** - Asst Athletic Director, UAB

### UAB Engineering and Biomedicine

**Larry DeLucas, OD, PhD** – Center for Biophysical  
Sciences and Engineering/NASA  
**Crawford Downs, PhD** - Center for Ocular  
Biomechanics and Biotransport (COBB)  
**Cali Fidopiastis, PhD** - Virtual Cognitive Rehabilitation  
**Dean Sicking, PhD** – Helmet design/field analysis

### Other Key Collaborators

**Craig Formby, MA, PhD** – UA(T) Communicative  
Disorders  
**Dennis Leonard** – Legos of UAB  
**Marsha Snow, OD** – VAMC

**Candace Floyd, PhD** –National Neurotrauma Society

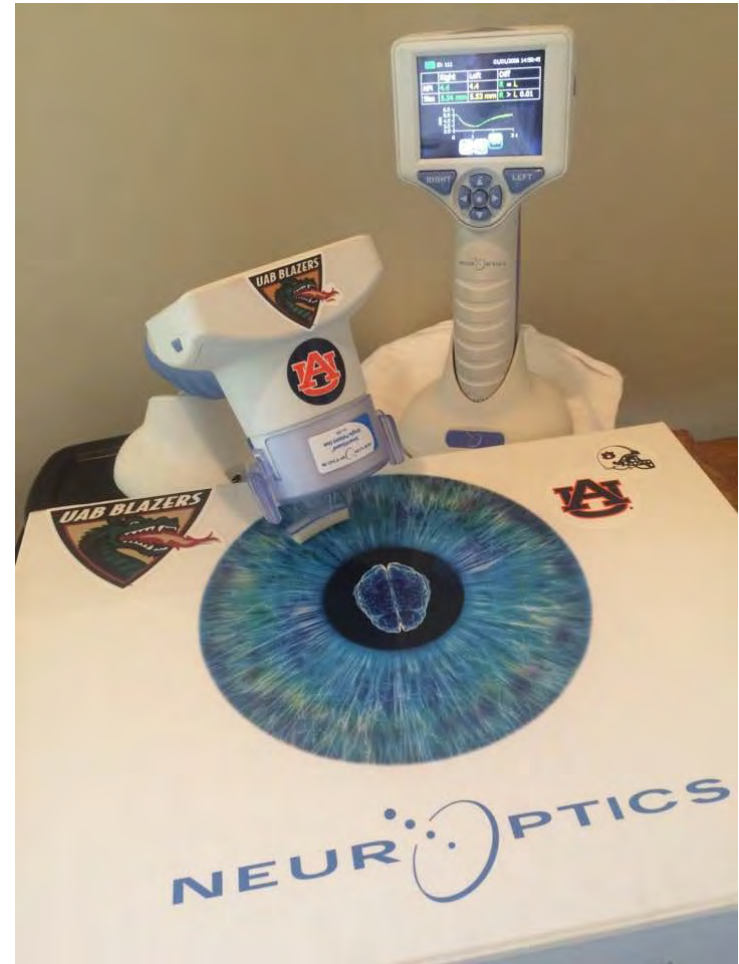
# UAB/COA VORClinic 2014



## UAB/COA VORClinic 2015



## UAB/COA VORClinic 2016



## 2017: Sidelines



# Shaping Research and Clinical Practice: How do we choose which tests are best?

- M. Heath Hale, MD, MPH – UAB
- Michael Goodlett, MD – AU
- Jimmy Robinson, MD – UA



M. Heath Hale, MD, MPH:

“I think we can beat concussion and I think it’s going to be through the eye.”



# 2019-2022

- **Weise KK**, Swanson MW, Galt SJ, Springer DB, Crosson JN, DeCarlo DK, Hale MH, Nicholson JR, Robinson JB. *Objective Vision-Related Indications for Clear and Tinted Football Helmet Visors*. Optom Vis Sci.
- **Weise KK**, Galt SJ, Swanson MW, Hale MH, Springer DB. *Preparticipation Vision Screening and Comprehensive Eye Care in NCAA Athletes*. Optom Vis Sci.
- Wallace J, Worts P, Moran R, Mason J, **Weise KK**, Swanson, M, Murray N. *Socioeconomic status and race as social determinants of health to be considered in clinical use of pre -season vestibular and oculomotor tests for concussion*. J Clin Transl Res 2020; 6(5):2. Published online October 7, 2020.
- Cochrane GD, Christy JB, Almutairi A, Busettini C, **Weise KK**, Swanson MW, Gould SJ. Vestibular, Oculomotor, and Balance Function in Children with and without Concussion. J Head Trauma Rehabil. Accepted Oct 2020.
- Cochrane GD, Gould SJ, Sheehan N, Busettini C, Christy JB, **Weise KK**, Swanson MW. Saccadic intrusions in paediatric concussion. Clin Exp Optom. 2020 Nov;103(6):929-930.
- Christy JB, Cochrane GD, Almutairi A, Busettini C, Swanson MW, **Weise KK**. Peripheral Vestibular and Balance Function in Athletes With and Without Concussion. J Neurol Phys Ther. 2019;43(3):153-159.
- Cochrane GD, Christy JB, Almutairi A, Busettini C, Swanson MW, **Weise KK**. Visuo-oculomotor Function and Reaction Times in Athletes with and without Concussion. Optom Vis Sci. 2019;96(4):256-265.
- Swanson MW, **Weise KK**, Dreer LE, Johnston J, Davis RD, Ferguson D, Hale MH, Gould SJ, Christy JB, Busettini C, Lee SD, Swanson E. Academic Difficulty and Vision Symptoms in Children with Concussion. Optom Vis Sci. 2017 Jan;94(1):60-67.
- **Weise KK**, Swanson MW, Penix K, Hale MH, Ferguson D. King-Devick and Pre-season Visual Function in Adolescent Athletes. Optom Vis Sci. 2017 Jan;94(1):89-95.
- Liu L, Marsh-Tootle W, Harb EN, Hou W, Zhang Q, Anderson HA, Norton TT, **Weise KK**, Gwiazda JE, Hyman L; COMET Group. A sloped piecemeal Gaussian model for characterising foveal pit shape. Ophthalmic Physiol Opt. 2016 Nov;36(6):615-631.
- Swanson MW, **Weise KK**, Penix K, Hale MH, Ferguson D. *Repeatability of Objective Pupillometry in Middle and High School Athlete Screening*. Invest Ophthalmol Vis Sci 2016; 57; E-abstract 4566.
- **Weise KK**, Penix K, Swanson MW, Ferguson D, Hale MH. *King-Devick Testing and Convergence, Alignment, and Pupil Response in Junior High and High School Athletes during Pre-Season Health and Vision Physicals*. Invest Ophthalmol Vis Sci 2016; 57; E-abstract 1520.
- Swanson M, Johnston J, Ferguson D, Davis D, Christy J, **Weise K**, Busettini C, Dreer L. *The Children's Hospital of Alabama Concussion Database*. Optom Vis Sci 2015; E-abstract 155094.

## 2018 – Research: Value of CEE in Division I Athletics, UAB Football



# Concussion:

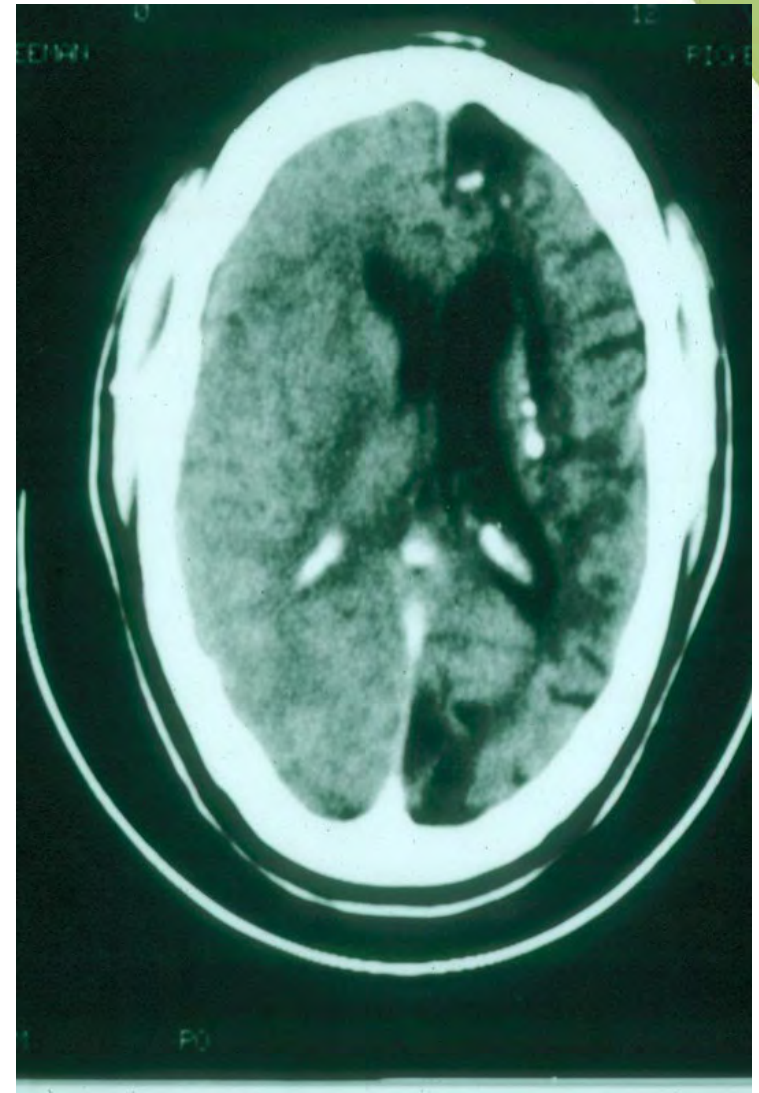
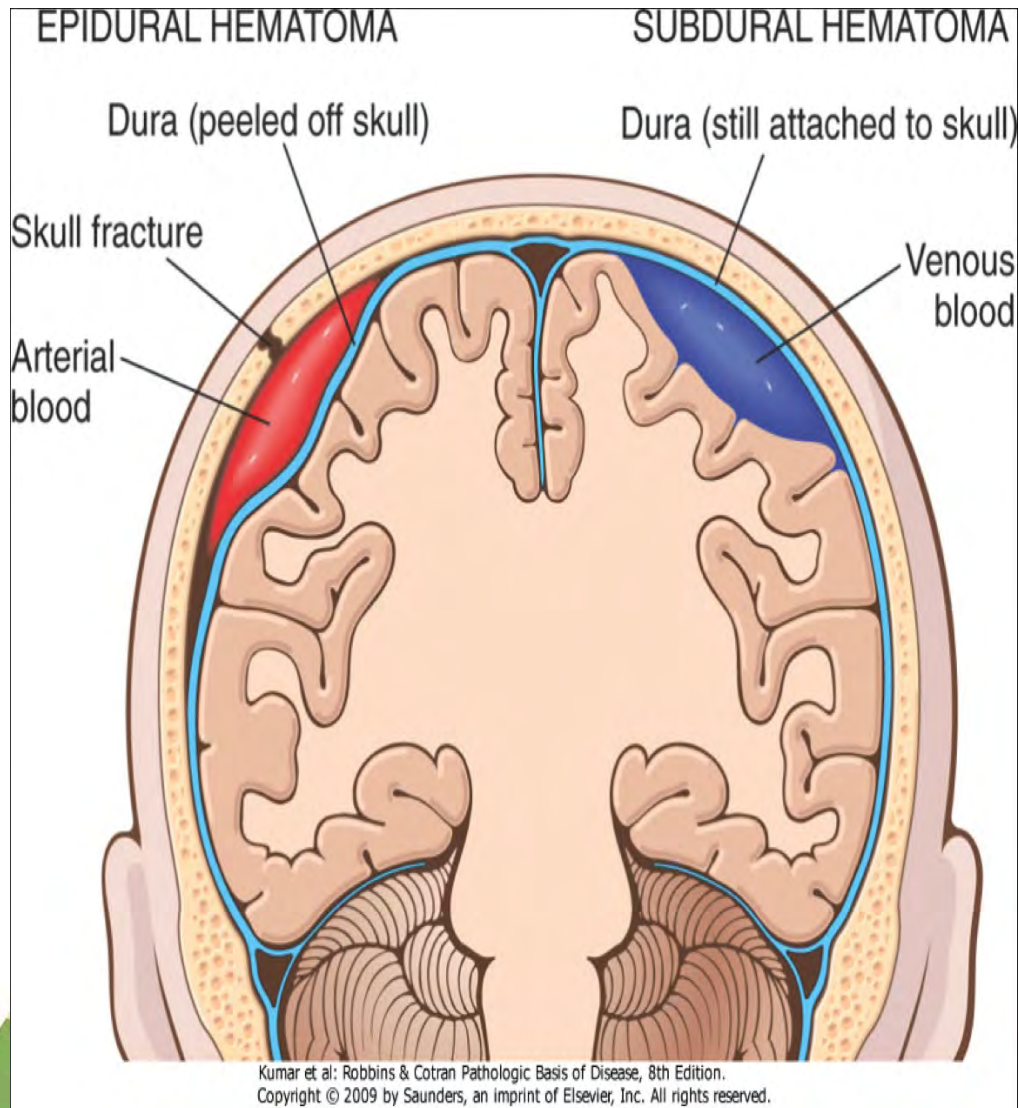
## The Hype, the Headlines, and the Hyperbole vs. The Evidence

### A Team Eye Doctor's Perspective

- I. Concussion
- II. Shaping the Research
  - A. Why the Eye
  - B. Objective Testing
  - C. Predictors of Prolonged recovery
  - D. Multi-system approach
- III. Shaping the Future



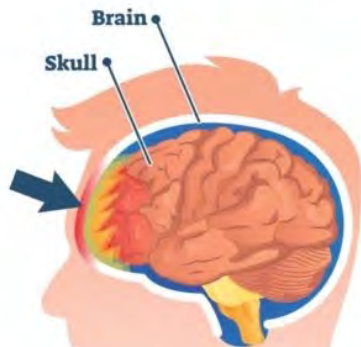
# What we're not talking about today: Brain Bleeds (Catastrophic)



# CONCUSSION

A concussion is a traumatic **brain injury** that affects your brain function

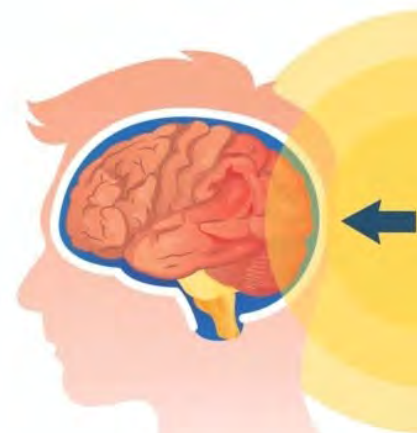
**Direct impact  
brain injury**



**Acceleration-deceleration  
brain injury**



**Blast  
brain injury**



## CONCUSSION SYMPTOMS

- Headache or a feeling of pressure in the head
- Temporary loss of consciousness
- Confusion or feeling as if in a fog
- Amnesia surrounding the traumatic event
- Dizziness or "seeing stars"
- Ringing in the ears
- Nausea
- Vomiting
- Slurred speech
- Delayed response to questions
- Appearing dazed
- Fatigue

Mom: My kid had a concussion and the ER didn't even do an MRI.

- Right or wrong?



# Concussion findings - CT and MRI

- Standard CT and MRI most often do not show anything
  - more advanced imaging techniques, like MRI-spect or fMRI, indicate **microstructural and functional neurobiological changes**
- Just because CT and MRI do not show anything, does not mean there is no damage.
  - Chronic traumatic encephalopathy
  - White matter in youth sports

What about the new magic bullet?

***“Concussions Can Be Detected With New Blood Test Approved by F.D.A” (Feb. 14, 2018)***

<https://www.nytimes.com/2018/02/14/health/concussion-fda-bloodtest.html>

- “FDA...approved a long-awaited blood test to detect concussions in people and more quickly identify those with possible brain injuries.”
- “...expected to reduce the number of people exposed to radiation through CT scans that detect brain tissue damage or intracranial lesions.”
- “It could **eliminate the need for CT scans** in at least a third of those with suspected brain injuries.”

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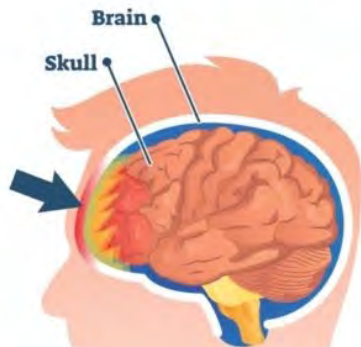
<https://www.nytimes.com/2018/02/14/health/concussion-fda-bloodtest.html>

- M. Heath Hale, MD, MPH (UAB Team MD)
  - It does NOT dx or rule in concussion.
  - **May help detect brain bleeds.**
  - May be a step in the right direction though
- Although the headline says concussion, it is designed to detect brain bleeds that show up on CT, which may be rare in concussion.

# CONCUSSION

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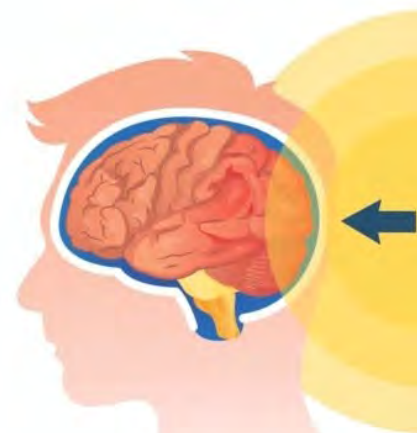
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# Concussion Definition and Terms:

## Typical short-term recovery

- Most symptoms of sports-related concussion are transient
  - Browne GJ, Br J Sports Med, 2006
- 1 week recovery in 90% of high school athletes
  - Symptoms recover to baseline within 1 week after sports-related concussion in 90%
    - Guskiewicz KM, J Athl Train, 2001
    - Iverson GL, Brain Inj, 2006
    - McCrory P, 2009

Guskiewicz KM, JAMA, 2003

McCrea M, JAMA 2003

# Post-Concussion Syndrome

- Mayo: Complex disorder in which various symptoms — such as headaches and dizziness — last for weeks and sometimes months after the injury that caused the concussion.
- “In most people, post-concussion syndrome symptoms occur within the first seven to 10 days and go away within three months, though they can persist for a year or more.”

