Interesting Concussion Case Studies

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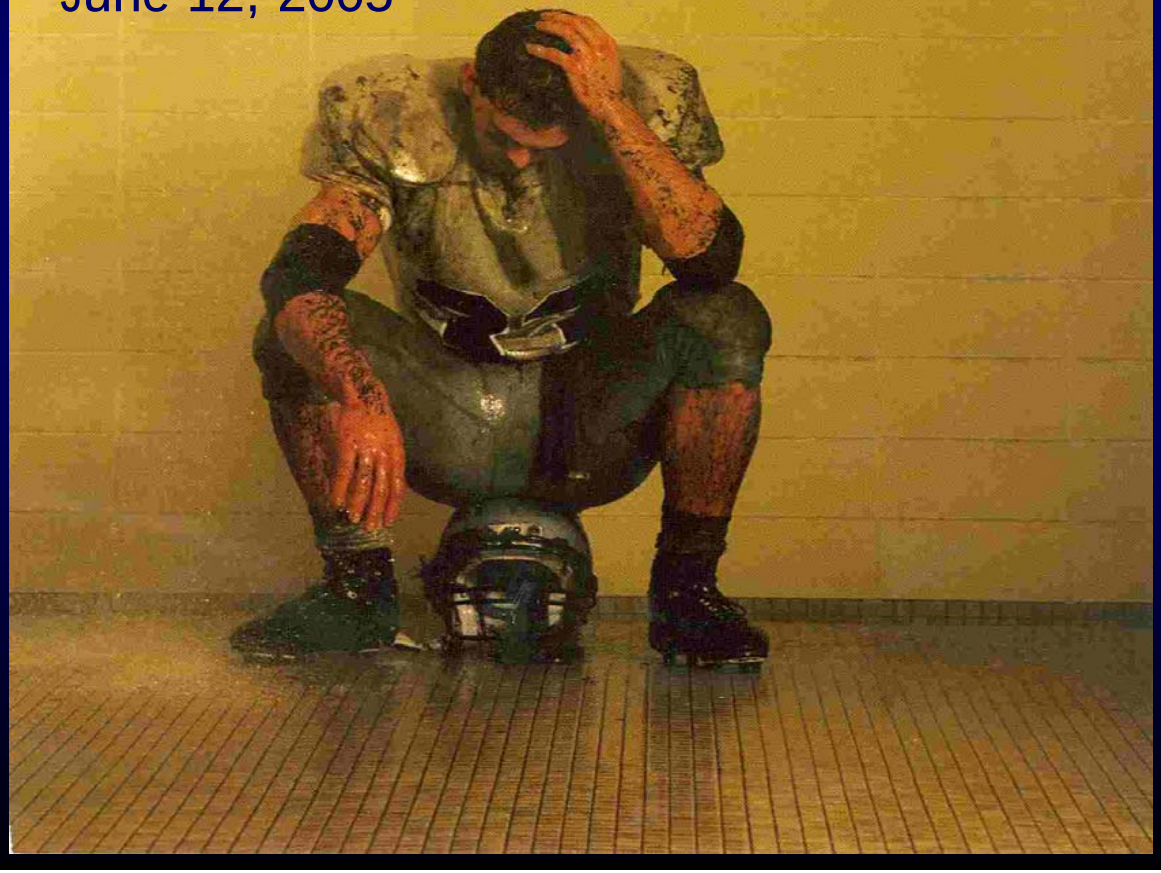
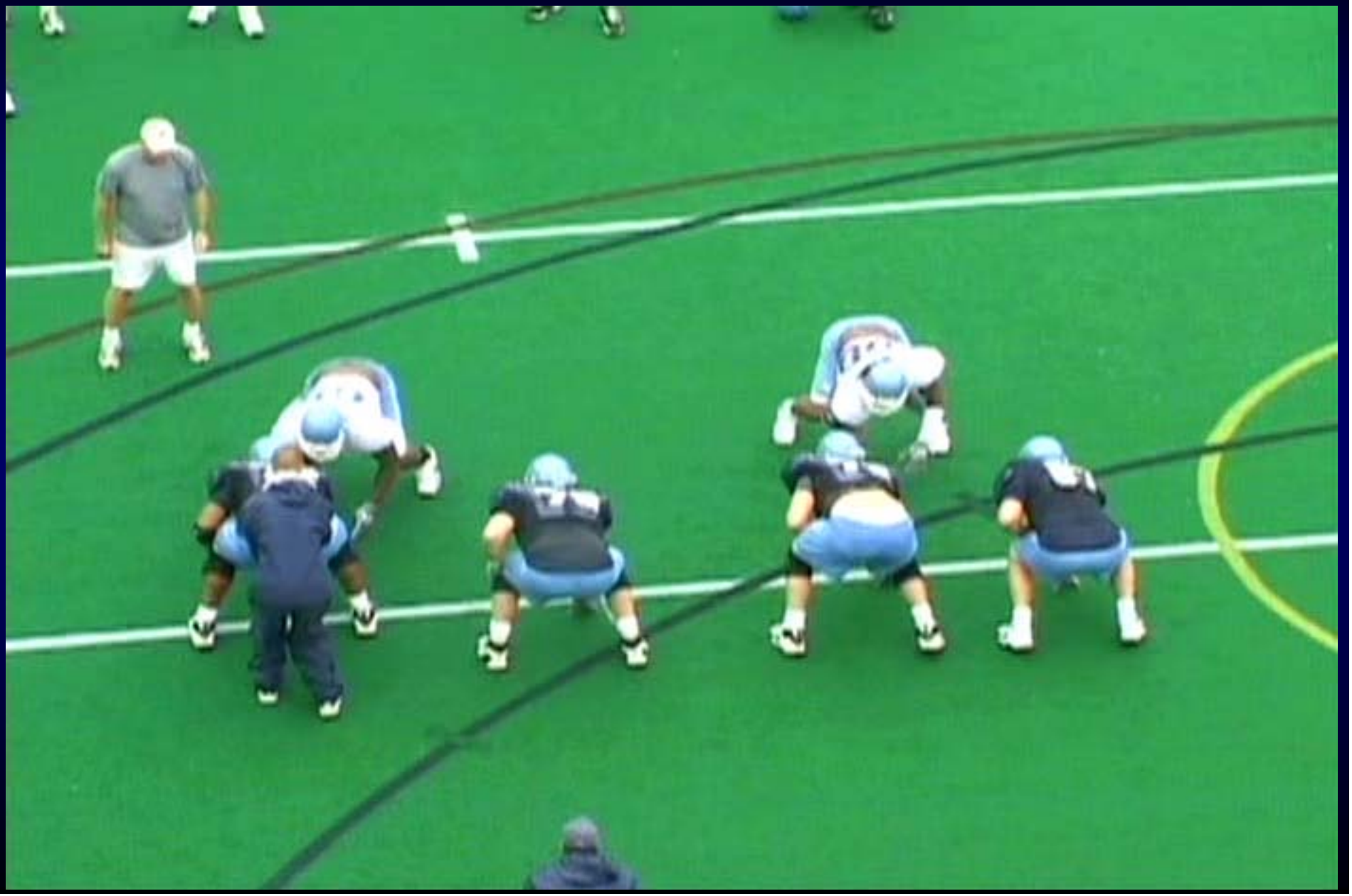
2005 NATA Advanced Track
Indianapolis, IN
June 12, 2005



