# Head Games:
## *What Every Parent Should Know About Concussions and the Long-Term Effects of Repetitive Brain Trauma*

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*Co-Founder, Center for the Study of Traumatic Encephalopathy*
*Director, Clinical Core, Alzheimer's Disease Center*
*Boston University School of Medicine*

BOSTON UNIVERSITY

***Beaver Country Day School***
**January 25, 2013**

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sportslegacy INSTITUTE

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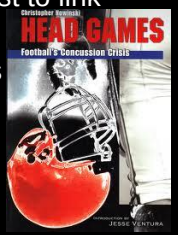
## Chris Nowinski

- Retired from WWE due to persistent symptoms
- Cantu 8th MD seen and first to link brain trauma to Sx
- Wrote book: Head Games
- Co-Founded SLI
- Make sports safer!

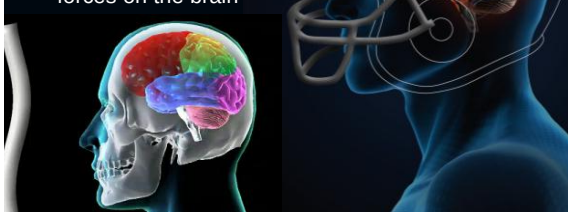


## Concussion

- Concussion is a temporary change in the *functioning* of the brain cells caused by biomechanical force to the head or body, resulting in alteration in mental status and related symptoms and signs.
- Does not require LOC; <1-2%
- Concussion is, by definition, a *non-structural* injury (cannot see it on routine neuroimaging).
- It is NOT a bruise to the brain

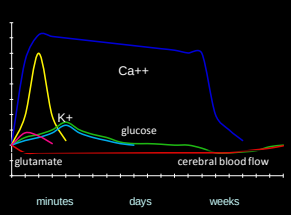
## Concussion:

- Invisible Brain Injury:
  - A result of linear acceleration/deceleration, lateral, and rotational forces on the brain



## Neurometabolic Cascade of Concussion

The brain abnormalities associated with concussion occur at the microscopic, cellular, molecular, and metabolic levels.




Neurometabolic Cascade of Concussion

*Giza and Hovda (2001)*

## Concussion

- Symptoms of Concussion
  - Headache
  - Feeling in a fog
  - Nausea
  - Double or poor vision
  - Fatigue
  - Poor Memory
  - Etc!
- Ding, Seeing Stars, Bell Rung = Concussion
- Again: Very few concussions involve loss of consciousness

## How is a Concussion Diagnosed?

- For now, concussion is a clinical diagnosis, based on the definition provided earlier (in short: a variety of symptoms following a blow to the head or body that could jolt to brain).
- Neurological examination, balance testing, cognitive assessment, SYMPTOMS
- ImPACT Testing is just ONE part of the equation
- Formal and informal sideline testing…..

## Concussion Recovery

- With appropriate rest and recovery, symptoms will resolve (hours to months).
- Rest means both physical and cognitive!
  - No texting, reading, tv, videogames, school
- Rest must continue until symptoms are gone.
- Stepwise return to activities, physical and cognitive.
- Schools play a critical role!

## Stepwise Return to Cognitive Activities

- If symptoms recur at any level, reduce activity, return one step
- This stepwise process could take many more days than described below:
- **Day 1**: Complete cognitive rest
  - Reading, Television, Texting, Schoolwork, Video games, Loud noise
- **Day 2**: When symptom free, add 2 hours of the more familiar and easier of the above tasks, with no more than 30 minutes at one time.
- **Day 3**: If asymptomatic for 24 hours with step #2, add 4 hours of any of above tasks, no more than 1 hour at a time.
- **Day 4**: If asymptomatic for 24 hours, attend half day of school, with no homework. Cognitive activities at home should be light and limited to no more than one hour at a time. If symptoms occur at school, go to the nurse's office, lie down, and skip the next period. If symptoms occur again in the next period after resting, go home.
- **Day 5**: If asymptomatic for 24 hours, attend full day of school, with no homework. Same recommendations apply as in #4.
- **Day 6**: If asymptomatic for 24 hours, resume normal cognitive activity, including homework.