# Key Issues for Young Athletes

- **1. When is it Appropriate to Return to Routine School Activities?**
- **2. When is it Safe to Return to Play??**

# Prolonged Recovery Characteristics

Corwin DJ, Zonfrillo MR, Master CL

J Pediatr 2014;165:1207-15

- N = 247 patients age 5 to 18 years with concussion
- Median
  - Return to Part-Time School: 12 days
  - Return to School without accommodations: 35 days
  - Symptom Free: 64 days
  - Return to Play (cleared for sports): 75 days



# Concussion Literature and Prolonged Recovery

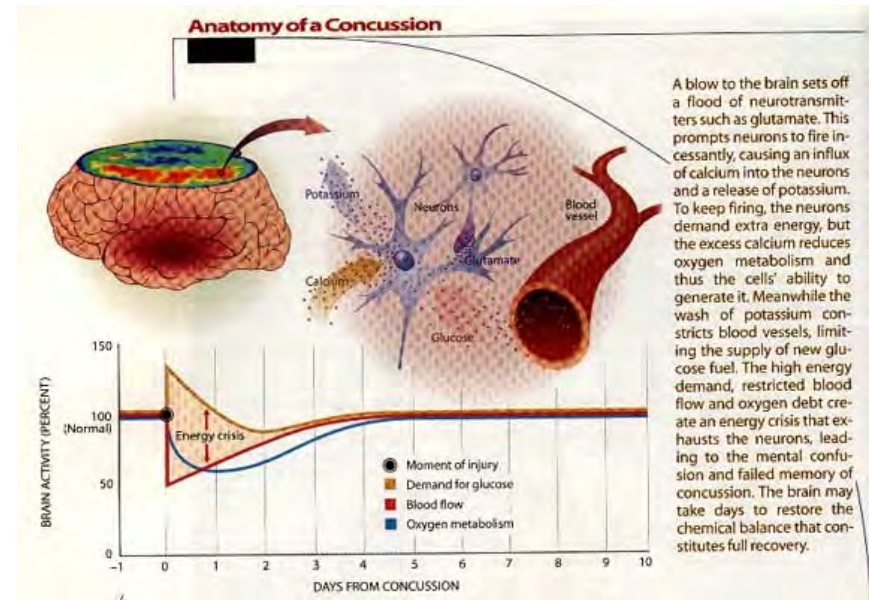
Shim et al. 2015. Critically Appraised Topic. Journal of Sport Rehabilitation

- Predictors of Prolonged Recovery
  - Moderate evidence: On-field post suspected concussive event (high school/college):
    - Dizziness
    - Disorientation
    - Amnesia

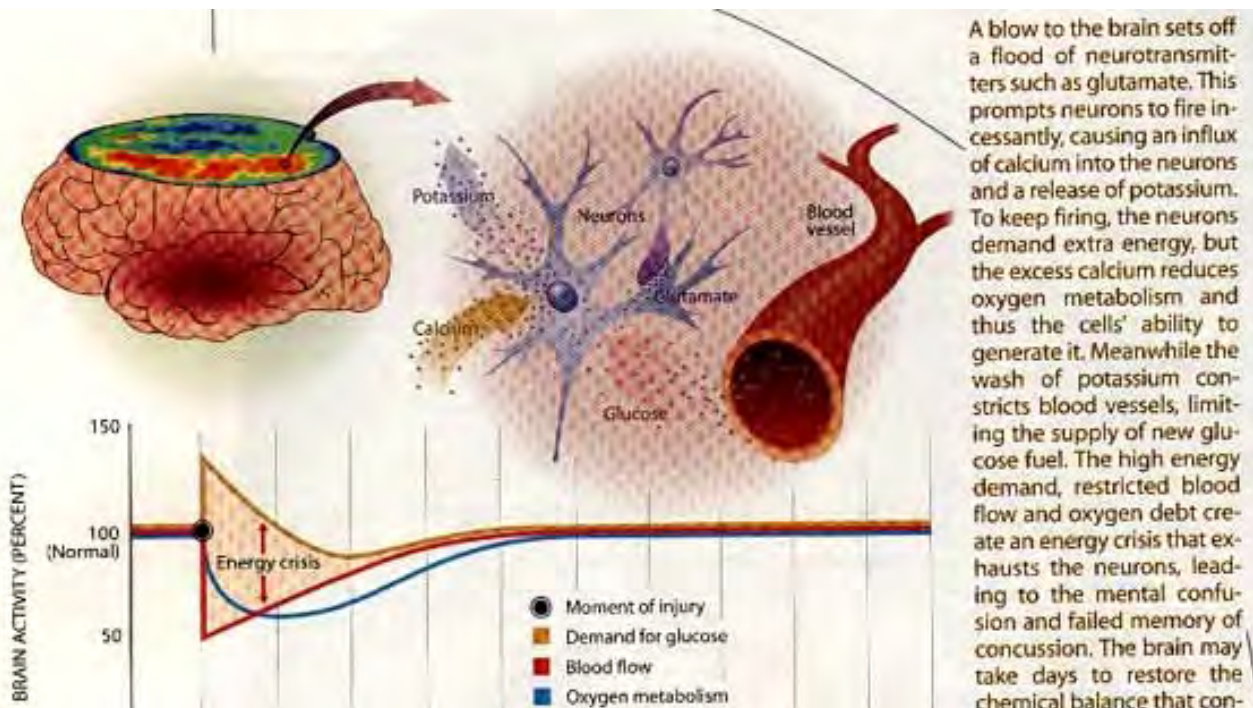


# Concussion's Metabolic Cascade

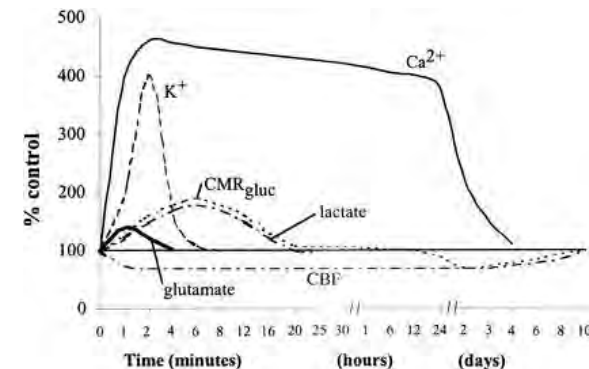
- At moment of high need, energy production and fuel for energy are both simultaneously decreased.
- **Two phases**
  - **Phase 1: Primary Insult**
  - **Phase 2: Secondary inflammatory response**



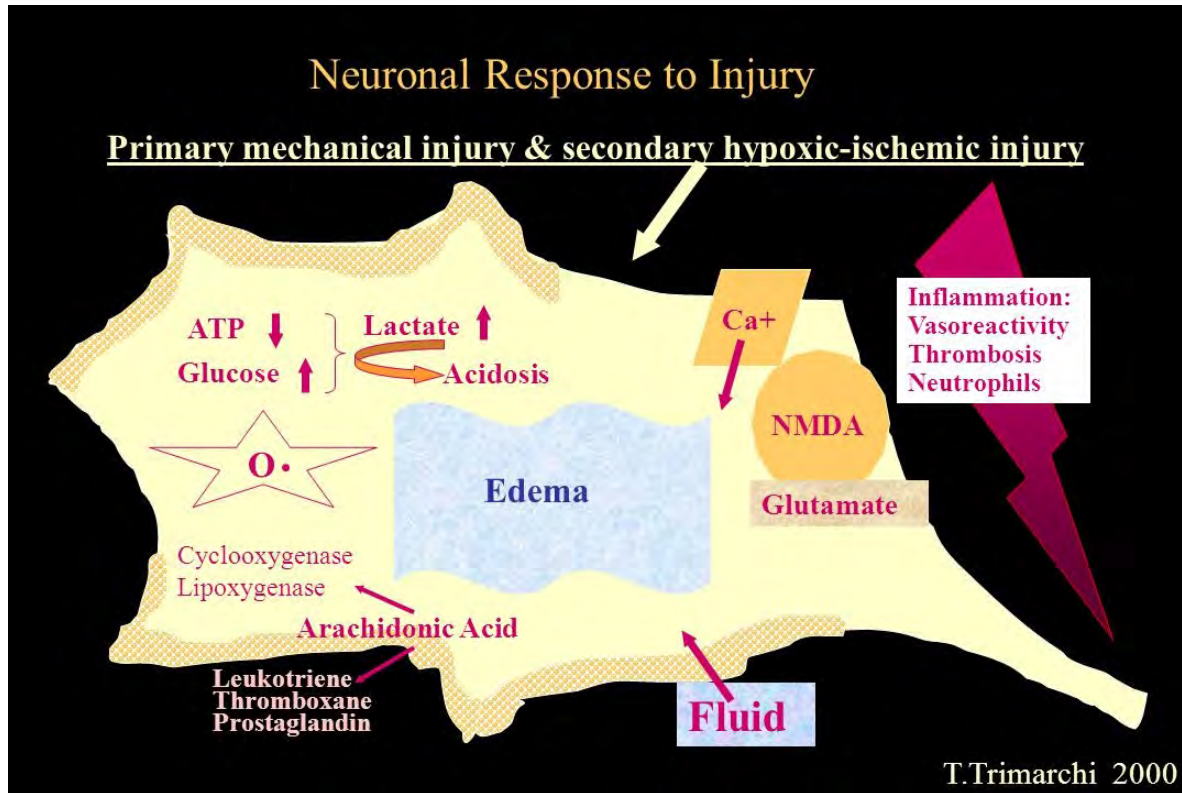
# Phase I - Primary Insult



## Concussion = Interstate Crash Phase 1 – The Crash



## Phase 2 – Secondary Inflammatory Response



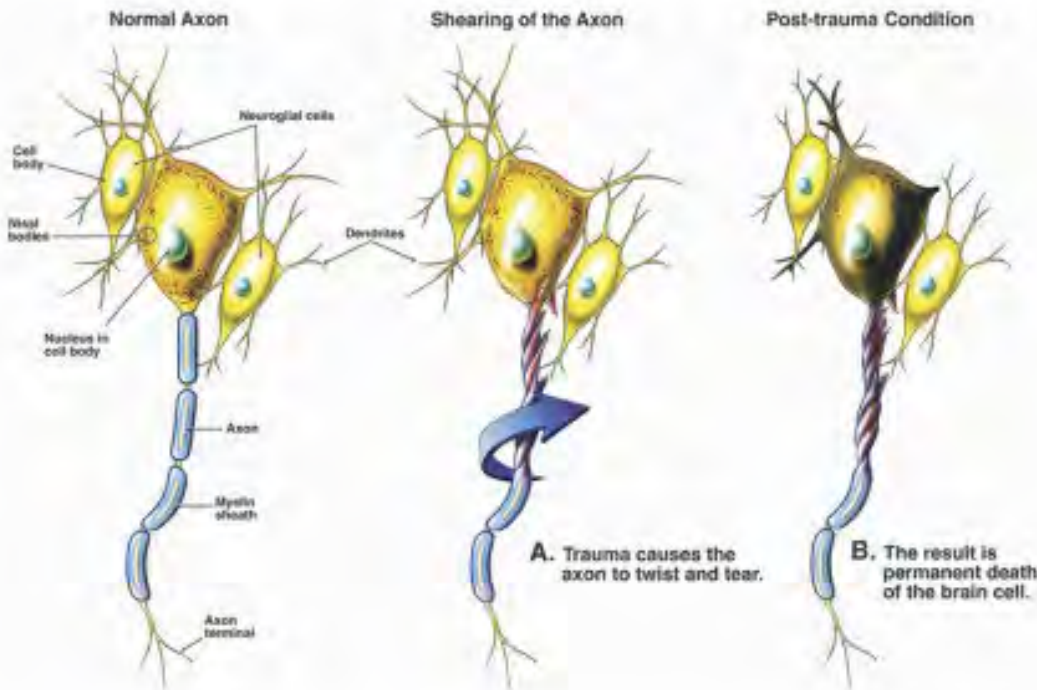
**Concussion =  
Interstate Crash  
Phase 2 – The Traffic  
(note that the roads  
are not damaged yet)**

**Symptoms worsen in  
first 6 to 24 hours**

# Impact Exposure: Will the injured brain catch up with itself?



# Post-Concussion (DAI: Diffuse Axonal Injury)



If the brain can't catch up from the crash: permanent damage.

**Worse,  
2<sup>nd</sup> Injury in 24 hours:  
Sodium channelopathy →  
significant axonal injury  
(2<sup>nd</sup> Concussion Syndrome,  
kids more susceptible)**

AllPosters

# Ann McKee, Boston University – Chronic Traumatic Encephalopathy

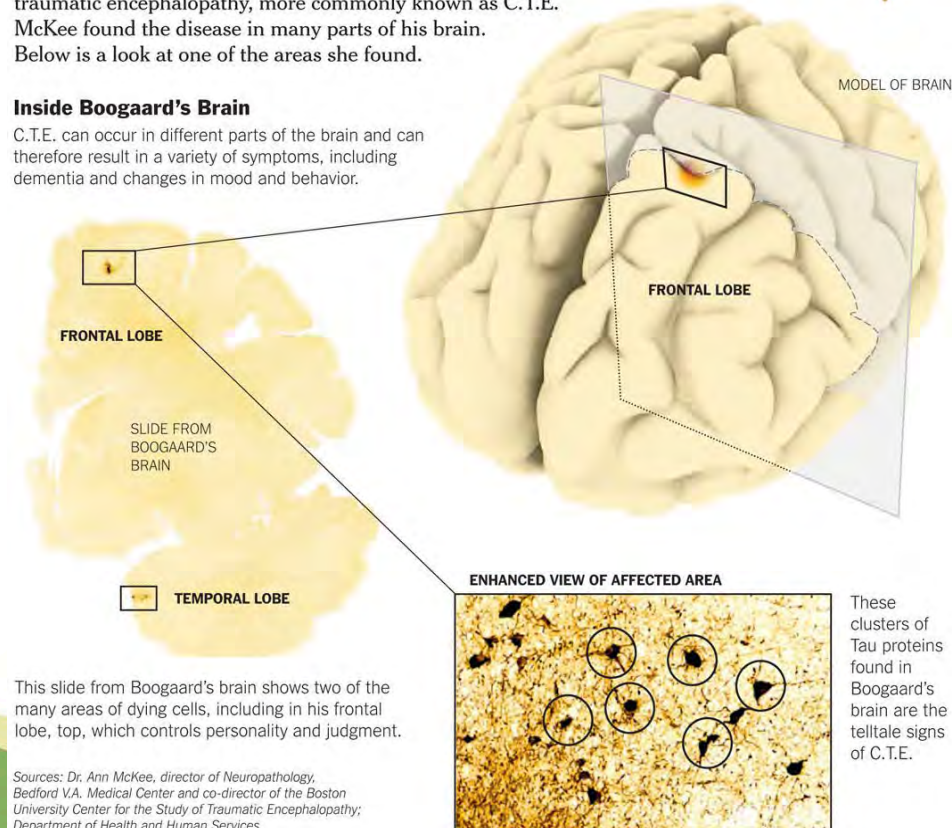


## The Signs and Science of C.T.E.

Dr. Ann McKee, a neuropathologist, received Derek Boogaard's brain within days of his death and began testing it for chronic traumatic encephalopathy, more commonly known as C.T.E. McKee found the disease in many parts of his brain. Below is a look at one of the areas she found.

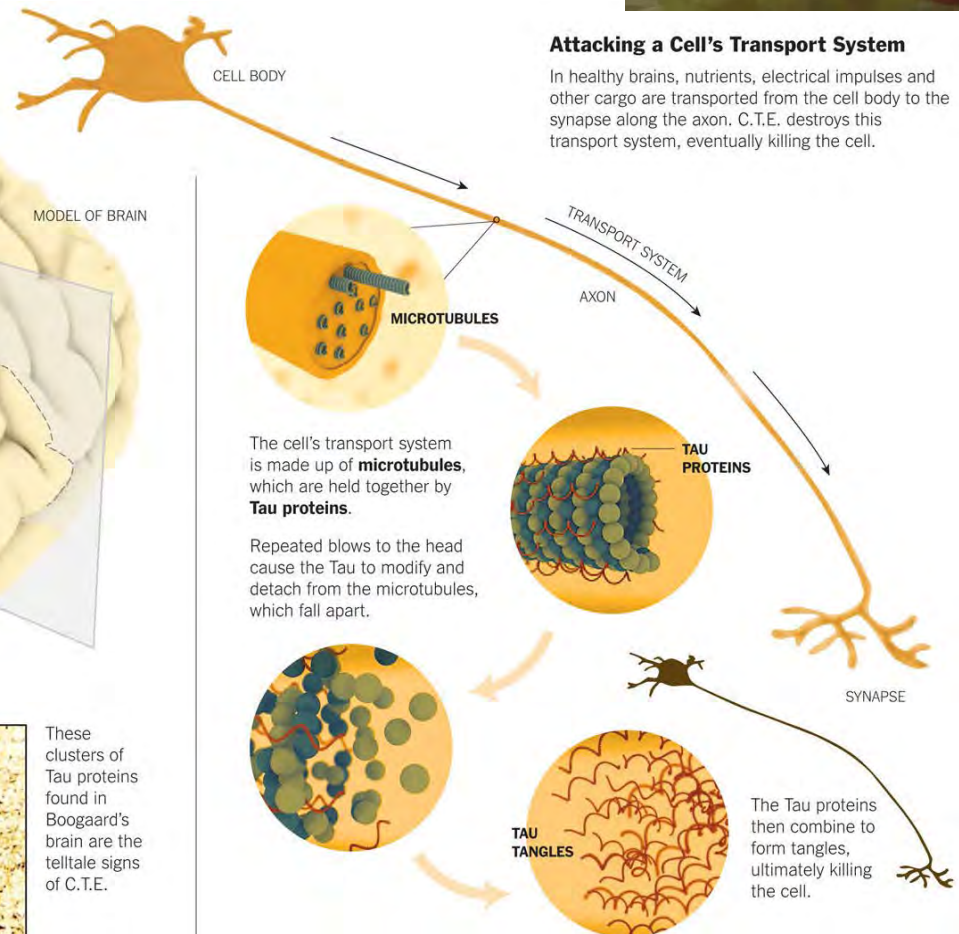
### Inside Boogaard's Brain

C.T.E. can occur in different parts of the brain and can therefore result in a variety of symptoms, including dementia and changes in mood and behavior.



This slide from Boogaard's brain shows two of the many areas of dying cells, including in his frontal lobe, top, which controls personality and judgment.

Sources: Dr. Ann McKee, director of Neuropathology, Bedford V.A. Medical Center and co-director of the Boston University Center for the Study of Traumatic Encephalopathy; Department of Health and Human Services



# NFL vs. Youth Football

- < 2,000 NFL players
- 2,000 Kids playing youth football for every 1 NFL player
- 3.5 Million kids playing youth football each year



## Why are Kids at higher risk? (R. Cantu, MD; BU)

- Decreased myelin
- Nerve fibers in the brain are more easily torn apart
- Dysautoregulation associated with 2<sup>nd</sup> impact
- 10-12 years old: wiring and pruning of brain circuits
- Weak necks
- Weak torsos that don't keep head from hitting ground
- Poor head: body ratio (bobble heads)
- Poor equipment
- Poor access to medical care on sideline  
dis-qualifying from game
- Poor language skills



# Why are Kids at higher risk?

- Size differences at young age:



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• <http://www.brainline.org/content/multimedia.php?id=9017>

# Age at First Exposure to Football Is Associated with Altered Corpus Callosum White Matter Microstructure in Former Professional Football Players.

- J Neurotrauma. 2015 Nov 15;32(22):1768-76.
- Stamm JM<sup>1,2,3</sup>, Koerte IK<sup>3,4</sup>, Muehlmann M<sup>3,4</sup>, Pasternak O<sup>3,5</sup>, Bourlas AP<sup>1,6</sup>, Baugh CM<sup>1,7</sup>, Giwerz MY<sup>3</sup>, Zhu A<sup>3</sup>, Coleman MJ<sup>3</sup>, Bouix S<sup>3</sup>, Fritts NG<sup>1</sup>, Martin BM<sup>8</sup>, Chaisson C<sup>1,6,8,9</sup>, McClellan MD<sup>10</sup>, Lin AP<sup>3,11</sup>, Cantu RC<sup>1,12,13,14</sup>, Tripodis Y<sup>1,6,9</sup>, Stern RA<sup>1,2,6,12,15</sup>, Shenton ME<sup>3,5,16</sup>.

- <sup>1</sup>CTE Center, Boston University School of Medicine , Boston, Massachusetts.

- **Abstract**

- Youth football players may incur hundreds of repetitive head impacts (RHI) in one season. Our recent research suggests that exposure to RHI during a critical neurodevelopmental period prior to age 12 may lead to greater later-life mood, behavioral, and cognitive impairments. Here, we examine the relationship between age of first exposure (AFE) to RHI through tackle football and later-life corpus callosum (CC) microstructure using magnetic resonance diffusion tensor imaging (DTI). **Forty retired National Football League (NFL) players, ages 40-65**, were matched by age and divided into two groups based on their **AFE to tackle football: before age 12 or at age 12 or older**. Participants underwent DTI on a 3 Tesla Siemens (TIM-Verio) magnet. The whole CC and five subregions were defined and seeded using deterministic tractography. Dependent measures were fractional anisotropy (FA), trace, axial diffusivity, and radial diffusivity.
- **Results showed that former NFL players in the AFE <12 group had significantly lower FA in anterior three CC regions and higher radial diffusivity in the most anterior CC region than those in the AFE ≥12 group.**
- This is the first study to find a relationship between AFE to RHI and later-life CC microstructure. These results suggest that incurring RHI during critical periods of CC development may disrupt neurodevelopmental processes, including myelination, resulting in altered CC microstructure.

