Sports Related Concussions

The King-Devick Test: the Science & Implementation
King-Devick Test: the Today Show

CLICK HERE for Video: King-Devick Test on the Today Show
Concussion by the Numbers

- Highest rates: Boy’s football & Girl’s soccer
- Epidemiology: **1.6 – 3.8 million** annually
- Concussions drawing national attention
- NFL interest in Chronic Traumatic Encephalopathy (CTE)
- 20-30% of Alzheimer’s patients report head trauma vs. 8-10% of controls
- Estimated **85%** go undiagnosed
- Need for validated, rapid screening tests

Thurman et al., 1998; Guskiewicz et al., 2000; Langlois et al., 2006; American College of Sports Medicine 2006; Guskiewicz et al., 2003; Collins et al., 2003; Mitka 2010; Halstead & Walter, 2010; Meehan et al., 2011;
Concussion Biomechanics

- Concussion or mTBI (mild traumatic brain injury)

- Linear & rotational accelerations cause:
  - Axonal shearing & stretching
  - Ionic imbalance, Biochemical cascade events
  - Disrupted neurotransmission

Meaney & Smith, 2011; Maruta et al, 2010
Signs & Symptoms

- **Emotion:**
  - Irritability
  - Anxiety
  - Depression
  - Extreme emotions

- **Cognitive:**
  - Concentration
  - Processing speed
  - Memory
  - Thinking

- **Sleep:**
  - Abnormal sleep
  - Difficulty sleeping
  - Excessive sleep

- **Physical:**
  - Saccadic dysfunction
  - Headache
  - Nausea
  - Balance
  - Vision/Diplopia
  - Sensitivity to noise and light

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US Dept of Health & Human Services CDC, 2012
Complications of Concussion

SHORT-TERM

- Increased risk of subsequent concussion
  - 3-4x more likely to sustain another concussion within 7-10 days

- Risk of Second Impact Syndrome
  - Sustaining a second concussion before “recovery” from first concussion
  - Rare complication
  - Majority in pediatric/adolescent populations (<20 years)
  - Enhancement of cerebrovascular congestion
    - Diffuse cerebral edema
    - Catastrophic outcome, Death within minutes in majority of cases

Guskiewicz et al., 2003; Holsinger et al., 2002; Plassman et al., 2000; Gavett et al. 2011, Meehan & Bachur, 2009, Putukian et al. 2011
Complications of Concussion

LONG-TERM

- Post-Concussion Syndrome
  - Prolonged concussion symptoms >3mos

- Correlation to neuro-degenerative
  - Chronic Traumatic Encephalopathy (CTE)

Guskiewicz et al., 2003; Holsinger et al., 2002; Plassman et al., 2000; Gavett et al. 2011, Meehan & Bachur, 2009, Putukian, 2011; Scherwath et al., 2011; Mitka et al., 2010; McKee et al. 2009; Guskiewicz et al., 2005
Complications of Concussion

LONG-TERM

- Correlation to neuro-degenerative disease
  - Alzheimer’s Disease
    - 20-30% Alzheimer’s patients report history of head trauma
    - vs. 8-10% of controls
  - Cognitive Impairment
    - 15% have cognitive impairment even after just ONE concussion
    - Retired professional football players with history of concussion 5x diagnosed with MCI (mild cognitive impairment)

Guskiewicz et al., 2003; Holsinger et al., 2002; Plassman et al., 2000; Gavett et al. 2011, Meehan & Bachur, 2009, Putukian, 2011; Scherwath et al., 201; Mitka et al., 2010; McKee et al. 2009; Guskiewicz et al., 2005
Approximately **85%** of sports-related concussions go undiagnosed

CLICK HERE for Video: Chris Nowinski

**Chris Nowinski**

Executive Director, Sports Legacy Institute  
Co-Director, Center for Study of Traumatic Encephalopathy  
Boston University School of Medicine

Source: American College of Sports Medicine
Challenges:
Recognition and Management of Concussion

1. Wide variety of symptoms:
   – easily “missed” by coaches, medical staff
1. Denial of symptoms (“I feel fine”)
   ▶ Metabolically-mediated euphoria (McKee 2010)
2. Most evaluation & management protocols not evidence-based
3. Traditional neurological / radiological studies
   (CT, MRI, EEG) normal with mTBI
   ▶ Metabolic vs. structural changes