Modified from the Permanente Medical Group: "Understanding Concussion: A parent's guide"

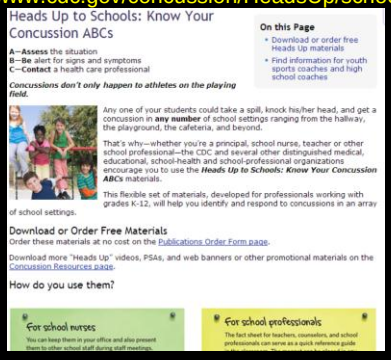
## Stepwise Return to Play

- If symptoms recur at any level, reduce activity, return one step
- This stepwise process could take many more days than described below:
- **Day 1**: Complete physical rest until free of symptoms.
- **Day 2**: Light aerobic exercise (walking, swimming , or stationary cycling) keeping exercise heart rate less than 70% of maximum predicted heart rate. No resistance training
- **Day 3**: Sport-specific exercise (e.g., skating in hockey, running in soccer, any activities that incorporate sport-specific skills). No head impact activities. Progressive addition of resistance training at days 3 or 4.
- **Day 4**: Non-contact training drills.
- **Day 5**: AFTER medical clearance: full contact practice, participate in normal practice activities.
- **Day 6**: Return to competition.

Based on the Consensus Statement on Concussion in Sport: The 3rd International Conference on Concussion in Sport, (Zurich 2008)

## CDC's Heads Up Program

www.cdc.gov/concussion/HeadsUp/schools



Heads Up to Schools: Know Your Concussion ABCs

**A—Assess** the situation
**B—Be** alert for signs and symptoms
**C—Contact** a health care professional

***Concussions don't only happen to athletes on the playing field.***

**On this Page**
- Download or order free Heads Up materials
- Find information for youth sports coaches and high school coaches

Any one of your students could take a spill, knock his/her head, and get a concussion in **any number** of school settings ranging from the hallway, the playground, the cafeteria, and beyond.

That's why—whether you're a principal, school nurse, teacher or other school professional—the CDC and several other distinguished medical, educational, school-health and school-professional organizations encourage you to use the ***Heads Up to Schools: Know Your Concussion ABCs*** materials.

This flexible set of materials, developed for professionals working with grades K-12, will help you identify and respond to concussions in an array of school settings.

**Download or Order Free Materials**

Order these materials at no cost on the Publications Order Form page.

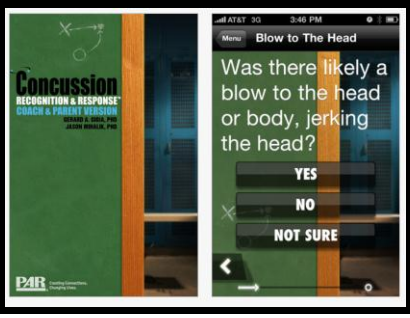
Download more "Heads Up" videos, PSAs, and web banners or other promotional materials on the Concussion Resources page.

How do you use them?

For school nurses

For school professionals

**Smart Phone Apps:**
**"Concussion Recognition & Response"**
**- Gioia & Mihalik (PAR)**




## Second Impact Syndrome

- A second brain trauma quickly following the original concussion may result in "second impact syndrome" (or "second impact dysautoregulation) and possibly death.
- Almost always occurs in youth/teens.
- Mechanism believed to involve the brain losing its ability to auto regulate intracranial and cerebral perfusion pressures, leading to massive and diffuse cerebral edema followed by brain herniation.

## Concussions are the Tip of the Iceberg

## *Subconcussive* Blows

- Impact to brain with adequate *g* force to have an effect on neuronal functioning but No Immediate Symptoms.
- Some sports and positions very prone
  - Football linemen may have 1000-1500 of these hits per season, each at 20-30 *g*.
  - Soccer heading = ~15 *g* also 1000+ per season.
- Car going 35 mph into a brick wall = 20 *g*

## *Force (g)* = Mass x Acceleration

- Athletes are getting bigger and faster!