# Subconcussive Head Impact Exposure and White Matter Tract Changes over a Single Season of Youth Football

- Radiology
- 2016 Oct 24  
Bahrami N, Sharma D, Rosenthal S, Davenport EM, Urban JE, Wagner B, Jung Y, Vaughan CG, Gioia GA, Stitzel JD, Whitlow CT, Maldjian JA
- Purpose: To examine the effects of subconcussive impacts resulting from a single season of youth (age range, 8-13 years) football on changes in specific white matter (WM) tracts as detected with diffusion-tensor imaging in the absence of clinically diagnosed concussions.
- Head impact data were recorded by using the Head Impact Telemetry system and quantified as the combined-probability risk-weighted cumulative exposure (RWECP).
- N = 25
- Conclusion: This study found a statistically significant relationship between head impact exposure and change of FA fractional anisotropy value of whole, core, and terminals of left IFOF and right SLF's terminals where WM and gray matter intersect, **in the absence of a clinically diagnosed concussion.**

# Concussion Vs. Sub-concussive?

## ~~Concussion~~ “Impact Exposure”

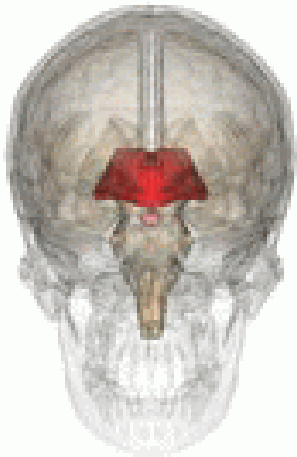


# Why The Eye in Concussion?

## It's built from the brain.

Week 3 – 10 of pregnancy

### Diencephalon (forebrain)



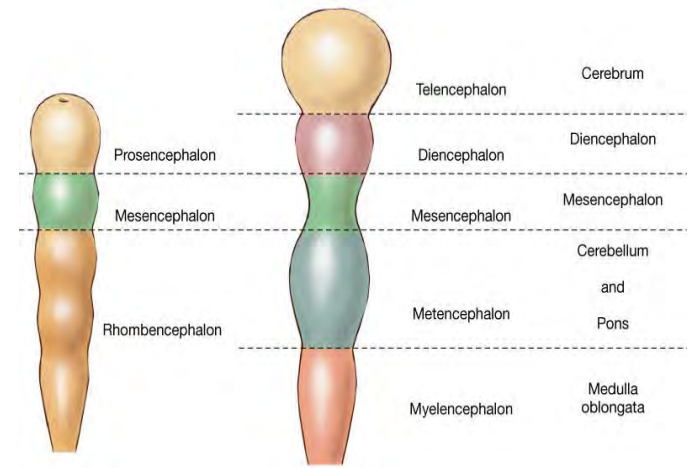
Forebrain

\* \* \* \* \*

Midbrain

\* \* \* \* \*

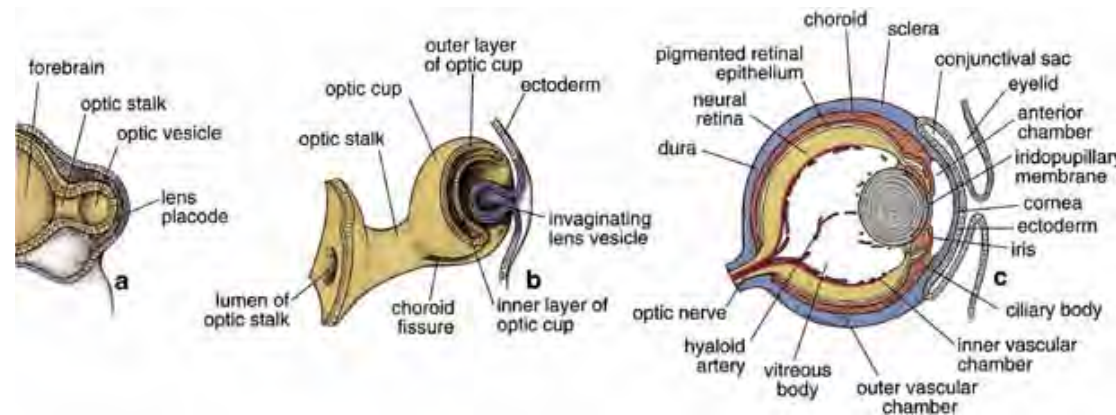
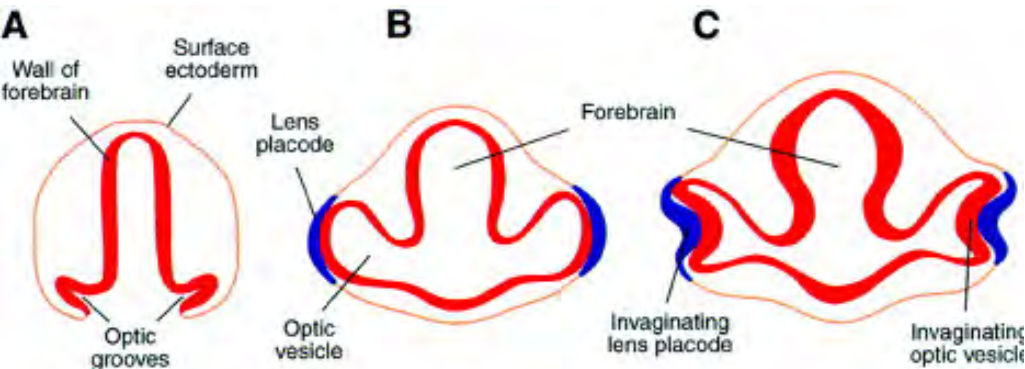
Hindbrain



# Why The Eye in Concussion?

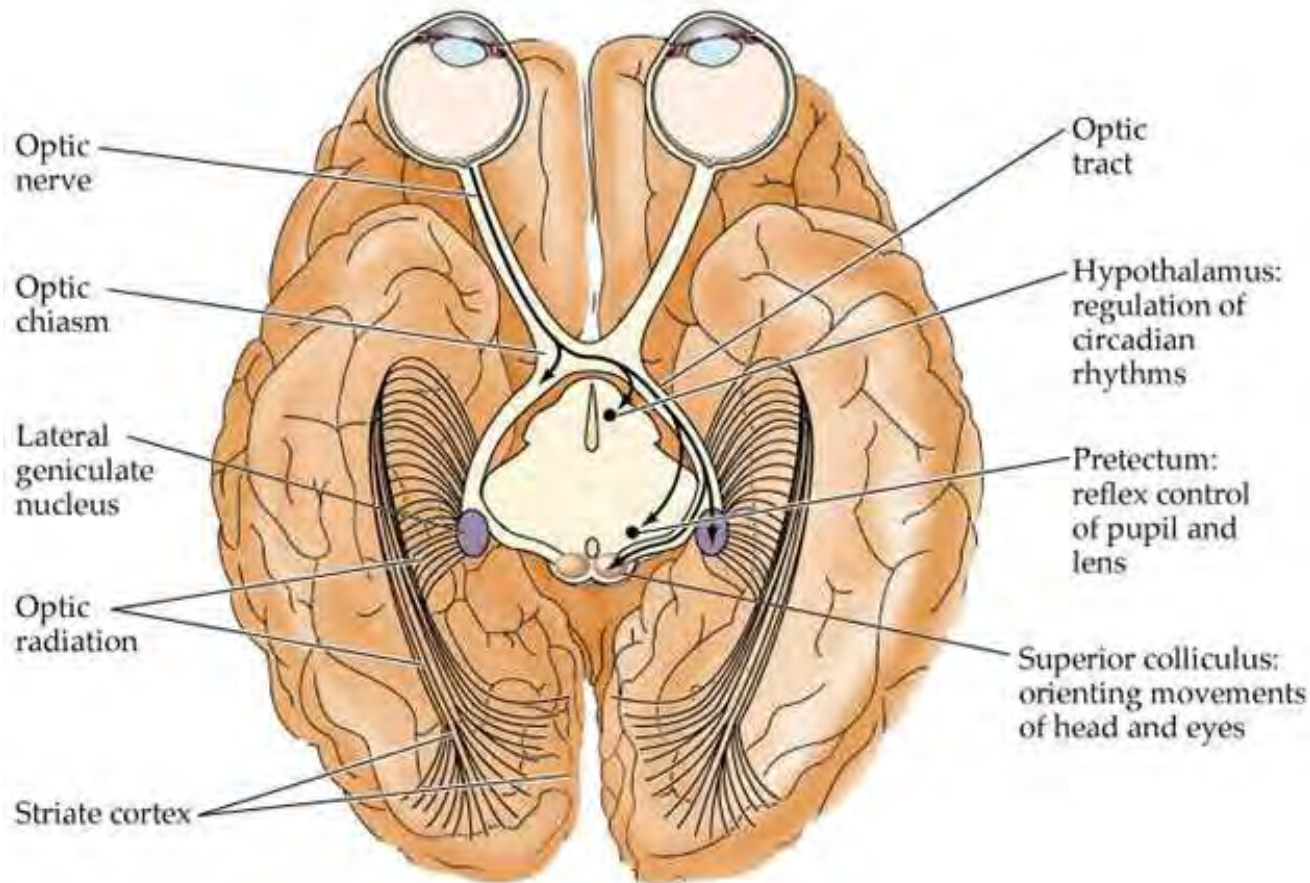
## It's built From the brain.

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# Why the Eye in Concussion?

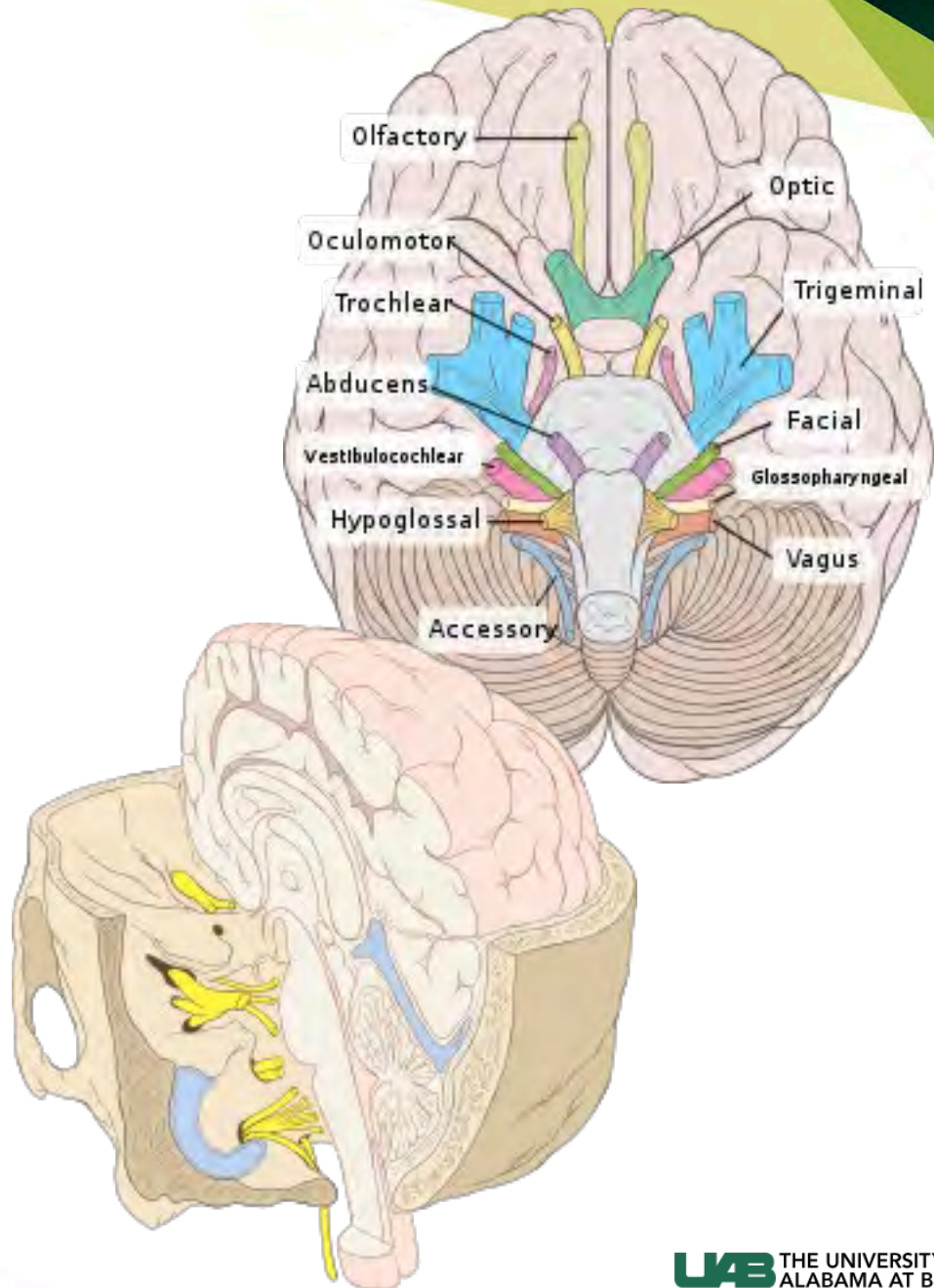
## It courses Through the brain.



# Why the Eye?

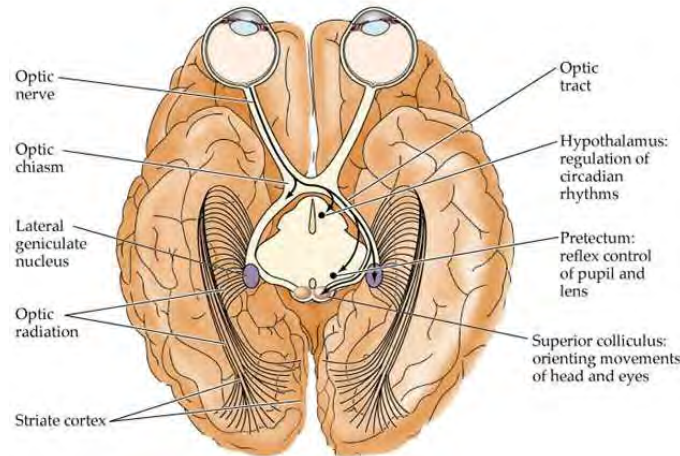
## • Cranial Nerves

- I - Olfactory
- II - Optic
- III - Oculomotor
- IV - Trochlear
- V - Trigeminal
- VI - Abducens
- VII - Facial
- VIII - Vestibulocochlear
- IX - Glossopharyngeal
- X - Vagus
- XI - Accessory
- XII - Hypoglossal



# Why The Eye in Concussion?

- The Eye
  - is built **from** the brain,
  - is built **like** the brain,
  - courses **through** the brain.



# Concussion and Vision

- Objective visual electrodiagnostic testing affected in concussion reported as early as **1976**.
  - Feinsod M, 1976
  - Freed S, 1997
- Studies of standard **clinical optometry testing** between 1999-2021 repeatedly show **vision issues related to concussion**.

# Concussion and Vision in Children

## Prevalence Studies: Signs

Study	N	Ave. age	Study Design	Conv Insuff	Accomm Insuff	Eye Tracking	Visual Field	Specialty if not Eye Care
Scheiman M Grady M Jenewin E 2021	113	15.2	pro	35%	35%			Sports medicine
Master C Scheiman M 2016	100	14.5	pro	49%	51%	29%		
Pearce KL 2015	78	14	pro	42%				Ortho
Stelmack 2009	103		retro	28%	47%	6%	14%	
Brahm 2009	191		retro	42%	42%	33%	32%	
Goodrich 2007	50		retro	30%	22%	20%	21%	Psychology
Suchoff 1999	62	19-70		42%	10%	40%	32%	
Normal population				BV = 5%	3%	2%		

# Vision rarely mentioned in Concussion Position Statements

- Consensus statement on **concussion** in sport: the 4th International Conference on **Concussion** in Sport, Zurich, November 2012.
  - **McCrory P**, Meeuwisse WH, Aubry M, Cantu RC, Dvořák J, Echemendia RJ, Engebretsen L, Johnston K, Kutcher JS, Raftery M, Sills A, Benson BW, Davis GA, Ellenbogen R, Guskiewicz KM, Herring SA, Iverson GL, Jordan BD, Kissick J, McCrea M, McIntosh AS, Maddocks D, Makdissi M, Purcell L, Putukian M, Schneider K, Tator CH, Turner M.
  - J Athl Train. 2013 Jul-Aug;48(4):554-75.
  - *Future study necessary: KD and reaction time*
- Sport-related concussion: Evaluation and management
  - Laura K Purcell, Canadian Paediatric Society, Healthy Active Living and Sports Medicine Committee
  - Paediatr Child Health. 2014 Mar; 19(3): 153–158.
  - **Candian Pediatric Society Paediatr Child Health**
- **American Academy of Pediatrics**. Clinical report--sport-related **concussion** in children and adolescents.
  - Halstead ME, Walter KD; Council on Sports Medicine and Fitness.
  - **Pediatrics**. 2010 Sep;126(3):597-615
- **American Medical Society for Sports Medicine** position statement: **concussion** in sport.
  - Harmon KG, Drezner J, Gammons M, Guskiewicz K, Halstead M, Herring S, Kutcher J, Pana A, Putukian M, Roberts W; **American Medical Society for Sports Medicine**.
  - Clin J Sport Med. 2013 Jan;23(1):1-18.

# 2014 National Athletic Trainers' Position statement

- Consider: smooth pursuits, nystagmus, pupil reflex; (CN testing)
- No convergence, accommodation, eye tracking recommended
- Broglio SP, Cantu RC, Giolia GA, Guskiewicz KM, Kutcher J, Palm M, Valovich McLeod TC, National Athletic Trainer's Association. **National Athletic Trainer's Association position statement: management of sport concussion.** J Athl Train 2014;49:245-65.
- 2015: Current and emerging rehabilitation for **concussion**: a review of the evidence.
  - Broglio SP, Collins MW, Williams RM, Mucha A, Kontos AP.
  - Clin Sports Med. 2015 Apr;34(2):213-31. doi: 10.1016/j.csm.2014.12.005.



- Vision Therapy
- Ciuffreda, Scheiman
- CI/AI/saccades, etc.

# Berlin 2016 – the new Zurich

- 1) Neuropsychological (NP) testing
  - Cornerstone of sports-related concussion management
  - NP are uniquely qualified to contribute to a multi-disciplinary approach
  - Cognitive recovery often overlaps with clinical symptom recovery, but may also precede or lag behind
  - NP testing should remain an important component of sports-related concussion recovery and in particular return-to-learn decisions.
- HOWEVER,
  - NP testing should NOT be the sole basis of management decisions
  - It should be used in a range of clinical assessments of different clinical domains
    - Mental status, cognition, **oculomotor function (!)**, gross sensorimotor, coordination, gait, vestibular function, and balance.

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Normal population				BV = 5%	3%	2%		

## SYMPTOMS OF MILD TBI –

### Children's of Alabama Concussion Database

M. Swanson, et al.  
2015

Symptom	n	%
AcademicDifficulty	141	13.7
AmnesticEvent	272	26.4
Balance ← 3	111	10.7
ConcentrationDifficulty	223	21.6
Confusion	318	30.8
Dizziness	576	55.9
Fatigue	329	31.9
Headache ← 1	962	93.2
HearingProblem	145	14.1
Irritable	150	14.5
Nausea	352	34.1
SleepDisturbance	107	10.4
SlurredSpeech	28	2.7
Vision ← 2	397	38.5
Vomiting	174	16.9

# COA REDCap Database: 2007-2013

Swanson M, et al, 2016

Swanson M, Weise KK, Dreer LE, Johnston J, Davis RD, Ferguson D, Hale MH, Gould SJ, Swanson E, Christy JC, Busettoni C, Lee SD.

- Cross-sectional study
- N = 1,033 (2007-2013)
  - Cohort of interest (N = 276)
    - 5 to 18 years
    - $\geq 3$  symptoms
    - > 10 days of concussion-related symptoms (self-report)

# COA REDCap Database: 2007-2013

Swanson M, et al, 2016

N = 276 Concussed, Symptomatic  $\geq 3$ ) kids > 10 days out

- Age
- Days since concussion
- Race
- Gender
- Insurance (Private vs. Public)
- Number of Previous Concussions
- Loss of consciousness
- Event Amnesia
- Imaging
- SCAT
- Balance Difficulty
- Concentration Difficulty
- Confusion
- Dizziness
- Fatigue
- Headache
- Hearing
- Irritable
- Nausea
- Sleep disturbance
- Slurred speech
- Vision
- Vomiting
- Education Difficulty

COA REDCap Database: 2007-2013

Swanson M, et al, 2016

N = 276 Concussed, Symptomatic  $\geq 3$ ) kids > 10 days out

- 29% (79/270) reported Academic Difficulty
- 46% (128/274) reported Vision Abnormalities
- >30 days (33%): Only **vision and concentration** remained statistically significantly **associated with academic difficulty**

ORIGINAL ARTICLE

## Academic Difficulty and Vision Symptoms in Children with Concussion

Mark W. Swanson\*, Katherine K. Weise<sup>†</sup>, Laura E. Dreer<sup>‡</sup>, James Johnston<sup>§</sup>, Richard D. Davis<sup>§</sup>, Drew Ferguson<sup>||</sup>, Matthew Heath Hale<sup>\*\*</sup>, Sara J. Gould<sup>\*\*</sup>, Jennifer B. Christy<sup>††</sup>, Claudio Busetini<sup>‡</sup>, Sarah D. Lee\*, and Erin Swanson<sup>§</sup>

### ABSTRACT

**Purpose.** Academic difficulty is reported in children with prolonged post-concussive symptoms. Despite growing evidence that vestibular-ocular and vision-specific dysfunction are common in children after concussion, vision is rarely mentioned in return-to-learn protocols. The purpose of this project was to evaluate a cohort of children with prolonged post-concussive symptoms to determine if vision symptoms are associated with those reporting academic difficulty.

**Methods.** Data were obtained from the Children's of Alabama Concussion Clinic REDCap dataset from the period January 2007 to October 2013. From this dataset of 1033 concussion events, a cohort of 276 children aged 5 to 18 years with three or more concussion-related symptoms present for 10 days or more was identified. A cross-sectional cohort study was undertaken to evaluate the association of concussion symptoms, SCAT2 scores, and demographic and concussion severity markers to reported educational difficulty among children with prolonged post-concussive symptoms. Univariate and multivariate logistic regression techniques were used to model the association of reported educational difficulty to self-reported vision abnormalities.

**Results.** Mean age was 13.8 years. Median time since the concussive event was 21 days, with 33% (95/276) reporting their concussion more than 30 days before data collection. Academic difficulty was reported by 29% (79/270) and vision abnormalities in 46% (128/274). After model reduction, vision symptoms (OR 2.17, 95% CI 1.02, 4.62), hearing disturbance (OR 2.39, 95% CI 1.06, 5.36), and concentration difficulty (OR 21.62, 95% CI 9.50, 44.47) remained associated with academic difficulty. For those with symptoms 30 days or more after concussion, only vision (OR 3.15, 95% CI 1.06, 9.38) and concentration difficulty (OR 15.33, 95% CI 4.99, 47.05) remained statistically significant.