There is a need for objective, validated sideline
Remove-From-Play concussion screening tools
Expert Opinion and Clinical Observation are the LOWEST forms of scientific evidence
Concussion Testing

Two types of tests:

1. Remove from Play (Screening/Diagnosis)
   - Sport Concussion Assessment Tool (SCAT2), Standardized Assessment of Concussion (SAC)
   - King-Devick Test (K-D test)
   - Hit Accelerometers (X2, Check Light)

2. Return to Play/School (Management)
   - REST (cognitive & physical)
   - Neurocognitive tests
   - CDC Return to Play Protocol
   - Ocular Motor Integrated training

King-Devick Test for Concussions

- Test of rapid number naming & eye movements

- Speed & error compared to baseline time
  - Best of 2 trials to determine Baseline Time (learning effect)
  - Retest after suspected head injury: INCREASED time or ERRORS $\rightarrow$ Concussion

*Can be administered by coaches/parents (non-medical professional)
*May help coaches/trainers with game time decisions

Galetta et al., 2011
King-Devick Test:
On The Sidelines

Eric Laudano, MHS, ATC
Head Athletic Trainer
Univ. of Pennsylvania

Laura Balcer, MD, MSCE
Vice Chair of Neurology, NYU Langone Medical Center
Professor of Neurology, Ophthalmology, Epidemiology at NYU School of Medicine

CLICK HERE for Video: King-Devick on Sidelines
Neurology of Concussion

- Many symptoms not captured by cognitive testing
- Vision alone accounts for >55% of the brain’s pathways
- Planning and execution of saccades involves a wide network of anatomical structures in the brain:
  - Frontal eye field (Frontal Cortex)
  - Dorsolateral prefrontal cortex
  - Supplementary motor area
  - Posterior parietal cortex
  - Middle temporal Area
  - Occipital Lobe, Striate cortex
  - Thalamus
  - Superior Colliculus
  - Brainstem structures

- Impaired eye movements are an indicator of suboptimal brain function (*Heitger et al, 2002*)

*Heitger et al, 2002; Heitger et al, 2010; Maruta et al, 2010; Pierrot-Deseilligny et al., 2005; Gaymard et al., 1998*
The King-Devick Test is an accurate and reliable method for identifying athletes with head trauma, and is a strong candidate rapid sideline screening test for concussion.

“...addresses the need for a quick, reliable test that can accurately identify concussion and thus reduces the potentially devastating effects of second impact syndrome and recurrent neurological injury.”

“Because the K-D test does not require a medical professional and can be administered in 1-2min, it is practical for sideline use at all levels of sports. The K-D test has the potential to capture brain impairment not observed in standard neurocognitive testing”

“...able to identify players with a suspected concussion, players with a concussion that was not reported or witnessed.”

“...the ease-of-use made it more acceptable to team management and players and, as it provided immediate feedback to the player and coach.”

“... the K-D test served to provide support for the decision made by the team medic to rule out the player from further match participation.”
“Three football players whose concussion diagnosis was confirmed by a neurologist did in fact demonstrate diminished KD test performances times.”

“Two players tested rink-side immediately following concussion had KD scores worsened from baseline. These athletes had no differences found for SCAT2 SAC components, but reported symptoms of concussion.”

“The K-D test was associated with reductions in Immediate Memory Scores and the overall SAC score.”

“…suitable for rapid assessment in a limited time frame on the sideline such as a five-minute window to assess and review suspected concussed players in rugby union.”

“…able to identify players that had not shown, or reported, any signs or symptoms of a concussion but who had meaningful head injury.”

“Three football players whose concussion diagnosis was confirmed by a neurologist did in fact demonstrate diminished KD test performances times.”