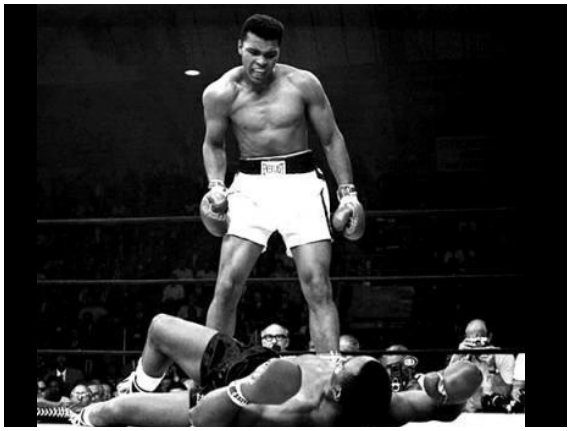
## *Subconcussive* Blows

- Broglio and colleagues (2011) found that high school football players received, on average, 652 hits to head in excess of 15 *g* of force. One player received 2,235 hits!
- Study of high school players at Purdue University (Talavage et al., 2011)
  - Subconcussive hits had impact on cognitive functioning and brain physiology more than concussive hits within season

## Helmets Cannot Fully Protect Against Concussions or Subconcussive Trauma

## Long-Term Consequences of Repeated Concussions and Subconcussive Blows

- After the initial symptoms of concussion resolve and after post-concussion syndrome recovers…
- In some people, a progressive brain disease may develop.




## Dementia Pugilistica

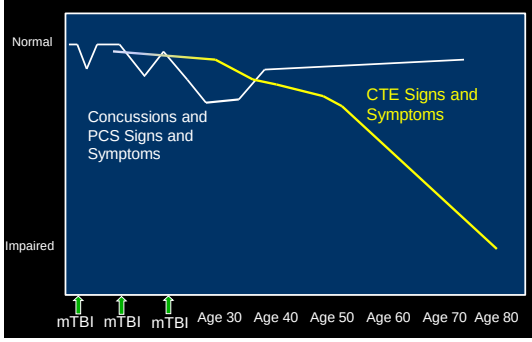
- First described in boxers in 1928 as "Punch Drunk" by Martland in *JAMA*
  - *"goofy…slugnutty…"*
- "Dementia Pugilistica" first used in 1937 by Millspaugh
- We now know that boxers are not the only people who can get this disease


Harrison S. Martland, MD, ca 1940

## Chronic Traumatic Encephalopathy (CTE) *is* Dementia Pugilistica

- Progressive neurodegenerative disease, similar to Alzheimer's disease but is a unique disease.
- Believed to be caused by repeated trauma to brain, including concussions and subconcussive blows.
- Not prolonged post-concussion syndrome.
- Not the cumulative effect of concussions.
- Symptoms begin years or decades after the brain trauma and continue to worsen.

## CTE is Not Long-Term Injury
## It's a Disease that Begins Early and Progresses




## Clinical Features

- McKee et al. (2009): Review of world's literature on CTE/DP
- BU ~ 65 confirmed cases of CTE.
  - All families interviewed (RAS) and medical records reviewed blind to neuropathological diagnosis .
  - Several cases of suicide or suicide-like behavior at early age.
  - Several cases of substance abuse and other addictions (e.g., gambling, sex)

## Clinical Features

- Typically begins in 30's-40's
  - Years or decades following exposure to repetitive brain trauma.
- Slow progression

## Clinical Features – Early Stage

- Cognitive
  - Memory Difficulties
  - Executive Dysfunction (e.g., poor planning, organization, multi-tasking, judgment)
- Behavior
  - Impulse control problems
  - Short fuse
  - "Out of Control"
  - Irritability and Agitation
- Mood
  - Depression and Suicidality
  - Apathy

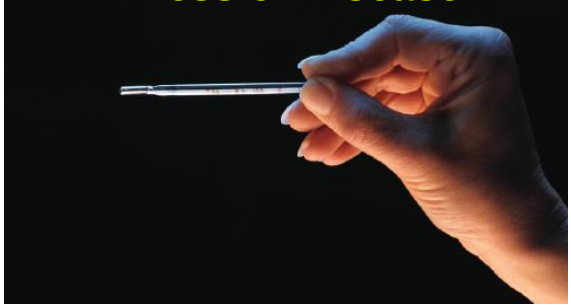
## Clinical Features – Late Stage

- Motor impairment, including speech difficulty, gait problems, poor balance/falling
- Subset with ALS-like symptoms (Chronic Traumatic Encephalomyelopathy)
- Progresses to Full-Blown Dementia

## What is Dementia?

Dementia refers to a new loss of memory and other cognitive functioning that are significant enough to get in the way of routine daily living.

## Dementia is Not an Illness or Disease



## Brain Diseases Cause Dementia

- CTE, Alzheimer's, and other diseases cause Dementia
- There is confusion about football players getting "early Alzheimer's". Probably Not…
- They likely get CTE if they get anything.