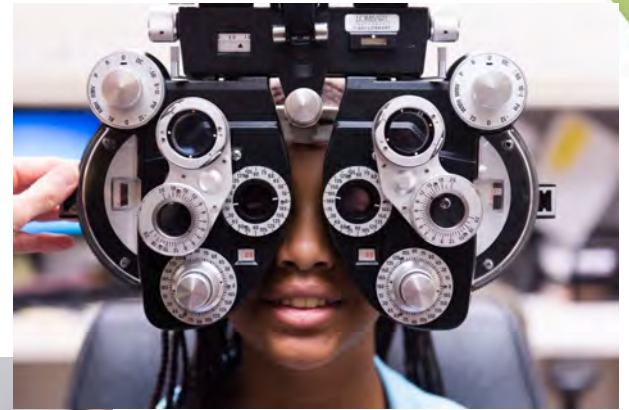
**Conclusions.** Vision problems were commonly reported in children with concussions and were independently associated with those reporting academic difficulty. Comprehensive vision assessment should be considered in children reporting academic difficulty and in the development of return-to-learn protocols.

(Optom Vis Sci 2017;00:00-00)

Key Words: concussion, school, education, vision, mild traumatic brain injury

# The eye is affected in concussion.

## Concussion Physicians: “Get an eye exam”



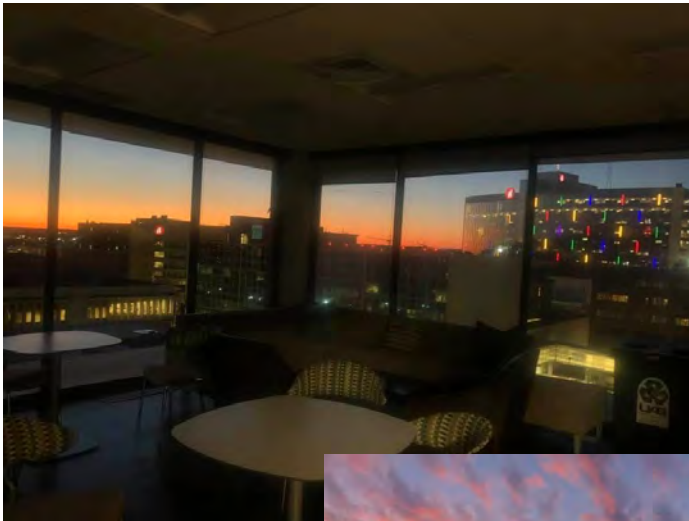
# Let's Do a Real Case!



14 yo beautiful WF with strong mama and with history of concussion



# What do you want to know about referral source?



## UAB'S FORCE AGAINST CONCUSSIONS

Researchers and physicians across campus are part of several multidisciplinary projects to study and prevent traumatic brain injury. These include:

- Expert Care**  
Clinicians in the **UAB Sports Medicine Concussion Clinic at Children's of Alabama** specialize in treating young patients injured while playing football, basketball, soccer and other sports.
- Better Diagnosis**  
Researchers in the **UAB Vestibular and Oculomotor Research Laboratory** are looking for biomarkers that could help doctors diagnose concussions, and evaluate a patient's recovery and response to treatment.
- Better Guidelines**  
Investigators are observing the brain and looking to determine when it is appropriate for a concussed patient to return to the classroom and how to best integrate them into full functionality and learning.
- Safer Recovery**  
UAB's unique **driving simulator lab** is being used for first-of-its-kind testing to help determine when it is safe for teens to begin driving after a concussion.
- Faster Treatments**  
Basic scientists at UAB are studying a compound that could eventually be used on the sidelines immediately after a concussion to reduce the body's damaging internal response to a traumatic brain injury.
- Smarter Helmets**  
Researchers in the **UAB School of Engineering**, led by renowned safety expert Dean Sicking, Ph.D., have developed a state-of-the-art **testing facility at Barber Motorsports Park** to simulate impacts using actual helmets in highly accurate game-like conditions, based on data acquired by analyzing thousands of helmet-to-helmet impacts during college games. And advanced materials designed in the School of Engineering are playing a key role in creating helmets that offer players more protection against head impacts.

**UAB THE UNIVERSITY OF ALABAMA AT BIRMINGHAM**  
Knowledge that will change your world

**Barber Motorsports Park**



What do you want to know about referral source?

1. Who

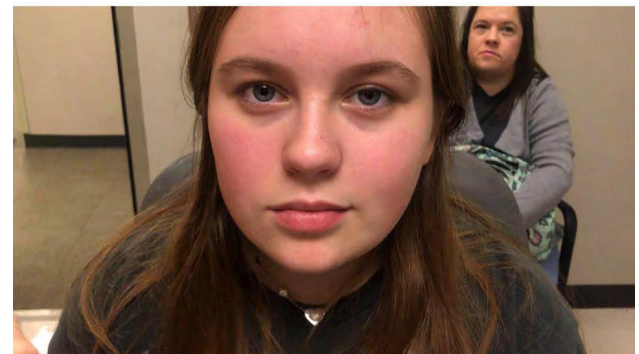
2. Where

3. When

4. Who's driving the bus?

# What do you want to know about the injury?

- Date of injury
- Loss of consciousness
- Event amnesia
- When
- How many concussions prior?
- MRI or CT?



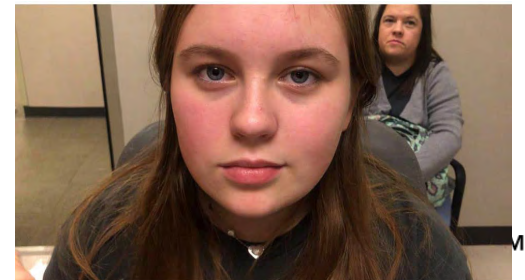
# What symptoms (visual or general) might she have?

- Dizziness
- loss of concentration
- brain fog
- academic difficulty
- Imbalance
- Vertigo
- Not herself
- Headaches
- Sleep issues
- Photophobia
- Difficulty switching from board to desk



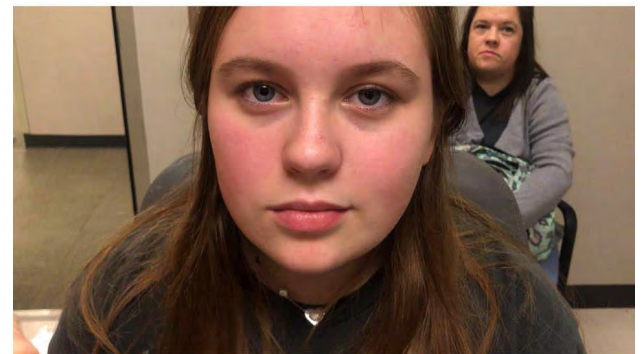
# What do you want to ask about school?

- Full time? Part time? At home?
- Passive? Active learning? Tests?
  - “Sponge learning”
- After school activities?
- Return to play?
- Accommodations (large print, sunglasses, leave class early, water at desk, reader/aide, earplugs, fewer items on page, no devices, double-sided copies, no devices)



## What other systemic conditions might go along with concussion?

- ADD/ADHD,
- depression,
- anxiety



Can you think of any other questions to consider?

- 1. Other doctors?
  - Vestibular
  - Vision
  - PT
  - Counseling
  - Audiology
- 2. Who's driving the bus? Who's overseeing all care?
- 3. Getting better or worse?
- 4. Scale of 1-100, how old are to your old self?

# What objective tests do you want to consider that tells us how the eyes are messed up after concussion?

- VA's (PH?)
  - 20/20 OD, OS
- CT
  - 0-1 XP
  - 0-6 XP'
- Amps (age minimums)
- MEM
  - Pl to 0.75 D
- Facility
  - +/-2.00 facility (normal ~10-12 cpm)
  - 3 BI/12 BO facility (normal ~15 cpm)
- NRA/PRA
  - +2.50/-2.50
- Vergences
  - Double demand
- DEM
  - Normative Data
- CISS
  - $\geq 16$  child = symptomatic
  - $\geq 21$  adult = symptomatic
- Refractive error (wet and dry)

What objective tests do you want to consider that tells us how we can use the eyes to tell us about the brain after concussion?

- (DFE? Yes, unless contra indicated...T1-4'-T1)
- CF
- EOM's
- Pupils
  - Pupillometer
- OCT
  - ONH, GCC
- VF
  - 120-point neuro screener
- VOMS or SVV

A computer monitor displaying a table of visual field test results. The table has columns for 'Right', 'Left', and 'Diff'. The data is as follows:

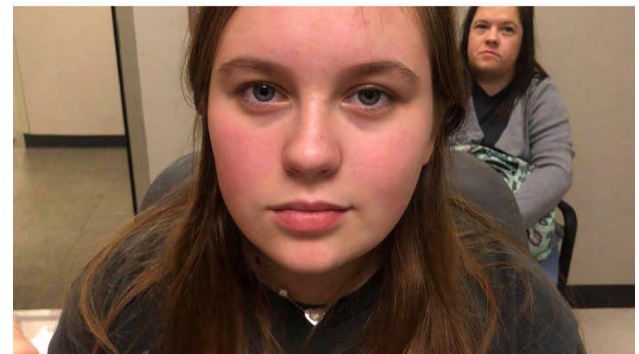
	Right	Left	Diff
NPI	4.6	4.7	L > R 0.1
Size	5.29 mm	4.62 mm	R > L 0.67
MIN	2.81 mm	2.61 mm	R > L 0.20
CH	47%	44%	
CV	4.21 mm/s	3.94 mm/s	
MCV	6.50 mm/s	5.87 mm/s	
LAT	0.23 sec	0.23 sec	
DV	1.73 mm/s	1.89 mm/s	

# Assessments

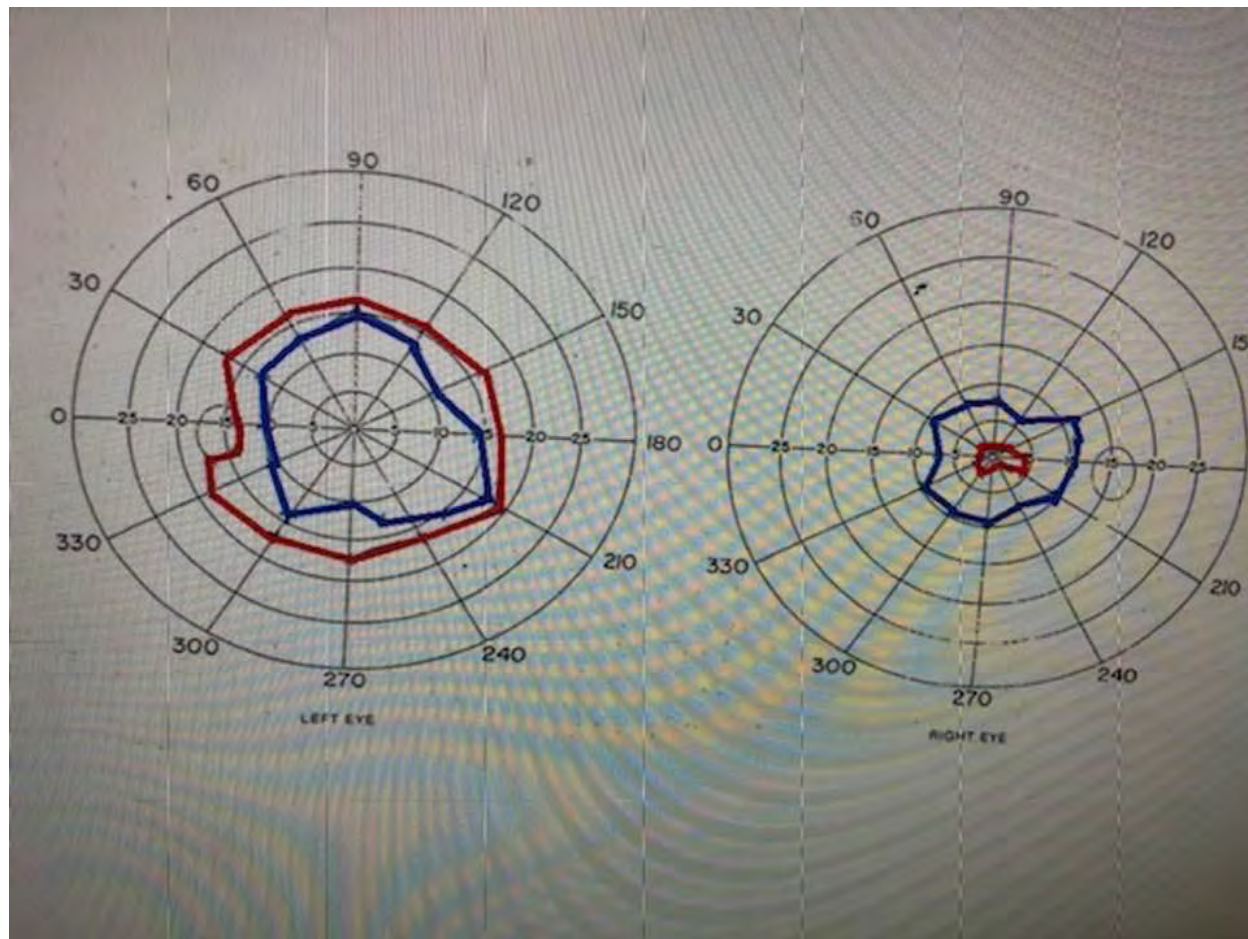
- Accommodative insufficiency:
  - Difficulty keeping near work clear, which could cause intermittent blur and eye strain
  - 5 D OD, OS: Eyes of a 40 year old
- Accommodative infacility/(vergence infacility)
  - Difficulty switching focus from distance to near to keep things clear (and single)
- Good convergence, good eye tracking, good objective pupil function
- Subnormal distance visual acuity (20/30 OD, OS)
- Minimal need for glasses in the absence of concussion
  - +0.50 D, OD, OS

Assuming anterior and posterior seg are normal as they typically are, what other diagnoses and tests should we consider?

- PH
- Tangent screen



# Tangent screen – visit 1 (not hers, but similar)



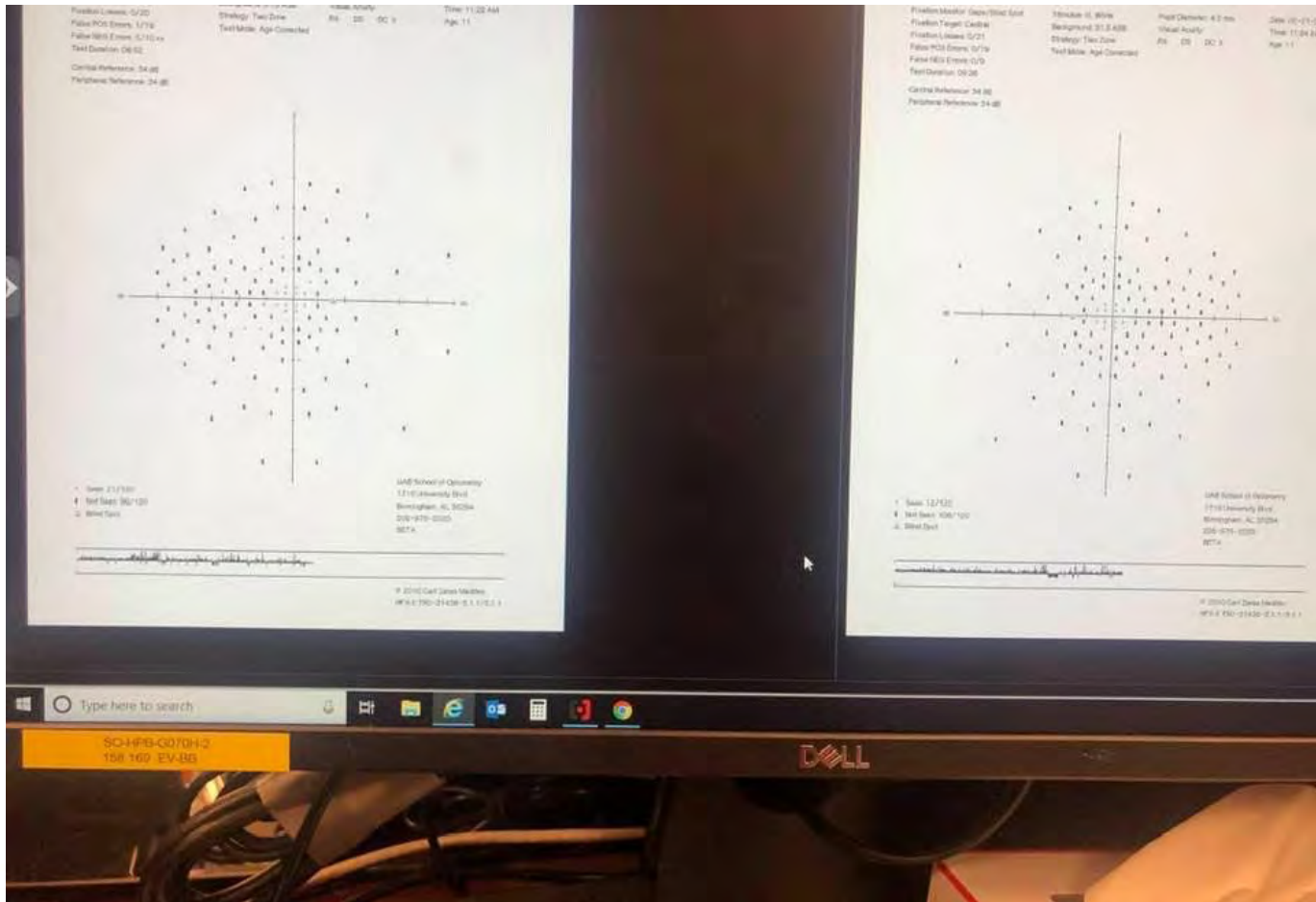
## What's your concern/diagnosis?

- Psychogenic amblyopia
- conversion reaction
- functional vision loss



Do you want to see 120-point screener?

Do you want to see 120-point screener?  
(not hers, but very similar)



## What's your added diagnosis?

- Psychogenic amblyopia
- conversion reaction
- functional vision loss

## What are your management suggestions?

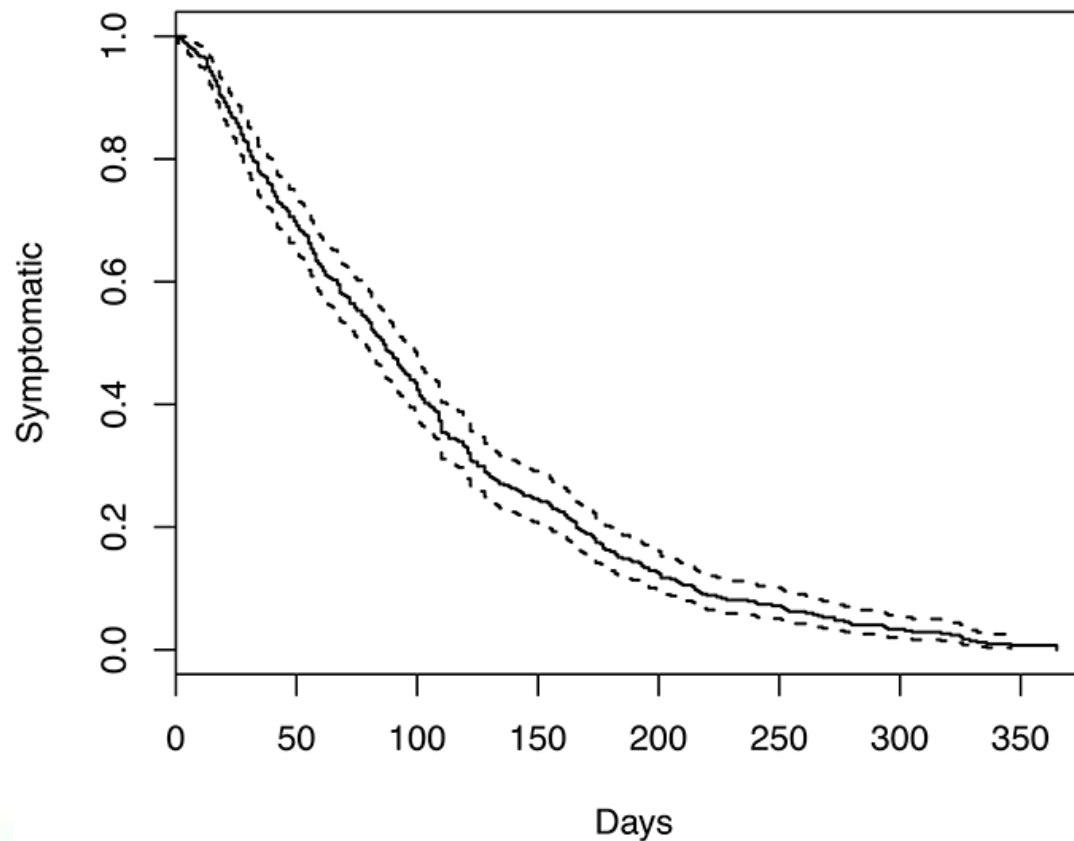
- 1. No glasses to see clearly in the absence of concussion, but perhaps helpful to see more comfortably
  - Anti-fatigues...Hoya Sync 9 or Eyezen3
- 2. Referral for counseling (Joe Ackerson, PhD)
- 3. Notes back to COA!