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King-Devick Test: Boxers & MMA Fighters Study

- Boston, MA

- K-D scores worse after head trauma
- K-D scores worse with loss of consciousness

Gaetta et al. Neurology. 2011
King-Devick Test: Penn Collegiate Athlete Study

- Football, Basketball, Soccer

- K-D scores **worse** after concussion
- K-D scores **not worse** after exercise

Galetta et al. *J Neurol Sci.* 2011
King-Devick Test: Amateur Rugby Studies

- New Zealand
- **Pilot Study:**
  - Participants: 50 athletes over 12 matches
  - Concussions: 5
    - 3 witnessed/self reported
    - **2 incidental, un-witnessed**
      (detected on post-game assessment with King-Devick test)

- **Follow-up Study:**
  - Participants: 37 athletes over 24 matches
  - Concussions: 22
    - 5 witnessed/self reported
    - **17 incidental, un-witnessed**
      (detected on post-game assessment with King-Devick test)

Saccades & Memory

Professional Ice Hockey: Philadelphia Flyers

- 27 athletes, 2011-2012 season

- Worse KD scores associated with:
  - Lower SCAT2 SAC Memory score
  - Lower overall SAC score

- 2 concussed athletes exhibited:
  - Abnormal KD test
  - Normal SCAT2 SAC test
  - +Symptoms

Working memory and saccades share closely related anatomical structures, including the dorsolateral prefrontal cortex (DLPFC)

Concussions in High School Football

- Participants: 47 high school football players, 2012 season

- Concussions: 3
  - Concussion confirmed by neurologist
  - ALL abnormal KD scores
    - Student 1: 41% worse
    - Student 2: 100% worse
    - Student 3: 143% worse

- Test-retest Reliability: ICC = 0.873 (p<0.05)

Poster Presentation at the Association for Research in Vision and Ophthalmology Annual Meeting 2013

King-Devick Test: Wheaton College Football

- Evans, G et al., unpublished data 2012

**Baseline vs. Concussion**
- $P = 0.004$ vs Baseline

**Baseline vs. Post-Workout**
- $P = 0.01$ vs Baseline

**Baseline vs. Post-Season**
- $P = 0.03$ vs Baseline

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*Evans, G et al., unpublished data 2012*
King-Devick Test: Sports Parents Study -- Pending Publication

- n=34 amateur boxers
- Ringside physician using MACE
- 6 Layperson testers in off-ringside testing room

- **Single boxer** sustained concussion (per ringside physician)
  - Accurately identified by layperson K-D tester
    - **3.2s** worsening compared to baseline

- In the absence of concussion, post-fight K-D scores better than baseline scores
  - Fatigue does not worsen K-D test performance

- High test-retest reliability: **ICC 0.90**
- **K-D test Reliably & Effectively Administered by Sports Parents**
King-Devick Test, ImPACT & Symptoms

- N=35 (12-19yo) concussed patients
- Evaluated with KD, ImPACT and Post-Concussion Symptom Scale (PCSS) over 4 clinical visits
- KD times improved with each visit and paralleled improvements in PCSS
- KD test is effective in objectively monitoring concussion recovery and symptom resolve

Tjarks B et al. 2013
Practice Management: Incorporating King-Devick into your practice

- **Educational Outreach**
  - Educate communities about sports concussions and the science behind the K-D test
  - Teach coaches/parents to administer the test and implement on sidelines

- **Create Brand Awareness for your Practice**
  - Offer K-D baseline testing at annual exam or at a pre-season practice
    - K-D baselines take 2 minutes, Technician can administer during pre-testing
    - Patient capture & retention: K-D baselines required EVERY year, encourages YEARLY office visit
King-Devick Test for Neurological Function

- **KD test for Neurological functions:**
  - **Multiple Sclerosis**
    - Penn & NYU: Disability and Quality of Life indicator
  - **Parkinson’s disease**
    - MAYO clinic: “Rapid tool for quantifying visual & cognitive function in Parkinson’s”
  - **Sleep Deprivation**
    - Penn: KD is sensitive to effects of sleep deprivation on cognitive functioning
  - **Hypoxia**
    - MAYO: KD test is an early indicator of hypoxia incapacitation
King-Devick Test Baseline: Normoxia
King-Devick Test: Under Hypoxic Condition
Practice Management

- Enhance your practice with evidence based science & technology
  - Annual K-D Baselines in your office
  - Post-injury evaluations & coordinated management
  - Ocular Motor Integration
  - Reading Remediation
  - Neurological function testing and monitoring with MAYO/Tobii/KD technology