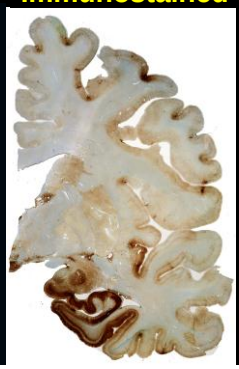
## CTE

- Like Alzheimer's and other neurodegenerative diseases, CTE can currently only be diagnosed postmortem.
- Dr. Ann McKee has examined more brains with CTE than any other neuropathologist and is responsible for all of our neuropathology findings.
  - ~90 brains examined; ~ 70 with CTE

## CTE Neuropathology

- Characterized by an abundance of an abnormal form of the microtubule stabilizer protein, **tau**:
  - Neurofibrillary tangles (NFTs)
  - Neuropil threads (NTs)
  - Glial tangles (GTs)
- Widespread distribution with specific areas:
  - Frontal lobes (behavioral control, personality, "executive functioning")
  - Medial temporal lobes, especially amygdala (emotions, impulses, rage)

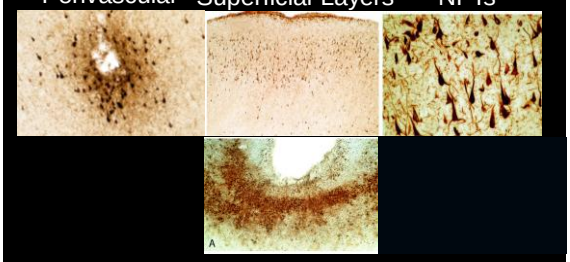
**Hyperphosphorylated Tau Protein**
**Brown = Immunostained for Tau**



## Unique Pathology of CTE

Hyperphosphorylated tau protein as neurofibrillary tangles

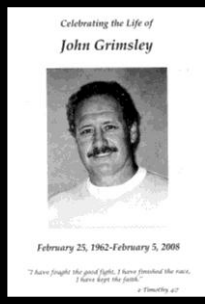
Perivascular Superficial Layers NFTs



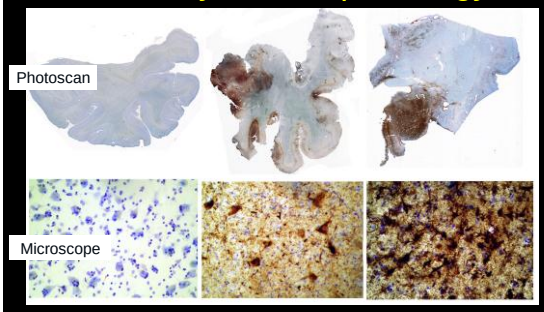

Depths of the Sulci

## John Grimsley - Died at Age 45

- Houston Oilers 1984-1990; Miami Dolphins 1991-1993; Linebacker; Pro-Bowl, 1988
- At least 8 concussions during NFL career.
- Hunting/Fishing guide post NFL
- For the 5 years prior to death at age 45, he experienced worsening memory and cognitive functioning, as well as increasing "short fuse."
- Died of gunshot to chest while cleaning gun. Not suicide.




## Grimsley - Neuropathology

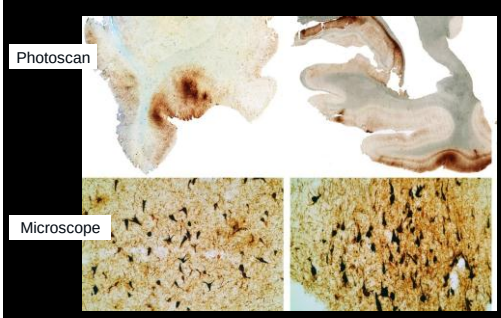



65 yr old healthy control | Grimsley 45 yr old CTE | 73 yr old boxer with dementia and CTE

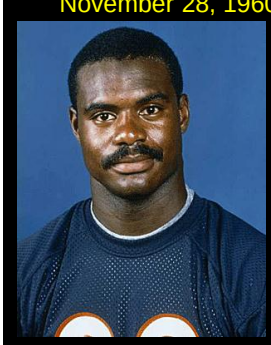
## Tom McHale
## Died at age 45

- Nine-year NFL veteran lineman
- No reported concussions, but as lineman had routine subconcussive blows
- Tampa Bay Buccaneer
- Cornell University graduate, successful restaurateur post NFL, husband and father of three boys
- Died due to drug overdose after a multi-year battle with addiction.