# Concussion Management Options

- 1. SRx
  - Normal prescribing patterns
  - Lower hyperopia thresholds
  - Anti-fatigues (Hoya or Eyezen) (or readers)
    - SV but shaped like a PAL
    - Low add on bottom (0.5, 0.9, 1.3)
  - ARC (full spectrum)
- 2. VT
- 3. Vestibular referral
  - VOMS abnormal or high CISS with minimal clinical findings
- 4. Classroom adjustments
- 5. Other referrals

Master CL, Master SR, Wiebe DJ, Storey EP, Lockyer JE, Podolak OE, Grady MF. Vision and Vestibular System Dysfunction Predicts Prolonged Concussion Recovery in Children. Clin J Sport Med. 2018 Mar;28(2):139-145.

### Time to Recovery, Full Cohort



## See Handouts

- 1. Vinogradov Weise Cheat Sheet
- 2. Classroom adjustments
- [kweise@uab.edu](mailto:kweise@uab.edu)

# “Randy Kardon, MD, PhD is the expert.”

Paul Gamlin, PhD, Summer 2013



# August 2013

## Coach Niemann:

- “There should be an optometrist on every sideline.”





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- **State-of-the-Art Concussion Baseline Testing**
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M. Heath Hale, MD

Director, Medical Athletics

Katherine K. Weise, OD, MBA

Co-Director, Optometry



# BlazerVision

# Pre-participation Vision Screening and Comprehensive Eye Care in National Collegiate Athletic Association Athletes

Katherine K. Weise, OD, MBA, FFAO,<sup>1,\*</sup> Sarah J. Galt, OD, FFAO,<sup>1</sup> M. Heath Hale, MD, MPH,<sup>2</sup> Daniel B. Springer, MAEd, LAT, ATC,<sup>3</sup> and Mark W. Swanson, OD, MSPH, FFAO<sup>1</sup>

**SIGNIFICANCE:** Pre-participation physical evaluation and its vision screenings have been the mainstay of medical clearance for competitive play for decades. The ability of screening to address athlete's sports-specific vision needs is unknown.

**METHODS:** Fifty-eight intercollegiate football players consented to participate in a comprehensive, sports-specific eye examination in addition to the standard pre-participation vision screening. Sensitivity, specificity, and positive and negative predictive values were determined for screening's ability to detect athletes whose vision might improve with correction, athletes who had significant ocular findings that impact safety, and either of the two conditions together. The effect no recent eye examination added to pre-participation vision screening results was evaluated for change in screening yield. Descriptive statistics of the cohort and associations with no recent comprehensive eye examination were generated.

**RESULTS:** The pre-participation vision screening was able to identify three athletes not meeting visual acuity requirements for medical clearance to play without a comprehensive assessment. A failed screening was poorly able to identify athletes who might benefit from improved acuity (sensitivity, 9.1%; specificity, 100%), have sports-specific significant ocular findings (sensitivity, 10.5%; specificity, 97.3%), or have either together (sensitivity, 7.5%; specificity, 100%). Sixty percent (33/55) of athletes reported never having a comprehensive examination or one within the last 10 years. Fifty-eight percent (34/58) had improved best-corrected visual acuity after comprehensive examination, and 81% (47/58) had improved acuity or a sports-specific significant finding.

**CONCLUSIONS:** The pre-participation vision screening was largely able to identify athletes meeting the minimum visual acuity requirement for athlete clearance. It poorly identified those who might benefit from improved vision with refractive correction and those in whom sport-specific significant eye findings were noted. Comprehensive eye care had a clear benefit for the majority of athletes tested. This benefit needs to be balanced with the potential added costs and time constraints to players and athletic department staff.



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The pre-participation physical evaluation has been the mainstay of medical clearance for athletic play since 1980.<sup>1,2</sup> It has been endorsed and modified by many organizations since its conception for all levels of athletic competition.<sup>3-13</sup>

The National Collegiate Athletic Association states that, before participation in any practice, competition, or out-of-season conditioning activities, student-athletes who are beginning their initial season of eligibility, along with students who are trying out for a team, shall be required to undergo a medical examination or evaluation administered or supervised by a physician (e.g., primary care provider and team physician). The examination must be completed within 6 months of beginning athletic participation. In the years after the initial evaluation, the student-athlete's medical history should be updated and a determination made if additional examinations are needed.<sup>14</sup>

The goals of the pre-participation physical evaluation center around (1) screening for conditions that may be life-threatening or disabling, (2) screening for conditions that may predispose to

injury or illness, and (3) providing health care to athletes, some of whom may have limited access to care.<sup>15</sup> In the last four decades, the pre-participation physical evaluation has expanded to include more and more systems. In its most recent form, there are questions that investigate a history of eye problems or eye injuries and whether or not the athlete wears corrective eyewear.<sup>12</sup> The eyes and vision are assessed, and visual acuity is tested as part of the physical examination. Snellen visual acuity of 20/40 or better with or without correction clears the athlete to play. If best-corrected vision is worse than 20/40 in one eye, the athlete should undergo an eye examination. Once the initial assessment is cleared, there is no requirement to receive another. An athlete could receive a single-vision screening upon arrival and subsequently not be evaluated again for four or more years (or ever) while on campus.

The National Collegiate Athletic Association specifically includes the 2014 National Athletic Trainers' Association position statement on its medical clearance Web site. This position statement further supports determining monocular and binocular visual acuity with

# Objective Vision-related Indications for Clear and Tinted Football Helmet Visors

Katherine K. Weise, OD, MBA, FFAO,<sup>1\*</sup> Mark W. Swanson, OD, MSPH, FFAO,<sup>1</sup> Sarah J. Galt, OD, FFAO,<sup>1</sup> Daniel B. Springer, MAEd, LAT, ATC,<sup>2</sup> Jason N. Crosson, MD,<sup>3</sup> Dawn K. DeCarlo, OD, PhD, FFAO,<sup>3</sup> Matthew Heath Hale, MD, MPH,<sup>4</sup> Joshua Ryne Nicholson, MA,<sup>2</sup> and James B. Robinson, MD<sup>5</sup>

**SIGNIFICANCE:** Football helmet visors are popular among players and may increase safety. However, they may also be costly or impractical, or impair the evaluation of head and neck injury. Determining an objective list of vision-related clinical conditions may help meet risk-benefit ratios while increasing access to care to athletes with special needs.

**PURPOSE:** The purpose of this study was to determine an objective list of vision-related conditions that may benefit from clear and tinted football helmet visor use in athletes.

**METHODS:** After comprehensive dilated eye examinations on 58 Division I collegiate football players at the University of Alabama at Birmingham between February 2017 and June 2018, an expert panel in vision care, sports medicine, and football equipment convened to determine vision-related conditions most important for clear or tinted football helmet visor use.

**RESULTS:** In August 2018, the list drafted by the expert vision and sports medical panel in which a clear football helmet visor might be justified included conditions associated with retinal detachment and unilateral or binocular vision loss as well as high refractive error, refractive surgery, corneal compromise, and other conditions, which would necessitate additional eye protection. Of the 58 players examined, 3 (5%) were determined to have eye conditions that would require a clear visor as deemed by the expert panel, and 3 (5%) were determined to have eye conditions for which a clear visor was recommended. No players met indications for a tinted visor including congenital eye conditions that limit useful vision in daylight or bright-light environments, acquired conditions that may increase light sensitivity, and light-induced systemic conditions.

**CONCLUSIONS:** This objective list of eye and vision-related systemic conditions is intended to mitigate the risk of long-term eye damage and/or vision deprivation. Clear and especially tinted football helmet visors require the sports medicine team to evaluate factors that will maximize the vision, head, and neck health of the athlete while increasing accessibility to sports for individuals with unique abilities.



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Name of Student: \_\_\_\_\_ DOB: \_\_\_\_\_

Name of School: \_\_\_\_\_ Sport: \_\_\_\_\_ Jersey #: \_\_\_\_\_

Date Seen by Physician: \_\_\_\_\_

Physician's Name: (please print) \_\_\_\_\_

Physician's Signature: \_\_\_\_\_

Comments: \_\_\_\_\_

**\*For an exception to wear a tinted helmet visor, the coach must present this form to the head official prior to the start of the contest.**

One or more of the following conditions that may indicate a use for tinted helmet visors during the \_\_\_\_\_ season:

**Eye and Systemic Conditions that may indicate Tinted Visors:**  
Inherited and/or congenital eye conditions that limit useful vision in daylight or bright-light environments including:

- ☐ Albinism
- ☐ Achromatopsia
- ☐ Aniridia
- ☐ Cone Dystrophy
- ☐ Cone-Rod Dystrophy
- ☐ Corneal dystrophies
- ☐ Iris coloboma

Acquired conditions that may increase light sensitivity including:

- ☐ Adies pupil
- ☐ Chronic recurrent uveitis (e.g. secondary to JRA)
- ☐ Traumatic mydriasis

Systemic Indications

- ☐ Light-induced migraine activity
- ☐ Light-induced seizure activity

Verizon LTE 7:50 AM 89%

**Katherine K. Weise, OD, M...**  
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**Katherine K. Weise, OD, M.D.** · 9/14/21

Thanks to the vision of UAB  
@CoachBillClark and others,  
optometrists, physicians, and trainers  
provide world-class healthcare to  
athletes, propelling our community into a  
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Great start of the day with some insightful tips from @WeiseKathy on getting involved in clinical research. Looking forward to learn more about clinical studies @aaopt Clinical investigator certification course #WomenInSTEM #dryeyes #goodclinicalpractice [pic.twitter.com/t86foUP9AV](https://pic.twitter.com/t86foUP9AV)



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Great start of the day with some insightful tips from @WeiseKathy on getting involved in clinical research. Looking forward to learn more about clinical studies @aaopt Clinical investigator certification course #WomenInSTEM #dryeyes #goodclinicalpractice [pic.twitter.com/t86foUP9AV](https://pic.twitter.com/t86foUP9AV)



# “Randy Kardon, MD, PhD is the expert.”

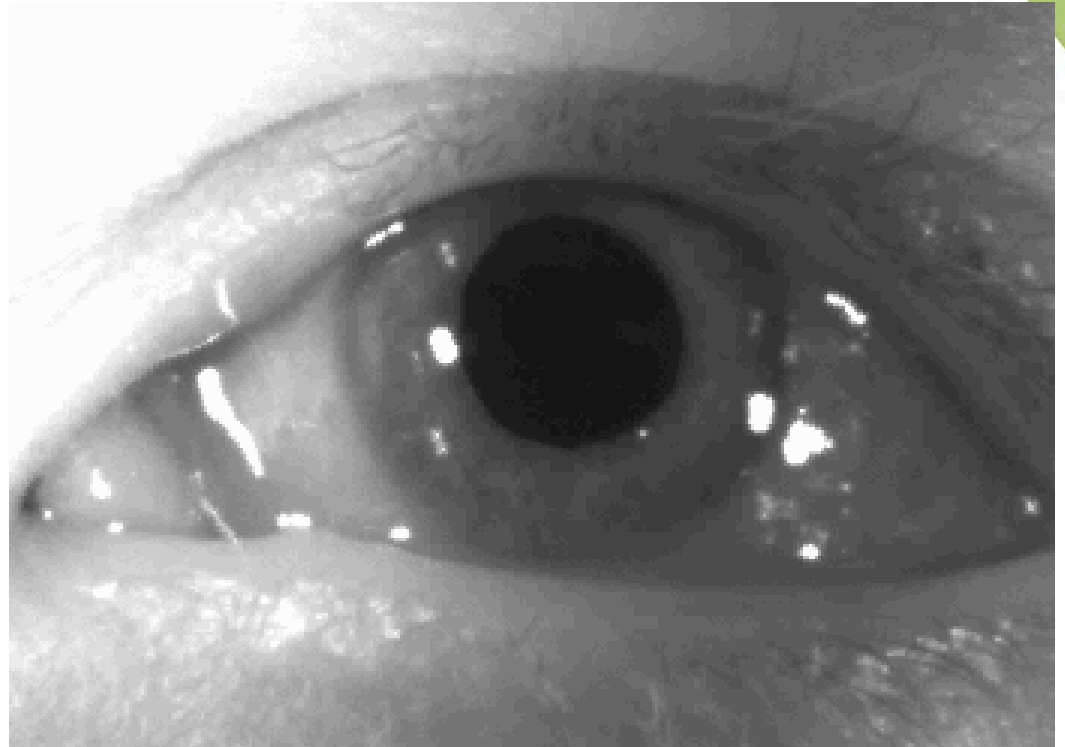
Paul Gamlin, PhD, Summer 2013



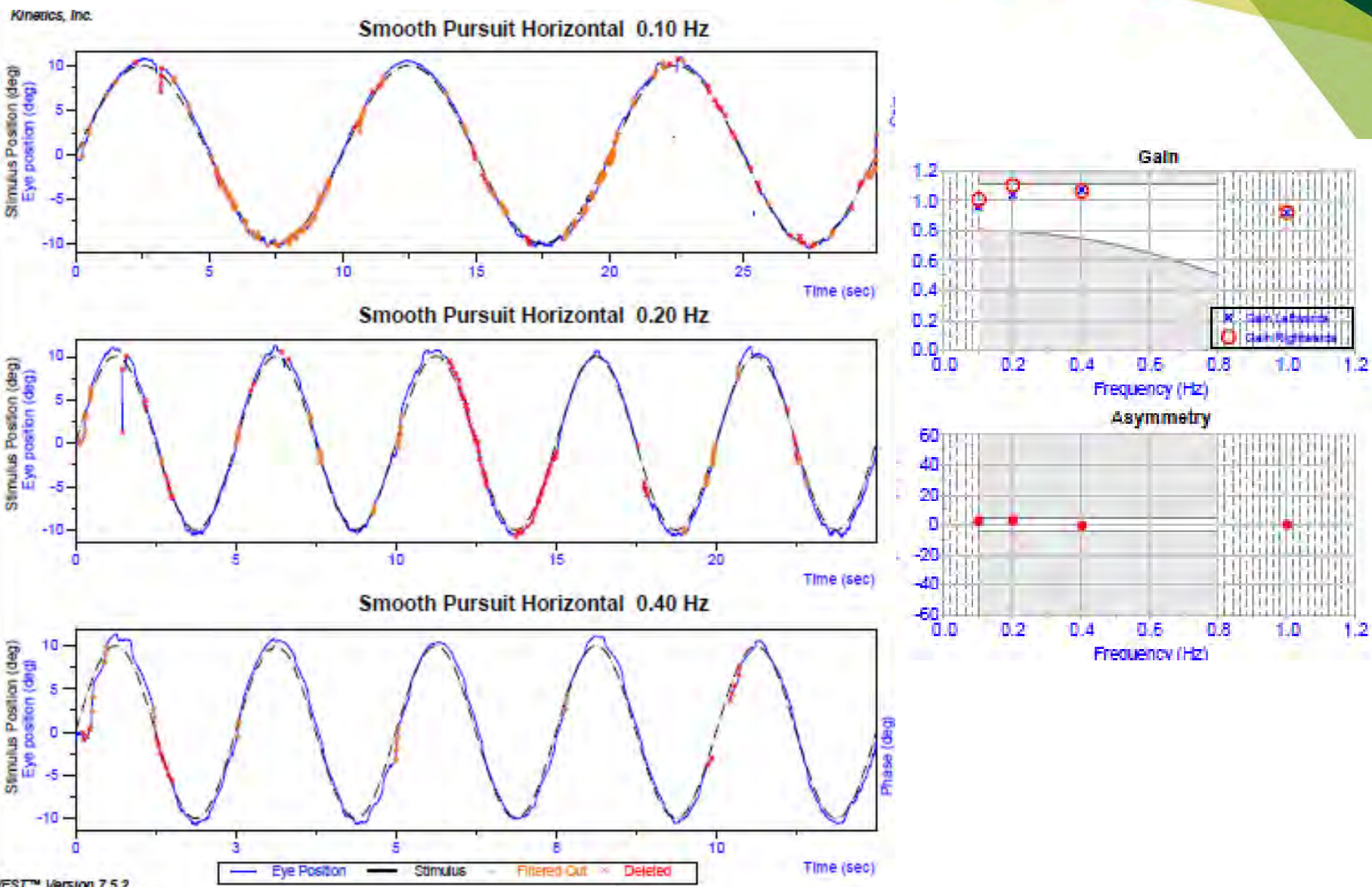
# UAB/COA VORClinic 2014



## 1.28 Hz sinusoid

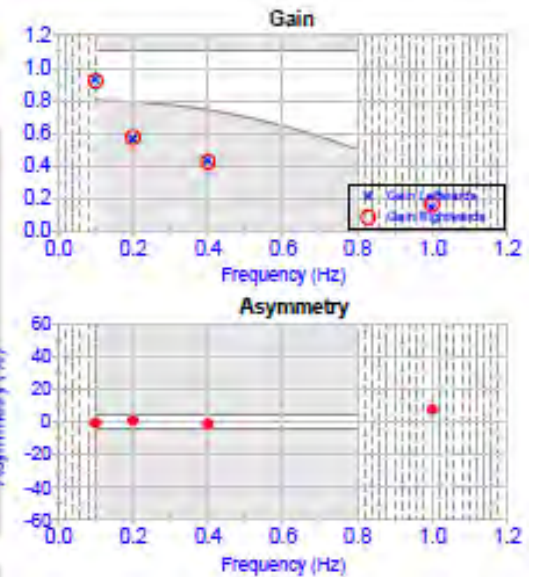
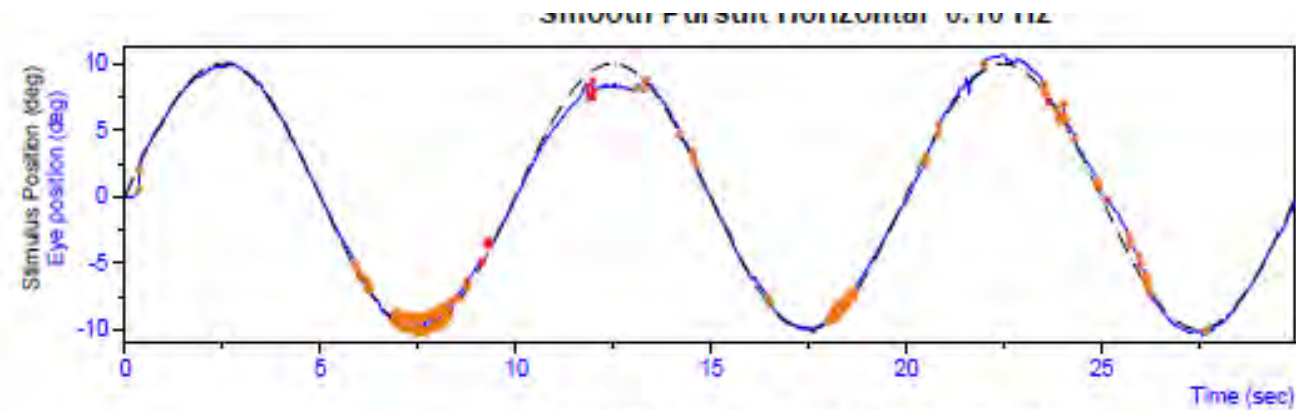


# BASELINE: HORIZONTAL SMOOTH PURSUIT



VEST™ Version 7.5.2

# POST mTBI: SMOOTH PURSUIT HORIZONTAL



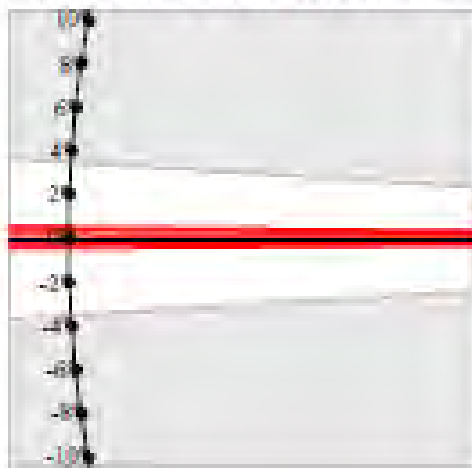
# BASELINE

# mTBI

Subjective Visual Vertical



Subjective Visual Horizontal



# Saccadic Intrusions Treated with 100 mg/d Gabapentin

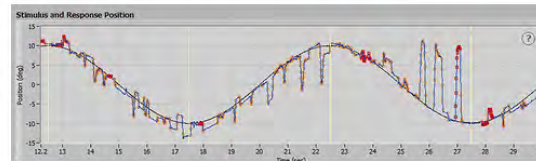
- Cochrane GD, Gould SJ, Sheehan N, Busetini C, Christy JB, **Weise KK**, Swanson MW. **Saccadic intrusions in paediatric concussion**. Clin Exp Optom. 2020 Nov;103(6):929-930. doi: 10.1111/cxo.13045. Epub 2020 Jan 22.