Case 2 – Collegiate Football Player

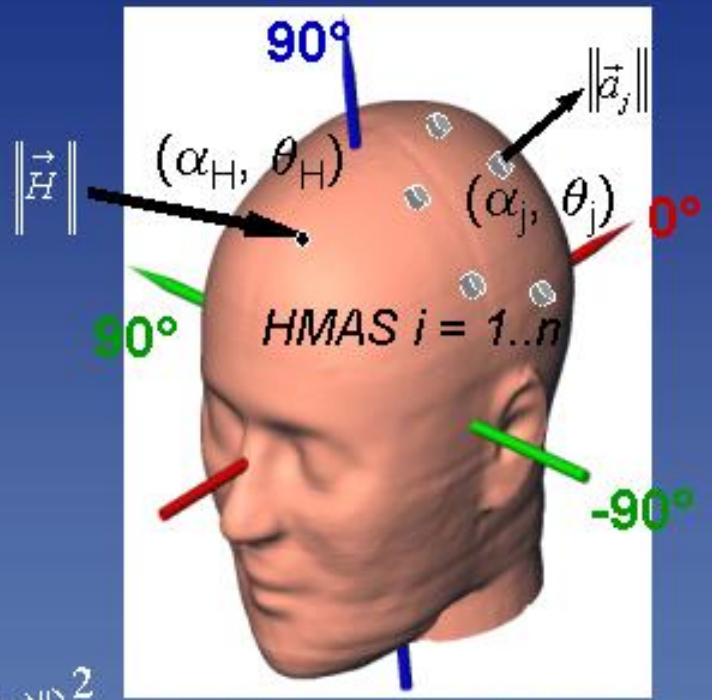


Accelerometry Instrumentation

- Head Impact Telemetry System (HITS)
- Sensors embedded in the padding of helmet
- Measures and records blows to the head:
  - Impact location
  - Impact magnitude
  - Impact duration
  - Linear and angular acceleration components
  - Exact times of impacts