## McHale - Neuropathology

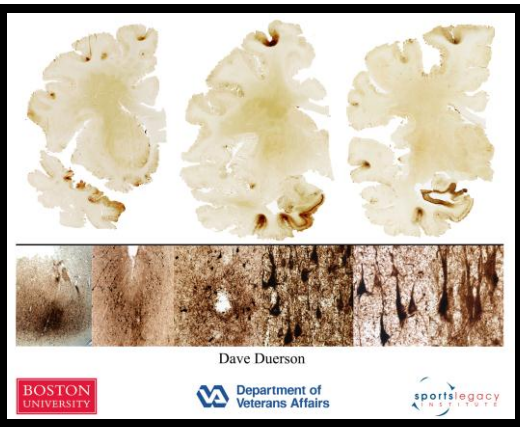



## Dave Duerson – Age 50
November 28, 1960 – February 11, 2011



## Duerson's Clinical History

- Successful businessman post NFL; on NFLPA disability committee.
- ~5 years prior to death, he had worsening short-term memory difficulties
- Increasingly out of control:
  - Short fuse, hot tempered, physically abusive, verbally abusive; lost business, marriage
- Committed suicide Feb 2011, shooting self in chest to avoid hurting brain.




## Junior Seau 1969 - 2012

## Not Just Football

- We have found CTE in 68 individuals, including mostly football players, but also:
  - Boxers
  - Pro Hockey Players – Enforcers
    - Reggie Fleming
    - Bob Probert
    - Derek Boogaard

## Not Just Pros

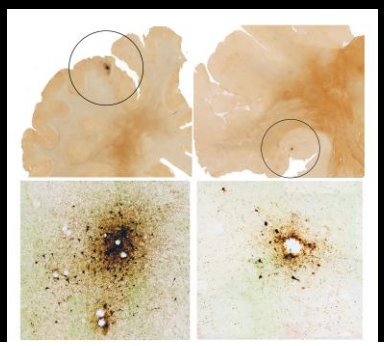
- College Football
- High School Football

## Owen Thomas (age 21)

*ESPN Outside the Lines*

## Eric Pelly – 18 years old

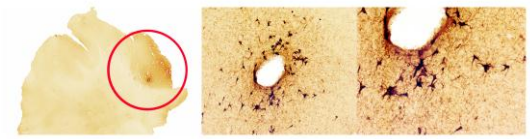
The brain of 18-yo Eric Pelly shows rare isolated areas with tau pathology centered on small blood vessels diagnostic of CTE stage I



## Not Just Pros and Not Just Football

- Military

## CTE in Military



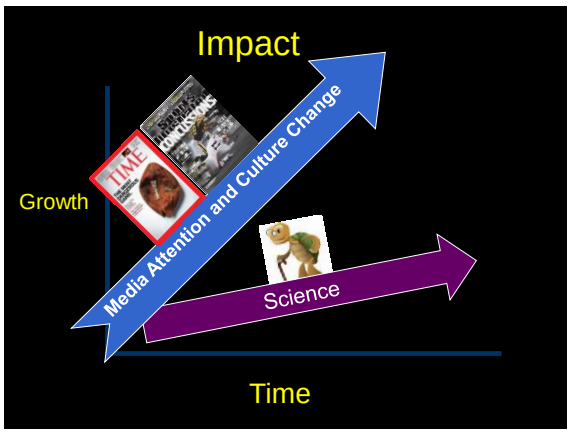
- Goldstein et al (2012): Neuropathologically confirmed CTE following repetitive brain trauma in four male military veterans.
- And developed and tested an animal model of blast injury which resulted in CTE-like changes in the brain even after a single blast.

## Neuropathology of CTE is Now Well-Described

BRAIN
A JOURNAL OF NEUROLOGY

The spectrum of disease in chronic traumatic encephalopathy

- Postmortem description of CTE has had a great impact on public policy and awareness.
- However, the public thinks that the science of CTE is far more advanced than it is.