## Patient 2

Patient 2 is a 10-year-old Caucasian female who sustained a mTBI on the playground. Immediately after injury she reported dizziness, headache, and blurred vision.

At her initial visit one month post-injury, the patient reported headache and dizziness, and saccadic intrusions were noted on examination. She was referred to the optometry clinic for vision therapy and for confirmation of saccadic intrusions (Figure 2) and was started on 100-mg gabapentin.

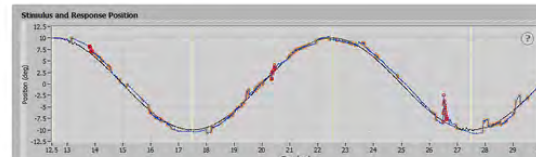
Figure 2 Patient 2, 0.1-Hz horizontal smooth pursuit trace before gabapentin treatment



[Display full size](#)

One month later, the patient had lower symptom exacerbation. She returned to the optometry clinic where her saccadic intrusions had objectively diminished (Figure 3).

Figure 3 Patient 2, 0.1-Hz horizontal smooth pursuit trace after two-months of gabapentin. Notice that the trace is still not entirely smooth but is more accurate and with smaller amplitude deviations than before gabapentin in Figure 2.



# UAB/COA VORClinic 2014 –present: Outcomes



Cochrane GD, Christy JB, Almutairi A, Busettini C, **Weise KK**, Swanson MW, Gould SJ. *Vestibular, Oculomotor, and Balance Function in Children with and without Concussion*. J Head Trauma Rehabil. Accepted Oct 2020.

Christy JB, Cochrane GD, Almutairi A, Busettini C, Swanson MW, **Weise KK**. *Peripheral Vestibular and Balance Function in Athletes With and Without Concussion*. J Neurol Phys Ther. 2019;43(3):153-159.  
[http://wolterskluwer.http.internapcdn.net/wolterskluwer\\_vitalstream.com/MP4s/permalink/jnpt/a/jnpt\\_43\\_3\\_2019\\_04\\_30\\_christy\\_jnpt-d-18-00108r2\\_sdc1.mp4](http://wolterskluwer.http.internapcdn.net/wolterskluwer_vitalstream.com/MP4s/permalink/jnpt/a/jnpt_43_3_2019_04_30_christy_jnpt-d-18-00108r2_sdc1.mp4)

Cochrane GD, Christy JB, Almutairi A, Busettini C, Swanson MW, **Weise KK**. *Visuo-oculomotor Function and Reaction Times in Athletes with and without Concussion*. Optom Vis Sci. 2019;96(4):256-265.

## Post concussion:

### VOR okay; VOR (VMS) Cancellation not okay

- Christy JB, Cochrane GD, Almutairi A, Busettoni C, Swanson MW, Weise KK. Peripheral Vestibular and Balance Function in Athletes With and Without Concussion. J Neurol Phys Ther. 2019 Jul;43(3):153-159.
- [https://cdn-links.lww.com/permalink/jnpt/a/jnpt\\_43\\_3\\_2019\\_04\\_30\\_christy\\_jnpt-d-18-00108r2\\_sdc1.mp4](https://cdn-links.lww.com/permalink/jnpt/a/jnpt_43_3_2019_04_30_christy_jnpt-d-18-00108r2_sdc1.mp4)
- **Central processes impaired (peripheral intact)**



# August 2013

## Coach Niemann:



- “There should be an optometrist on every sideline.”
- “The demise of football won’t be the safety. It will be the cost of football.”

## Post concussion:

### VOR okay; VOR (VMS) Cancellation not okay

- Christy JB, Cochrane GD, Almutairi A, Busettini C, Swanson MW, Weise KK. Peripheral Vestibular and Balance Function in Athletes With and Without Concussion. J Neurol Phys Ther. 2019 Jul;43(3):153-159.
- [https://cdn-links.lww.com/permalink/jnpt/a/jnpt\\_43\\_3\\_2019\\_04\\_30\\_christy\\_jnpt-d-18-00108r2\\_sdc1.mp4](https://cdn-links.lww.com/permalink/jnpt/a/jnpt_43_3_2019_04_30_christy_jnpt-d-18-00108r2_sdc1.mp4)
- Central processes impaired (peripheral intact)**



Figure 5. Horizontal VOR.



Figure 6. Vertical VOR.



Figure 7. VMS.

# Auburn UAB fMRI Football Think Tank 2017

- “Are we sending these fellas back out into the wolves?”



# Vision-related Biomarkers in Concussion?

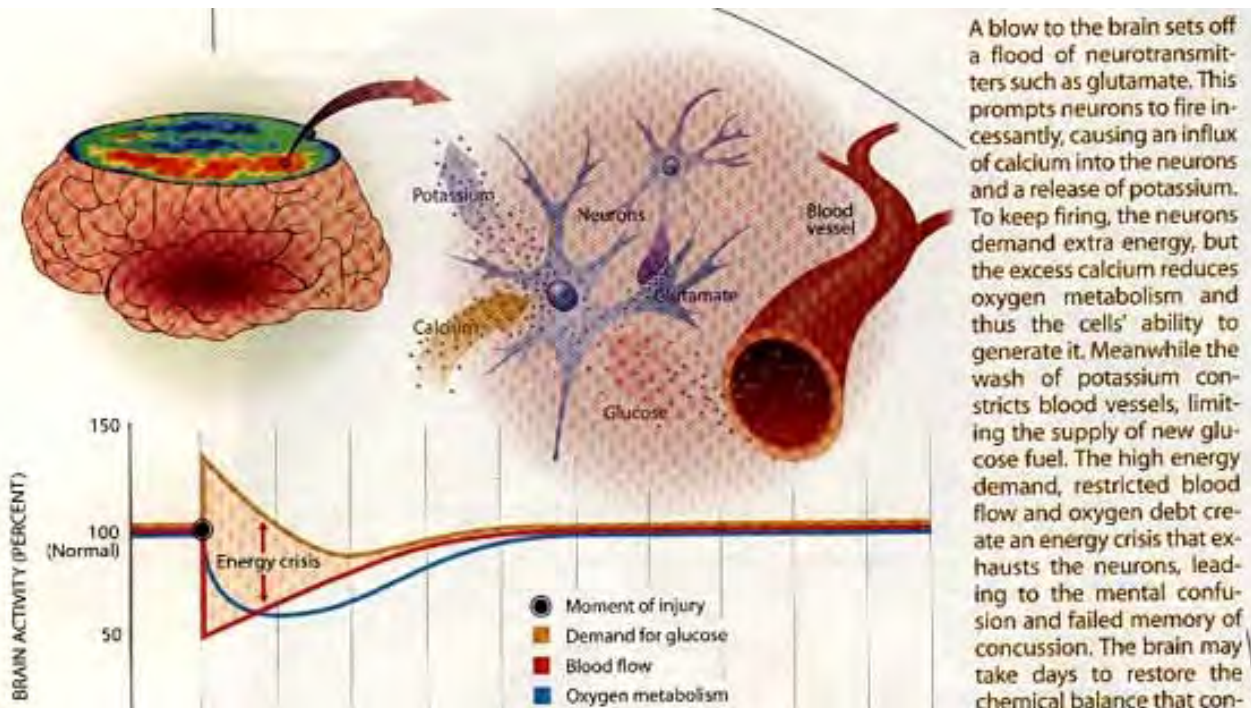


# Auburn UAB fMRI Football Think Tank 2017

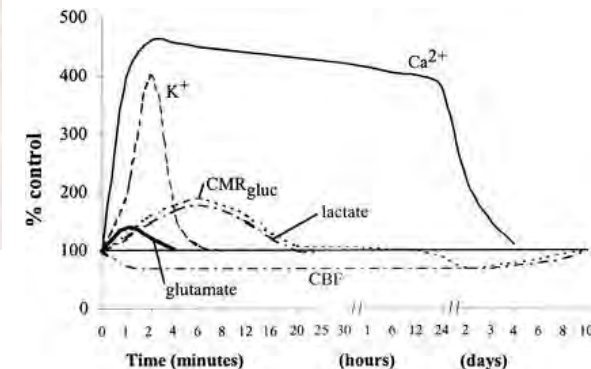


- “What is the mechanism of concussion?”

# Metabolic Cascade Theory of Concussion



**Concussion =  
Interstate Crash**



# Metabolic Cascade Theory of Concussion: The brain needs to catch up with itself.



# Vision-related Biomarkers in Concussion?



# Pupillometry Post Concussion?

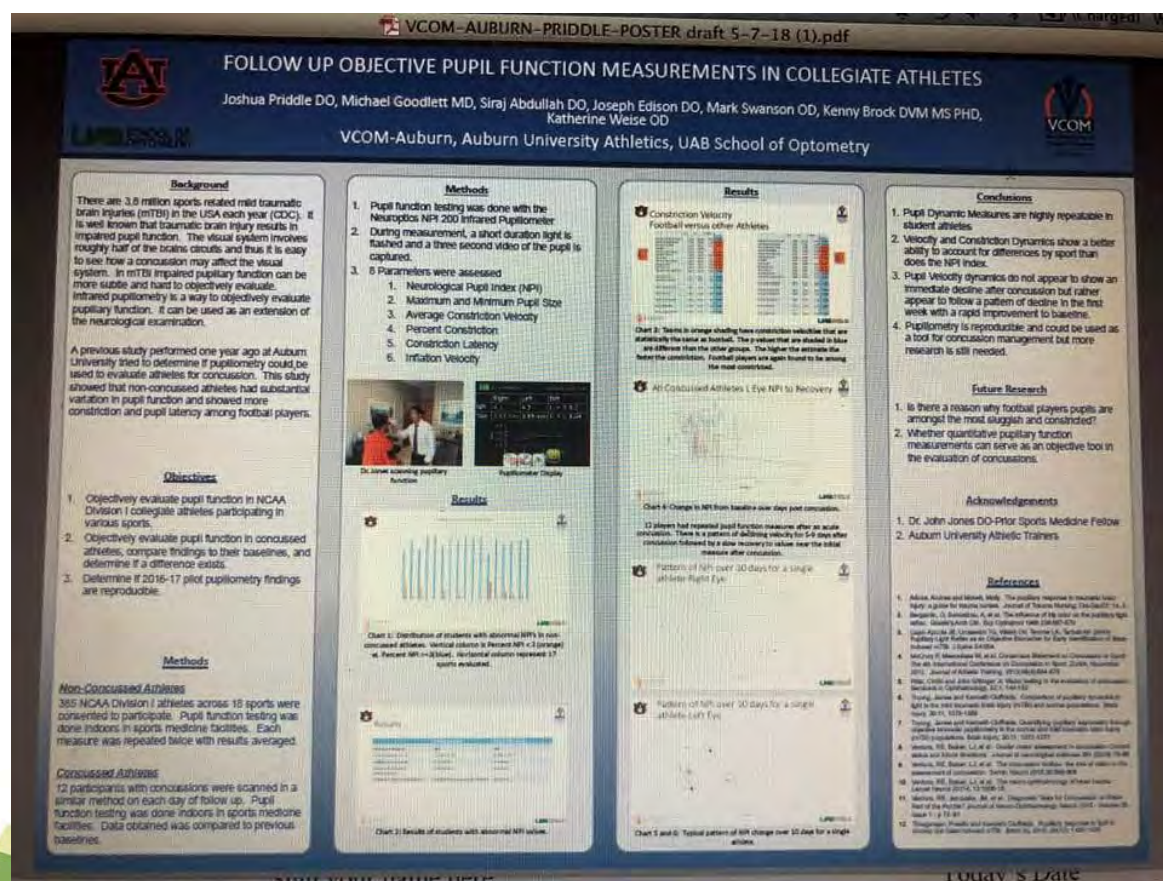


# Award Winning Presentation: Auburn-UAB

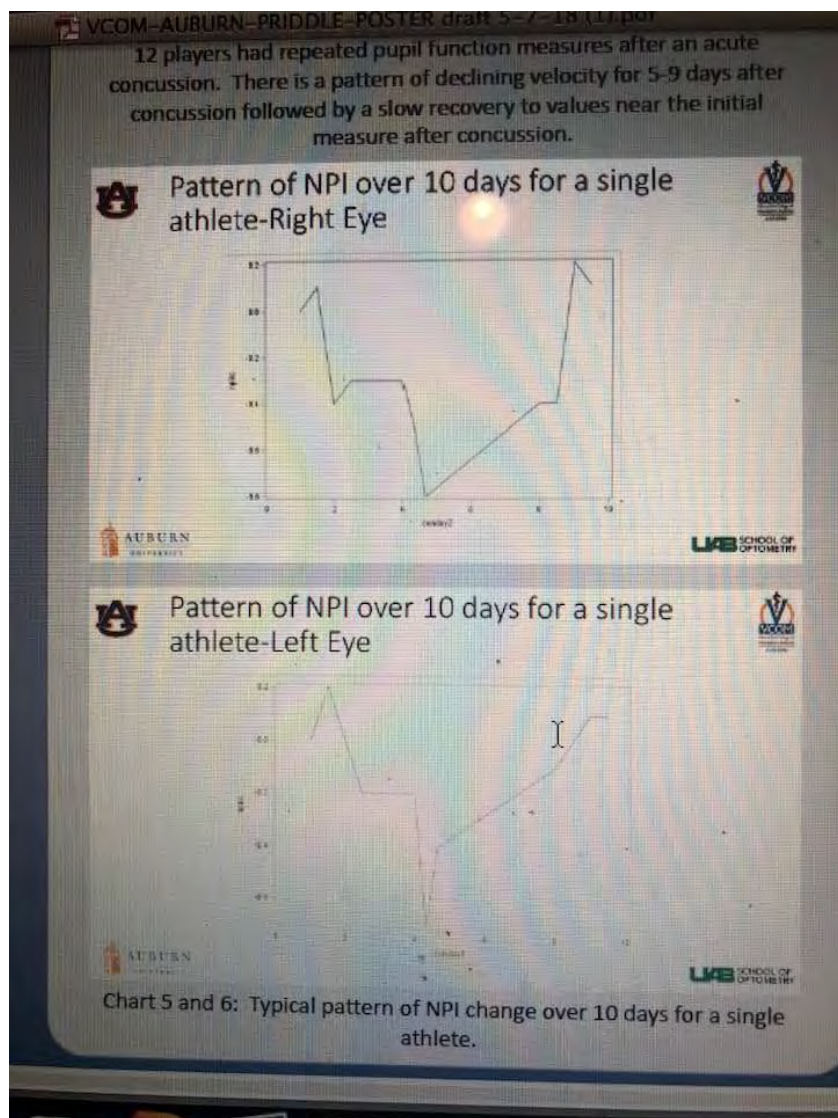
## Follow-up Objective Pupil Function in Concussed Athletes

J. Priddle, DO; M. Swanson, OD, MPSH, Weise KK, et al

### American Osteopathic Academy of Sports Medicine 2018



N = 385 athletes across 18 sports  
N = 12 concussed followed daily  
until RTP

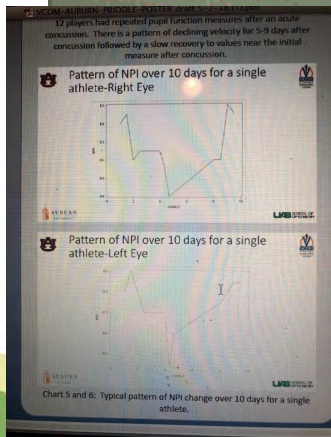


UAB AU:

**“Pupil Velocity Dynamics** do not appear to show an immediate decline after concussion, but rather to follow a **pattern of decline in the first week with rapid improvement to baseline.”**

# Metabolic Cascade Theory of Concussion:

## Will the injured brain catch up with itself?



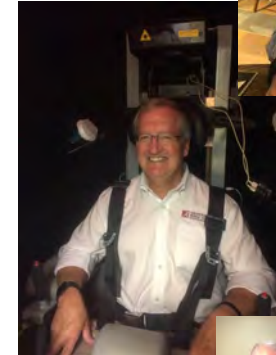
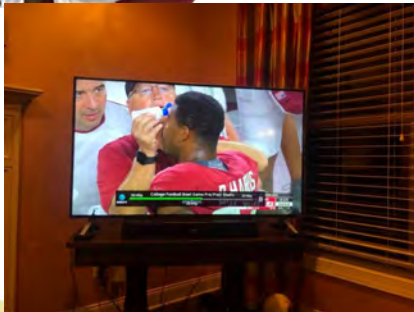
# More on Pupils: Master C, 2020

- Master CL, Podolak OE, Ciuffreda KJ, Metzger KB, Joshi NR, McDonald CC, Margulies SS, Grady MF, Arbogast KB. Utility of Pupillary Light Reflex Metrics as a Physiologic Biomarker for Adolescent Sport-Related Concussion. JAMA Ophthalmol. 2020 Sep 24;138(11):1135–41.
- **Conclusions and Relevance** These findings suggest that enhancement of PLR metrics characterize acute adolescent concussion, while exercise produced smaller pupil sizes and overall slowing of PLR metrics, presumably associated with fatigue. **Quantifiable measures of the PLR may serve in the future as objective physiologic biomarkers for concussion in the adolescent athlete.**

Jimmy Robinson, MD:

If you could know 1 thing about concussion right now, what would it be?

“A way to predict who will be out longer.”



# Predictors of Prolonged Recovery

- NPC?!
- DuPrey, May 2017 (Am J Sports Med)
  - *Convergence Insufficiency Identifies Athletes at Risk of Prolonged Recovery From Sport-Related Concussion*
- N = 270 athletes age 10-21
- NPC  $\geq 6$  cm = abnormal



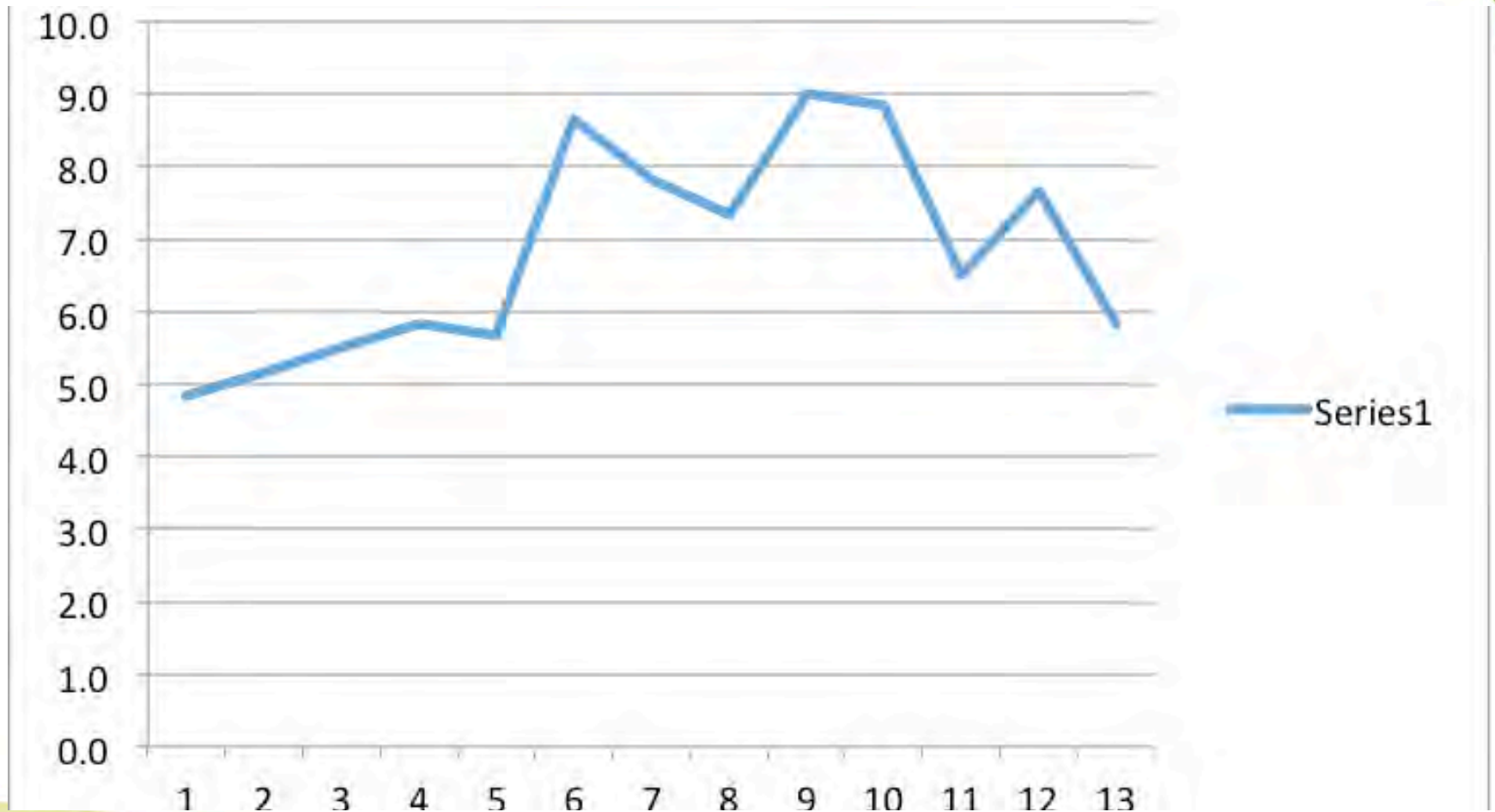
# Predictors of Prolonged Recovery

- DuPrey, May 2017 (Am J Sports Med)
  - *Convergence Insufficiency Identifies Athletes at Risk of Prolonged Recovery From Sport-Related Concussion*
- 50.4% had receded **NPC** (n = 136)
  - **Recovery = 51.6 days vs. 19.2 days** ( $p < 0.001$ )
  - Odds of prolonged recovery increased by **12.3 fold** ( $p < 0.001$ ) in convergence insufficiency