HIT System™
Impact Algorithm

- Determines *magnitude* and *direction* of head c.g. acceleration (H) from 6 single axis accelerometers
- Determines 2 of 3 rotational accelerations depending on impact location (no z-axis rotation)



Head Coordinate System
Azimuth = α
Elevation = θ

$$\sum_{i=1}^{n}\left(\left\|\vec{H}\right\|\left(\cos\alpha_i\cos\alpha_H\cos\left(\theta_i-\theta_H\right)+\sin\alpha_i\sin\alpha_H\right)-\left\|\vec{a}_i\right\|\right)^2$$

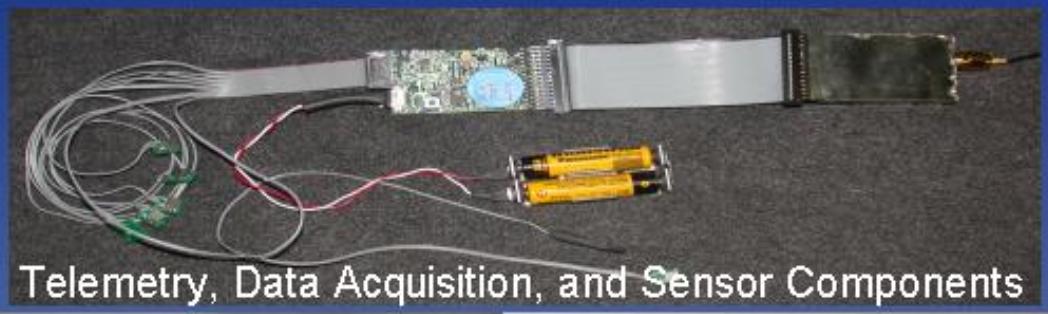
Simbex

HIT System Hardware

The HIT System™

Accelerometry Instrumentation

HIT System™
Hardware in the Helmet



Telemetry, Data Acquisition, and Sensor Components

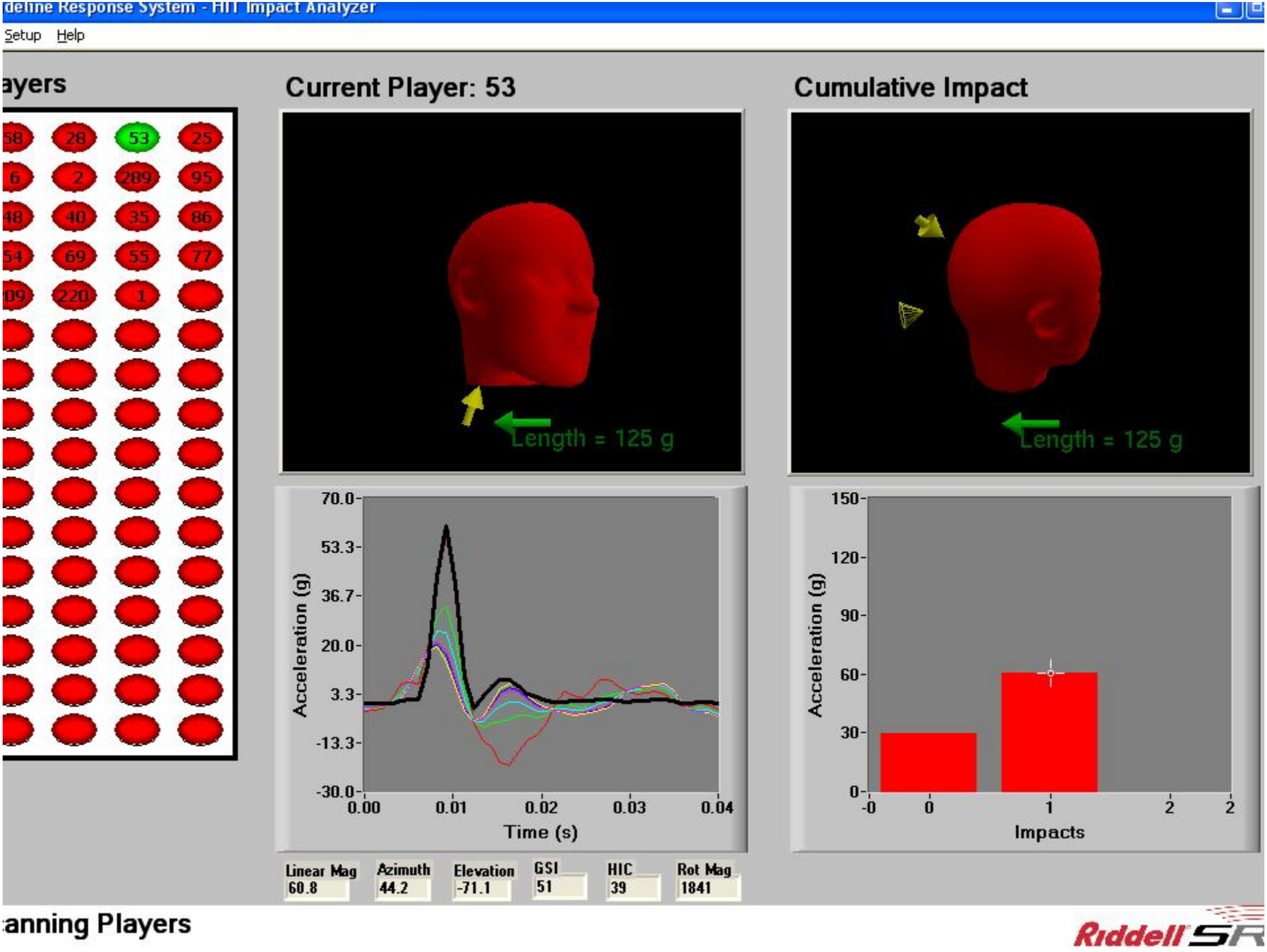
Player Units

HIT System™ Equipped

Simbex

HIT System

- In-helmet units (6 single axis accelerometers, battery, and radio) communicate with a signal receiver and laptop computer system on the sideline (coverage: approx 150 yard radius).
- Positioned around the 50 yard line for games; centrally located between fields for practices
- 128 on-board memory – *can store up to 128 impacts during one session*
- Battery life – approx. 3-5 days


deline Response System - HIT Impact Analyzer
Setup Help
ayers
58 28 53 25
6 2 289 95
48 40 35 86
54 69 55 77
09 220 1
Current Player: 53
Length = 125 g
Cumulative Impact
Length = 125 g
70.0
53.3
36.7
20.0
3.3
-13.3
-30.0
Acceleration (g)
0.00 0.01 0.02 0.03 0.04