## CTE Questions

- Is CTE Common?
  - We just don't know!
  - 34 of 35 Pro Football players in VA CSTE Brain Bank have had CTE.
  - What is the denominator? What if next 65 football players' brains were "clean"?
  - Need for longitudinal research with large sample size

## CTE Questions

- Why do some people get CTE and others do not?
  - all neuropathologically confirmed cases (>100) have had h/o repetitive mTBI
  - repetitive brain trauma is a *necessary* but not *sufficient* cause of CTE
- What are the risk factors?
  - Genetics (e.g., APOE)
  - Severity and type of trauma
  - Amount of rest/time between traumas
  - Age at time of first injuries
  - Duration of overall exposure

## Diagnosis of CTE <u>During Life</u> is an Important Next Step

- Differentiate between CTE and other causes of cognitive and behavioral change, including AD, FTLD, PTSD, and persistent/chronic sequelae of previous repetitive mTBI (PCS)
- Understand the true incidence and prevalence of the disease
- Determine the risk factors (including genetic) for CTE
- Begin clinical trials for treatment and prevention

# DETECT

*Diagnosing and Evaluating Traumatic Encephalopathy using Clinical Tests*

*Goal: To Develop Biomarkers to Diagnose CTE During Life*

Principle Investigator: R. Stern
NIH R01 Grant funded by:
*National Institute of Neurologic Diseases and Stroke*
*National Institute of Aging*
*National Institute of Childhood Health and Development*

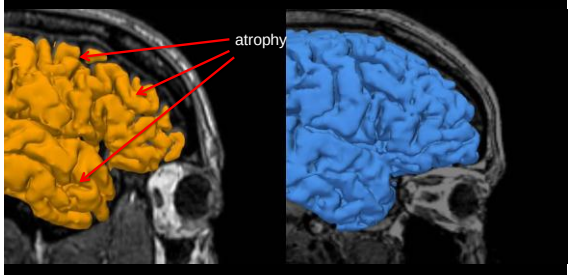
## DETECT

- 100 former NFL players, ages 40-69, with highest exposure to repetitive brain trauma based on positions played; symptomatic.
- 50 same age former elite athletes, asymptomatic, no head trauma exposure
- Neuroimaging (MRI, DTI, SWI, MRS, etc.)
- Lumbar Puncture (CSF Tau, beta amyloid)
- EEG
- Genetics
- Clinical Exams (Neuro, Cognitive, Psych)

## 3D MRI (Shenton *et al*., BWH)

Marked Frontal, Parietal, & Temporal Atrophy

NFL Control

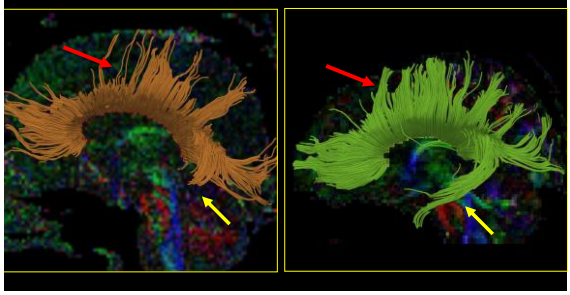


## Diffusion Tensor Imaging (DTI)

(Shenton *et al*., BWH)

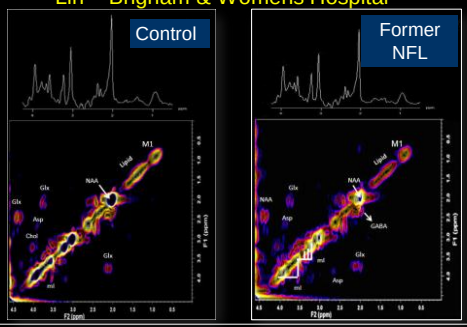
Diminished Corpus Callosum Fiber Bundles

NFL Control



## MRS Biochemical Metabolites

Lin – Brigham & Womens Hospital




statistically significant increases in glutamate/glutamine, choline, phenylalanine, a fucoslyated species and myoinositol.

## Additional Studies

- NIH-Funded BU Alzheimer's Disease Center Repetitive Brain Trauma Cohort
  - 100 older participants with and without Sx, with history of sports-related RBT
  - NACC UDS and FTLD batteries, as well as RBT battery (from R01), MRI, and CSF proteins
  - Compare clinical and biomarker presentations of CTE, AD, and FTD and follow longitudinally

## Additional Studies

- LEGEND: Longitudinal Examination to Gather Evidence of Neurodegenerative Disease
  - Goal of Study: Examine clinical presentation and course of presumed CTE and study potential risk factors.
  - Annual Telephone- and Web-Based Evaluations
  - Participants: 1000 Athletes, age 18+
  - All sports, all positions, with and without brain trauma exposure
  - Assessment: RBT Exposure, Medical History, Formal Cognitive Testing (BTACT), Mood and Behavior Evaluation
  - Saliva/DNA collected at Baseline
  - Follow throughout life => brain donation

## Future Research

- Specific biomarker comparisons between Alzheimer's and CTE, including amyloid and tau PET imaging
- Soccer heading
- Treatment clinical trials
- Genetic and other risk factors
- Additional animal modeling

## Until We Have Answers…

- What should parents do?
- What should schools and leagues do?