# NPC Post Concussion? Sidelines 2017 - UAB

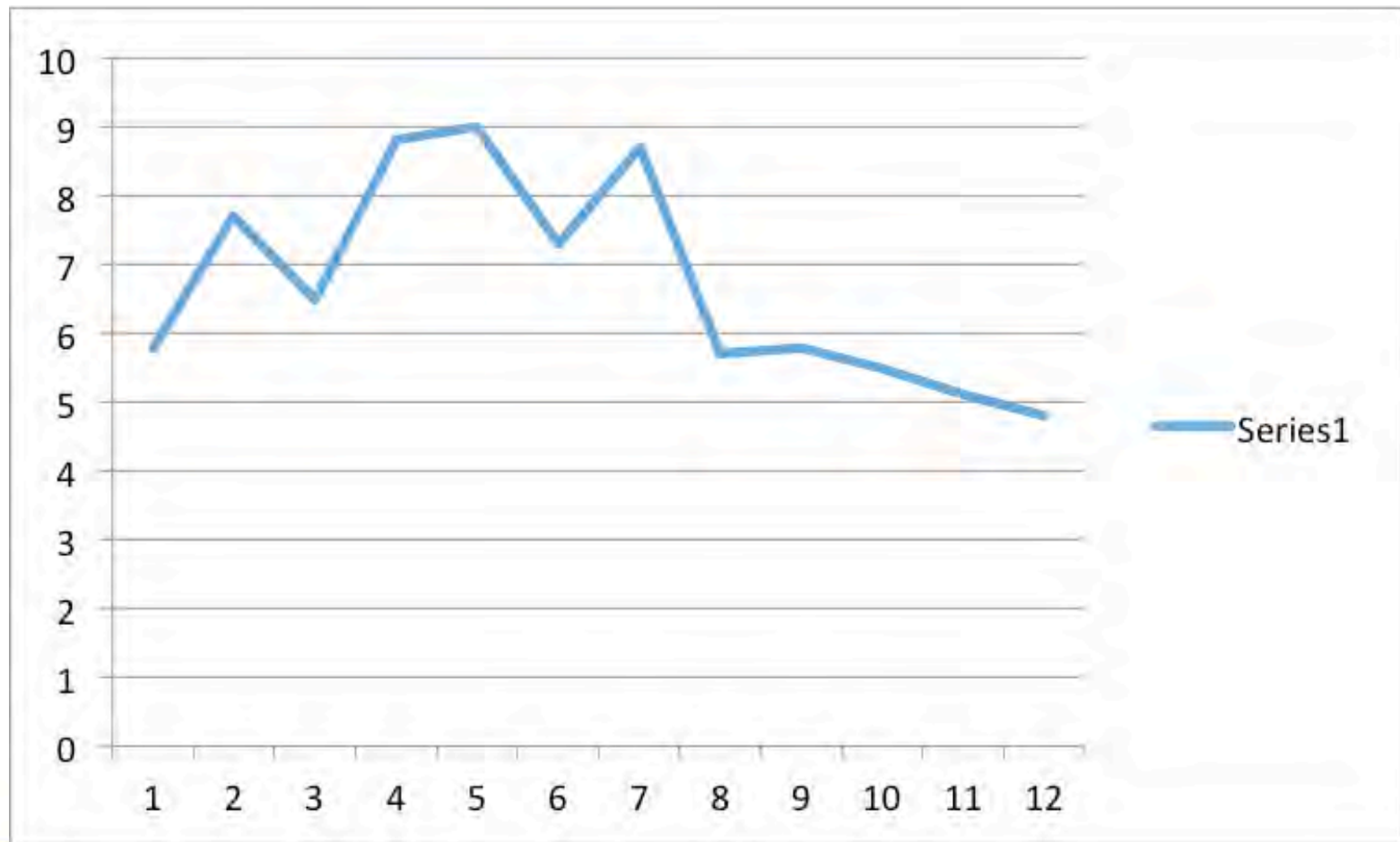


## NPC Post Concussion Fall 2017 – Player 1: Baseline, Day 1, 2,...40



# NPC Post Concussion Fall 2017 – Player 2

BL, Day 1, 2, ... Day 40; Plateau day 18



# Metabolic Cascade Theory of Concussion: Will the injured brain catch up with itself?



# August 2013

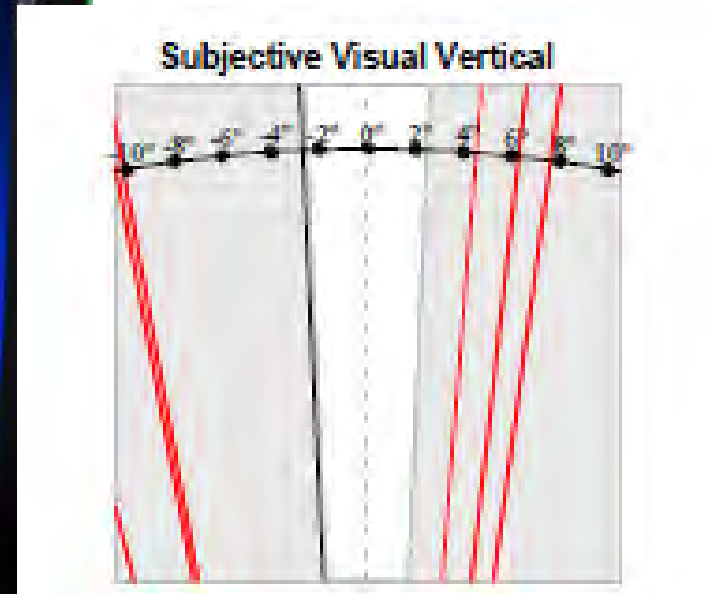
## Coach Niemann:



- “There should be an optometrist on every sideline.”
- “The demise of football won’t be the safety. It will be the cost of football.”

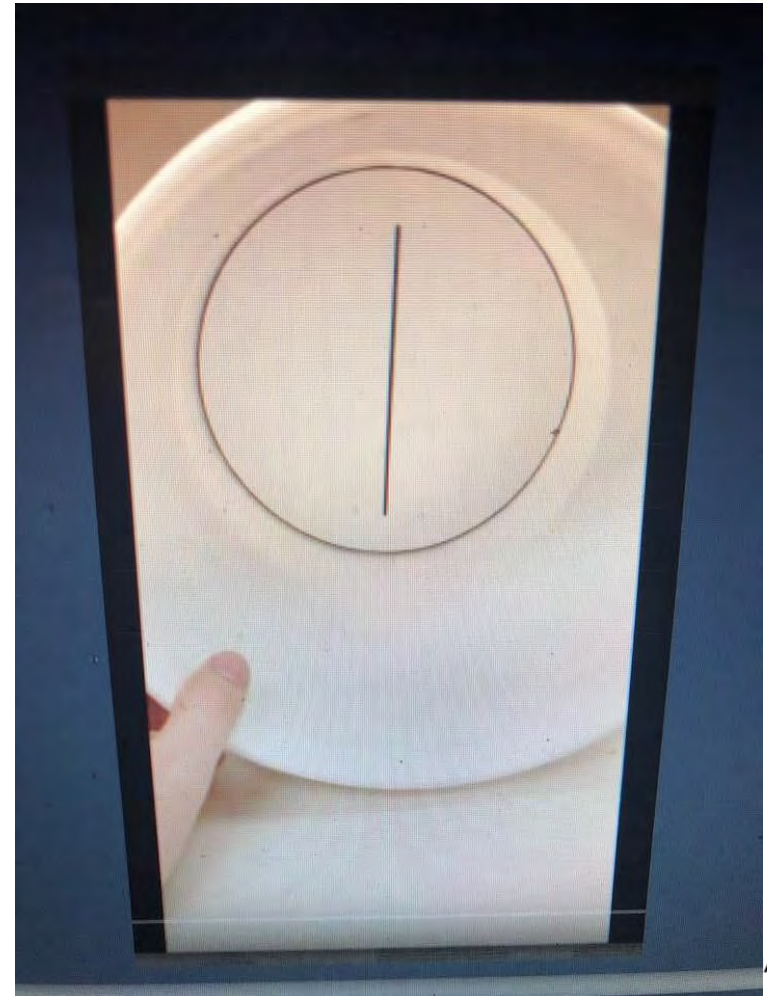


“The demise of football will be the cost of the equipment.”



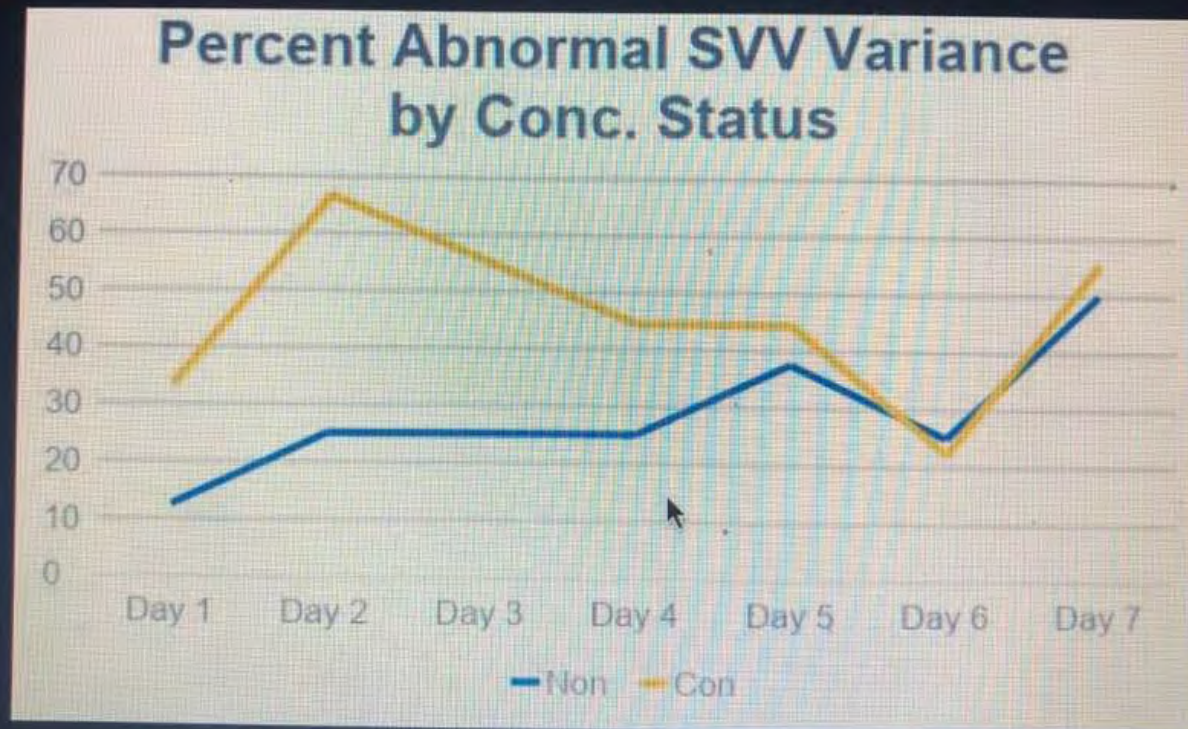


“The demise of football will be the cost of the equipment.”

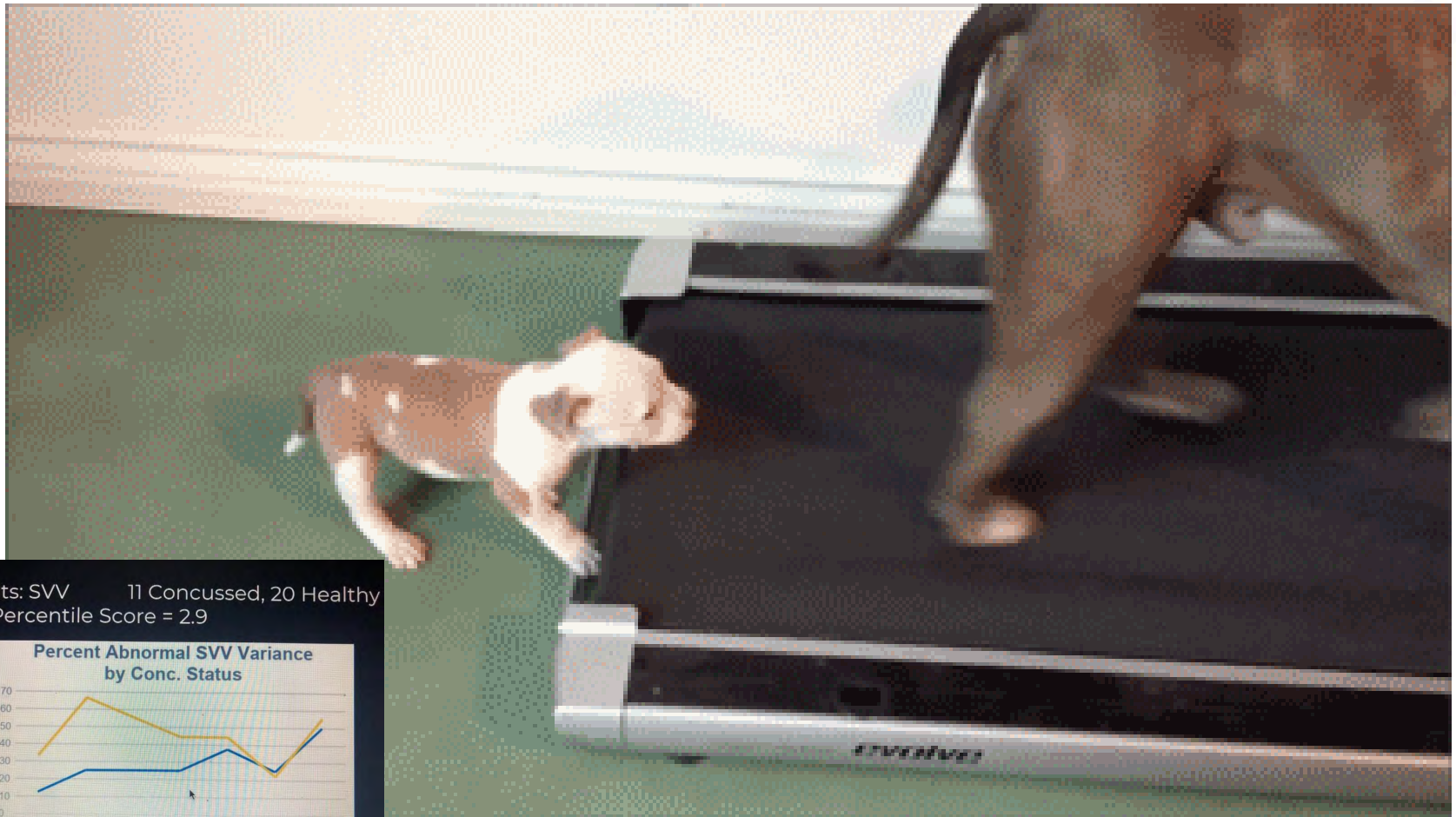


## SVV Sidelines 2017: Day 1 - 6

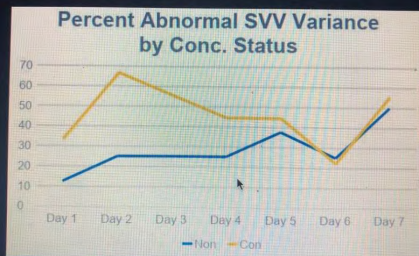
Results: SVV      11 Concussed, 20 Healthy  
68<sup>th</sup> Percentile Score = 2.9



# Metabolic Cascade Theory of Concussion: Will the injured brain catch up with itself?

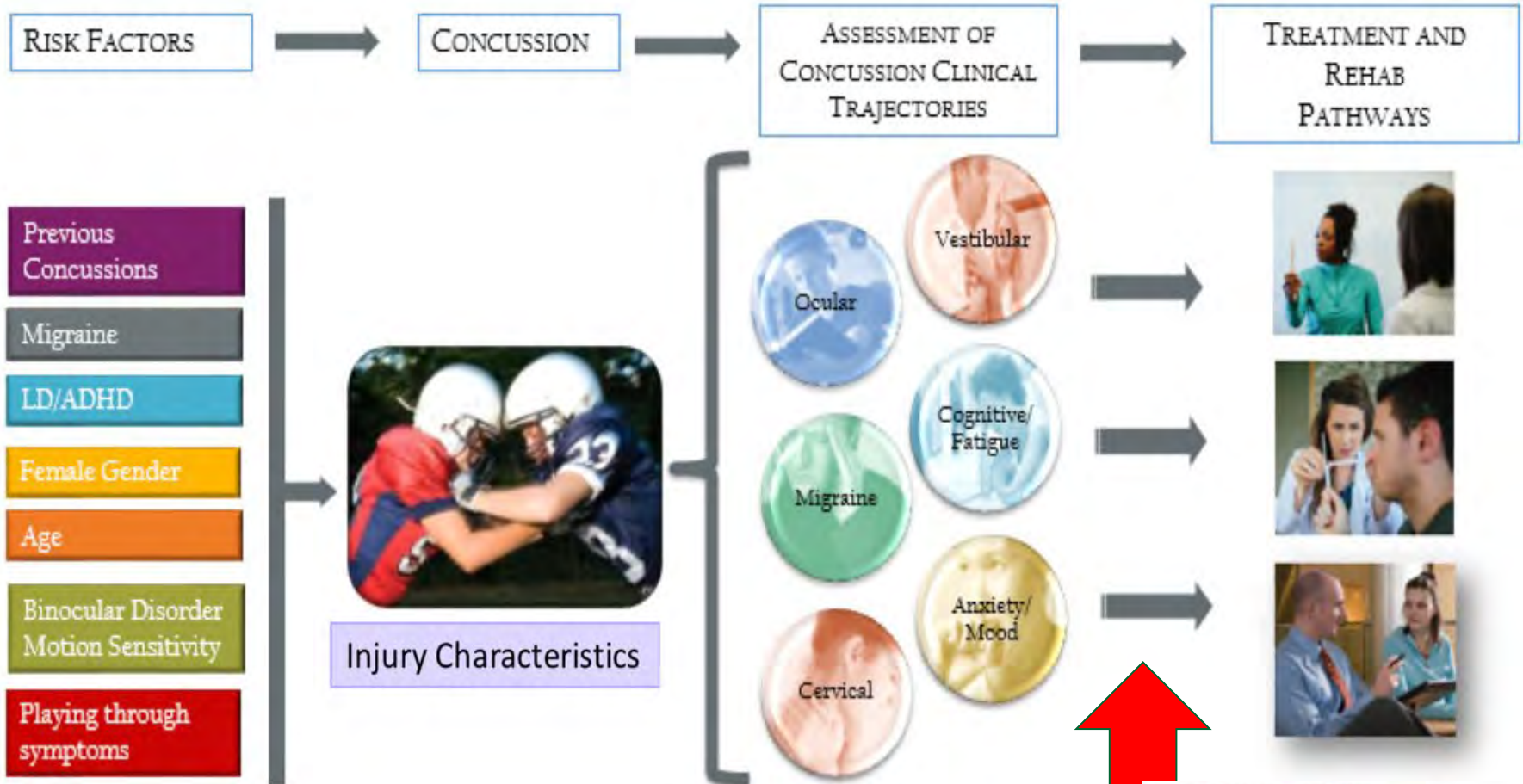


Results: SVV 11 Concussed, 20 Healthy  
68<sup>th</sup> Percentile Score = 2.9



# Vision-related Biomarkers in Concussion?





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WHERE LEGENDS ARE MADE



THE UNIVERSITY OF  
**ALABAMA**

# “Where are the holes in TBEye?”

Suresh, November 2021



## What are the Ideal Characteristics of Tests for Vision-Related Concussion Biomarkers?

Measurable									
Intervenable									
Objective									
Frugal									
Portable									
Fast									
Uncorrectable									
Impactful									
Normed									
Plausible									
Investigated									
Repeatable									
Predictable									

## What are the Ideal Characteristics of **Tests** for **Vision-Related Concussion Biomarkers?**

	NPC	DEM	KD	SVV	NPi	Acc Facility	Acc Amps	Verg Facility	VOMS	VORC
Measurable										
Intervenable										
Objective										
Frugal										
Portable										
Fast										
Uncorrectable										
Impactful										
Normed										
Plausible										
Investigated										
Repeatable										
Predictable										

## What are the Ideal Characteristics of Tests Vision-Related Concussion Biomarkers?

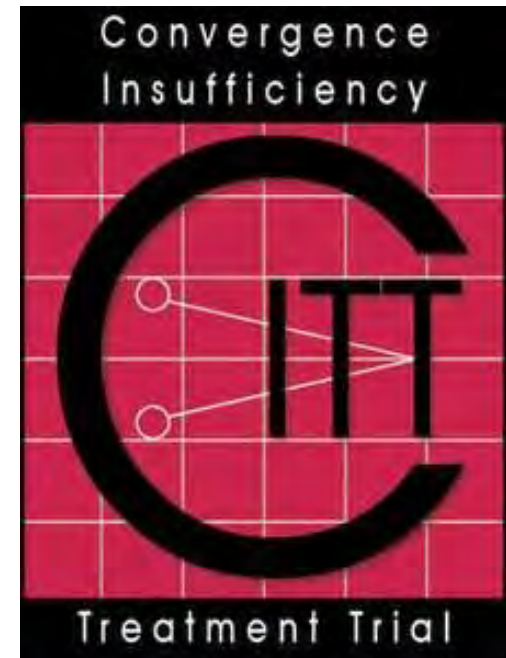
	NPC	DEM	KD	SVV	NPi	Acc Facility	Acc Amps	Verg Facility	VOMS	VORC
Measurable										
Intervenable										
Objective										
Frugal										
Portable										
Fast										
Uncorrectable										
Impactful										
Normed										
Plausible										
Investigated										
Repeatable	0.91	0.895	0.92	0.72	0.985	Not great	Not great	Not great	multi	multi
Predictable										

# Repeatability

- **NPC:** Rouse MW, Borsting E, Deland PN; Convergence Insufficiency and Reading Study (CIRS) Group. Reliability of binocular vision measurements used in the classification of convergence insufficiency. *Optom Vis Sci.* 2002 Apr;79(4):254-64.
- **DEM:** Facchin A, Maffioletti S. The Reliability of the DEM Test in the Clinical Environment. *Front Psychol.* 2018 Jul 25;9:1279.
- **KD:** Weise KK, Swanson MW, Penix K, Hale MH, Ferguson D. King-Devick and Pre-season Visual Function in Adolescent Athletes. *Optom Vis Sci.* 2017 Jan;94(1):89-95.
- **SVV:** Cochrane GD, Christy JB, Kicker ET, Kailey RP, England BK. Inter-rater and test-retest reliability of computerized clinical vestibular tools. *J Vestib Res.* 2021;31(5):365-373.
- Michel AW, Kronberg BP, Narváez J, Zimmerman G. Comparison of 2 multiple-measurement infrared pupillometers to determine scotopic pupil diameter. *J Cataract Refract Surg.* 2006 Nov;32(11):1926-31.

# Convergence Insufficiency Treatment Trial (non-concussed kids)

- Convergence Insufficiency Treatment Trial Study Group. Randomized clinical trial of treatments for symptomatic convergence insufficiency in children. Arch Ophthalmol. 2008 Oct;126(10):1336-49.
- Most highly accessed article in 2008 for Archives of Ophthalmology



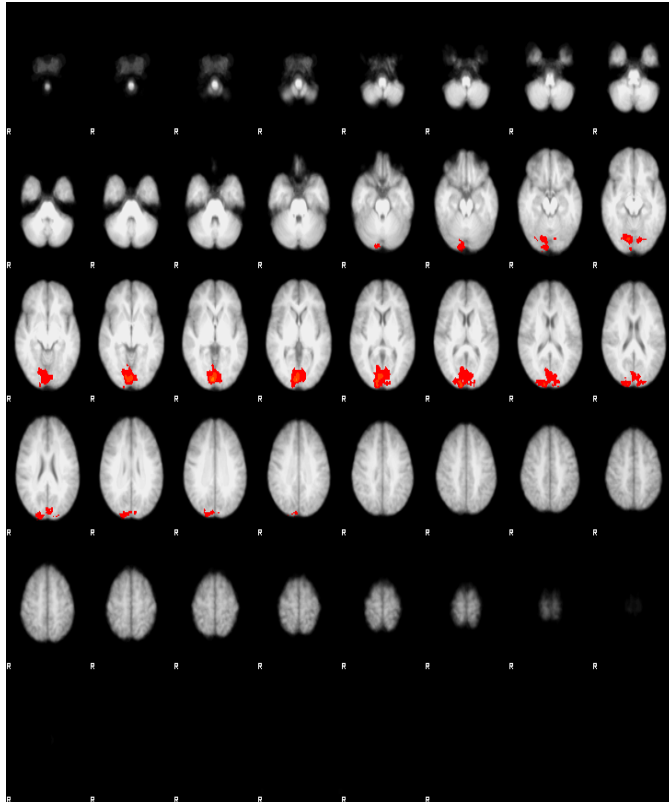
# CITT-ART 2014-2019

- Convergence Insufficiency Treatment Trial – Attention and Reading Trial n = 324
  - Southern California College of Optometry at Marshall B Ketchum University
  - Pennsylvania College of Optometry at Salus University
  - The Ohio State University College of Optometry
  - NOVA Southeastern University College of Optometry
  - University of Alabama at Birmingham School of Optometry
  - State University of New York College of Optometry
  - Akron Children's Hospital
  - Bascom Palmer Eye Institute
  - [www.clinicaltrials.gov](http://www.clinicaltrials.gov)

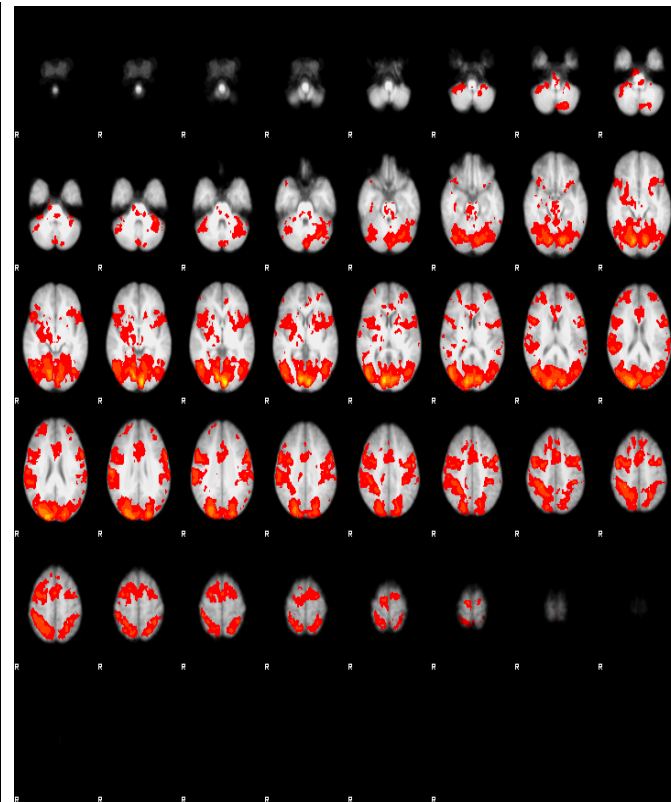


# Oechslin T (PhD OSU/UAB)

## Convergence in Normal binocular vision subjects



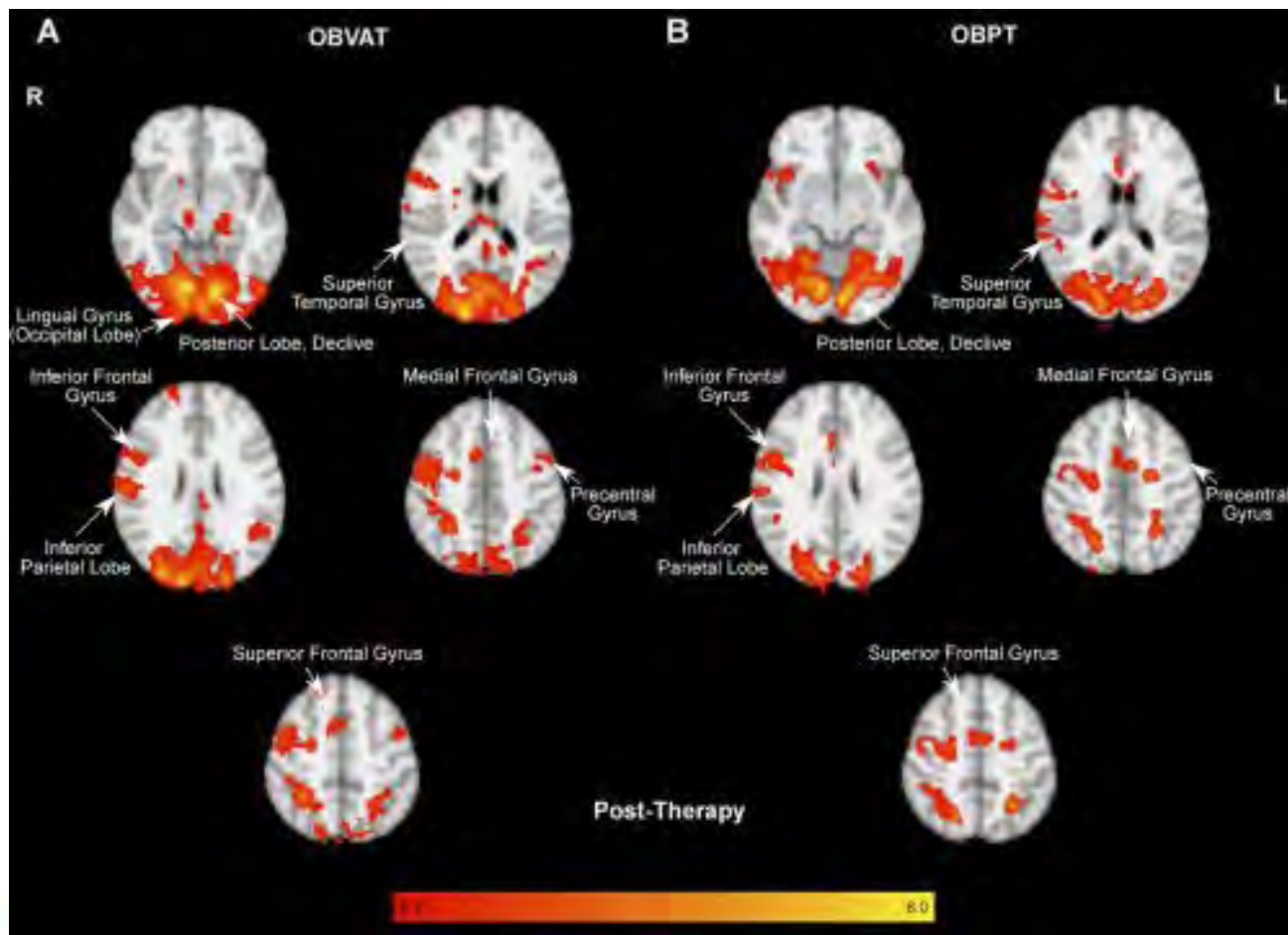
NBV mean



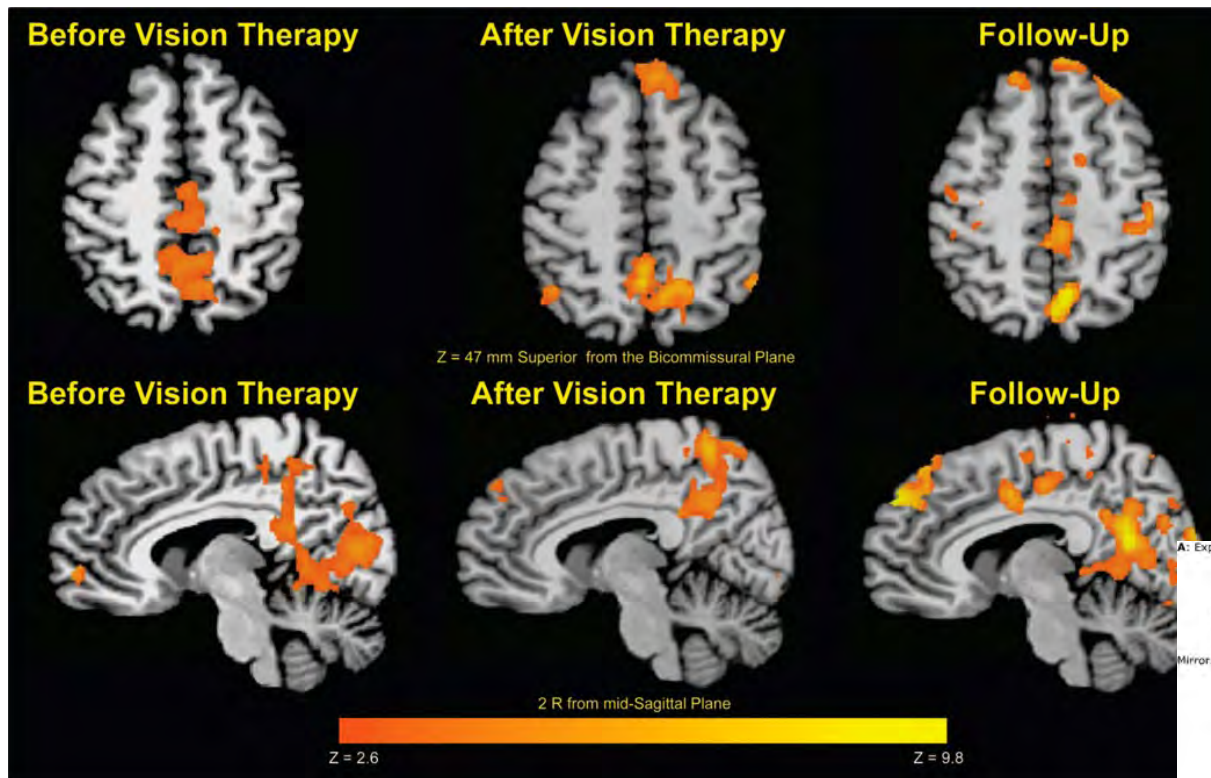
Pre-VT CI mean

## Post-therapy Functional Magnetic Resonance Imaging in Adults with Symptomatic Convergence Insufficiency.

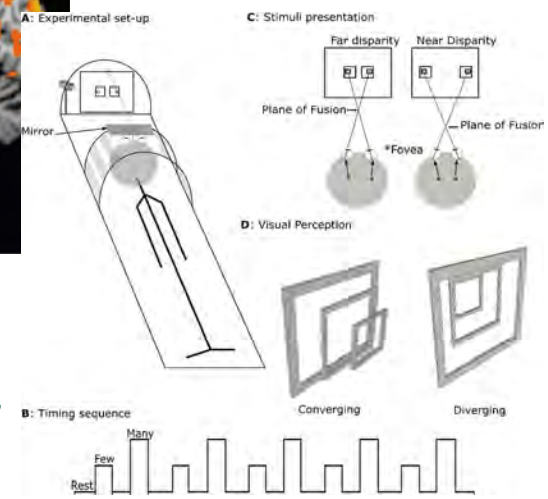
Widmer DE, Oechslein TS, Limbachia C, Kulp MT, Toole AJ, Kashou NH, Fogt N. Optom Vis Sci. 2018 Jun;95(6):505-514.



# T Alvarez, PhD, 2010/OVS



**The Convergence Insufficiency  
Neuro-mechanism in Adult  
Population Study (CINAPS)  
Randomized Clinical Trial: Design,  
Methods, and Clinical Data**  
Tara L. Alvarez,<sup>a</sup> Mitchell  
Scheiman,<sup>b</sup>



## Making NPC better

- 1. Train and certify
- 2. Use Objective response (loss of convergence)
- 3. Place at lateral canthus



# SES and Race as Social Determinants of Health and Race in pre-season VOR testing (Wallace J et al, 2020)

## ORIGINAL ARTICLE

### Socioeconomic status and race as social determinants of health to be considered in clinical use of pre-season vestibular and oculomotor tests for concussion

Jessica Wallace<sup>1\*</sup>, Philip Worts<sup>2,4</sup>, Ryan Moran<sup>3</sup>, Justin Mason<sup>3</sup>, Katherine K. Wessik<sup>3</sup>, Mark Swanson<sup>3</sup>, Nicholas Murray<sup>1</sup>

<sup>1</sup>Department of Health Sciences, University of Alabama, 270 Kilgus Lane, Capitol Hall 2108, Tuscaloosa, AL 35405, United States; <sup>2</sup>Tennessee Orthopaedic Clinic, 3334 Capital Medical Blvd Suite 400 Tallahassee, FL 32309, United States; <sup>3</sup>Department of Nutrition, Food and Exercise Sciences, Florida State University, Tallahassee, FL 32306, United States; <sup>4</sup>Florida State University Institute of Sports Science and Medicine Tallahassee, FL 32306, United States; <sup>5</sup>Department of Occupational Therapy, University of Florida, 1221 Conner Drive, Room 2116, Gainesville, FL 32611, United States; <sup>6</sup>School of Optometry, University of Alabama at Birmingham, 1716 University Blvd, Hurst Patten Building 506, Birmingham, AL 35293, United States; <sup>7</sup>School of Community Health Sciences, University of Nevada, 1664 N. Virginia Street, Box 6274, Reno, NV 89557, United States

#### ARTICLE INFO

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**Keywords:**  
socioeconomic status  
concussion  
vestibular/ocular motor screening  
vestibular  
King-Devick

#### ABSTRACT

**Background:** Aside from racial and socioeconomic disparities in computerized neurocognitive testing and symptomology, there is a scarcity of research representing more diverse populations in other widely used tests for concussion, including vestibular and oculomotor.

**Aim:** The aim of the study was to investigate if racial and socioeconomic differences exist on baseline vestibular/ocular motor screening (VOMS) and King-Devick (K-D) test performance in high school student athletes.

**Methods:** A total of 670 participants (66.1% White, 33.9% Black) with a mean age of 15.43 (± 2 years) were administered a baseline VOMS, average Near Point of Convergence (NPC) distance, and K-D test. The exposure variables included race (White or Black) and socioeconomic status (SES) defined as free and reduced lunch status (FRL or No-FRL). FRL status was determined by each participant's school SES. The outcome variables consisted of baseline VOMS items (component provocation scores, average NPC distance, and K-D baseline time). A series of Mann-Whitney U tests were performed for K-D baseline time, NPC distance, and VOMS items with FRL status or race as a between-subject factor. Two multivariable linear regressions were run to assess the associations of (1) K-D baseline time using FRL, race, sex, and controlled vision as variables in the model and (2) average NPC distance using FRL, race, sex, and controlled vision as variables in the model.

**Results:** When adjusting for multiple comparisons, FRL athletes had slower (worse) K-D times ( $p < 0.001$ ) than non-FRL athletes. Black athletes had significantly lower mean NPC distance compared to White athletes at baseline ( $p < 0.02$ ) and FRL status athletes reported a significantly greater (worse) mean symptom provocation following the visual motion sensitivity item on the VOMS ( $p < 0.02$ ); however, these findings were no longer significant following adjustments for multiple comparisons. No differences were noted for any remaining VOMS items. The first model explained 3.9% of the total variance of K-D baseline time, whereas the second model was not significant.

**Conclusions:** Racial and SES differences existed on average NPC distance and the K-D test at baseline. Possible explanations for group differences may be neurobiological, anatomical, and/or disparity in



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**UAB SCHOOL OF OPTOMETRY**

THE UNIVERSITY OF ALABAMA

Joe Ackerson, PhD (Chair, ASCT):

“Never use a single test to determine concussion or no concussion.”



- **Alabama Statewide Sports Concussion Taskforce (ASCT)**
  - chaired by Dr. Joe Ackerson
- With the assistance of Alabama State Representative Paul DeMarco and the sponsorship of State Representative Ron Johnson and State Senator Greg Reed, and the advocacy efforts and of Steve Savarese, director of the Alabama High School Athletic Association (AHSAA). **2011-541 HB 108** (passed and signed into law in **2011** with a technical amendment added in 2012)
- helps to prevent the long-term adverse consequences of youth concussions by requiring all schools and athletic organizations to:
  - provide information on sports concussions to all athletic participants and their families;
  - ensure that all coaches have training in the recognition of concussions;
  - the immediate removal of any athletic participant suspected of having a concussion from participation and not allow him/her to return the same day they are injured and until cleared by a physician.
- Children's of Alabama (COA) Concussion Clinic - <https://www.childrensal.org/concussion>

# Filling the holes: It is incumbent upon US to:

- Listen Intentionally to ALL
- Help develop ideal testing to monitor vision-related concussion biomarkers
- Collaborate
- Improve
- “There should be an optometrist on every sideline.”



	NPC	DEM	KD	SVV	NPi	Acc Facility	Acc Amps	Verg Facility	VOMS	VORC
Measurable										
Intervenable										
Objective										
Frugal										
Portable										
Fast										
Uncorrectable										
Impactful										
Normed										
Plausible										
Investigated										
Repeatable	0.91	0.895	0.92	0.72	0.985	Not great	Not great	Not great	multi	multi