## Balance of Protecting our Kids and Avoiding Knee-Jerk Decisions Not Based on Data

## Major Policy and Rules Changes for Concussion Detection and Management

- NFL
- Ivy League
- Southeast Conference
- Pop Warner

## Major Policy and Rules Changes for Concussion Detection and Management

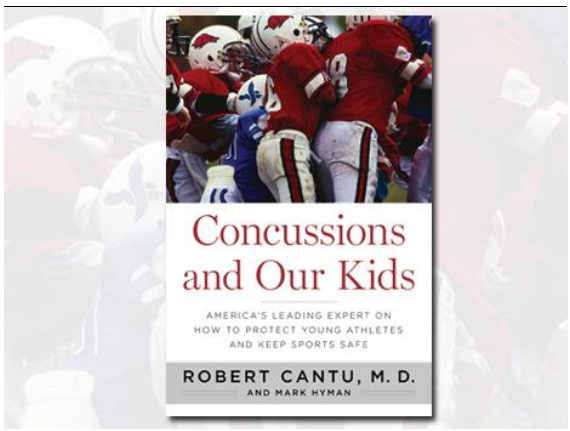
- 30+ State laws (MA certification)
- Not Private Schools

## What about Subconcussive Trauma? Reduce Overall Exposure To Repetitive Brain Trauma

- Reduce full-contact practices in football, hockey, boys lacrosse
- Reduce or eliminate heading drills in soccer
- Begin contact sports at older age
- Improve neck and upper body strength

## Available Resources

- www.cdc.gov/concussion/sports
- www.sportslegacy.org
- www.sportsconcussions.org
- www.childrensnational.org/score
- www.headgamesthefilm.com



## Hit Count - SLI

- Based on Pitch Count
- Goal of developing and promoting numerical guidelines to regulate the amount of brain trauma that a child is allowed to incur in sports

Hit Count™ SPORTS LEGACY INSTITUTE

CONCUSSION COALITION.ORG

SLI SPORTS LEGACY INSTITUTE

CONCUSSION CHECKLIST

- ✓ **REQUIRE** preseason education all stakeholders
- ✓ **RECOMMEND** baseline testing for both remove-from-play and return-to-play
- ✓ **RECOGNIZE** the symptoms of a brain injury
- ✓ **RESPOND** appropriately to concussion symptoms
- ✓ **REMOVE** players with signs or symptoms of a brain injury for the rest of the day
- ✓ **REST** concussed players both physically and cognitively
- ✓ **REQUIRE** clearance from a medical professional trained in concussion management
- ✓ **REDUCE** exposure to brain trauma by using Hit Count™ technology
- ✓ **RESPECT** the head by aggressively penalizing dangerous play
- ✓ **REINFORCE** proper techniques to minimize the risk of brain trauma
- ✓ **REINTRODUCE** the forgotten art of neck strengthening
- ✓ **REJECT** helmets greater than 10 years old
- ✓ **REVOLUTIONIZE** sports by changing the culture of the game

*IN RETURN FOR AGREEING TO IMPLEMENT THE MEASURES LISTED ABOVE TO THE BEST OF YOUR ABILITY, YOUR ORGANIZATION IS ELIGIBLE TO RECEIVE THE SLI "HEADS FIRST" CERTIFICATE.*

SLI Official Education Partners

BROCK

DMR

## BU CSTE Funding

National Institutes of Health
NINDS/NIA/NICHD R01 NS078337

Boston University Alzheimer's Disease Center -NIA
NIA P30 AG13846 supplement 0572063345-5

Boston University School of Medicine

Department of Veteran's Affairs

NFL – Unrestricted Gift

NFL Players Association – Travel for study participants

JetBlue – Travel for study participants

Center for Integration of Medicine and Innovative Technology (CIMIT) - Grant

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