Time (s)
150
120
90
60
30
0
Acceleration (g)
-0 0 1 2 2
Impacts
Linear Mag 60.8
Azimuth 44.2
Elevation -71.1
GSI 51
HIC 39
Rot Mag 1841
anning Players
Riddell SR

Case Study:
UNC Football Player

- 20-year-old Division I football defensive end
- Concussion #1: August 14, 2004
- Concussion #2: October 16, 2004

Concussion #1: August 14, 2004
Clinical Findings

- At the time of injury player reported experiencing 16 of 18 concussion symptoms on the Graded Symptom Checklist (GSC).

- SAC and BESS performed on the sideline revealed moderate deficits. Follow-up computerized neuropsychological (NP) and postural stability (PS) testing revealed moderate deficits through postinjury day 3.

Post Concussion Symptom Checklist

SYMPTOM	NONE		MILD		MODERATE		SEVERE
	0	1	2	3	4	5	6
Headache							
Nausea/ Vomiting							
Balance Problems							
Dizziness							
Sensitivity to Light							
Blurred Vision							
Sensitivity to Noise							
Nervousness							
Numbness/ Tingling							
Feeling Slowed Down							
Feeling Like “In a Fog”							
Difficulty Concentrating							
Difficulty Remembering							
Neck Pain							
Fatigue/ Drowsiness							
Difficulty sleeping							
Sadness							
Irritability							

Balance Error Scoring System (BESS)

Clinical Test Battery

- Six 20 sec trials using 3 different stances (double, single, tandem) on 2 different surfaces (firm, foam)

Recorded errors

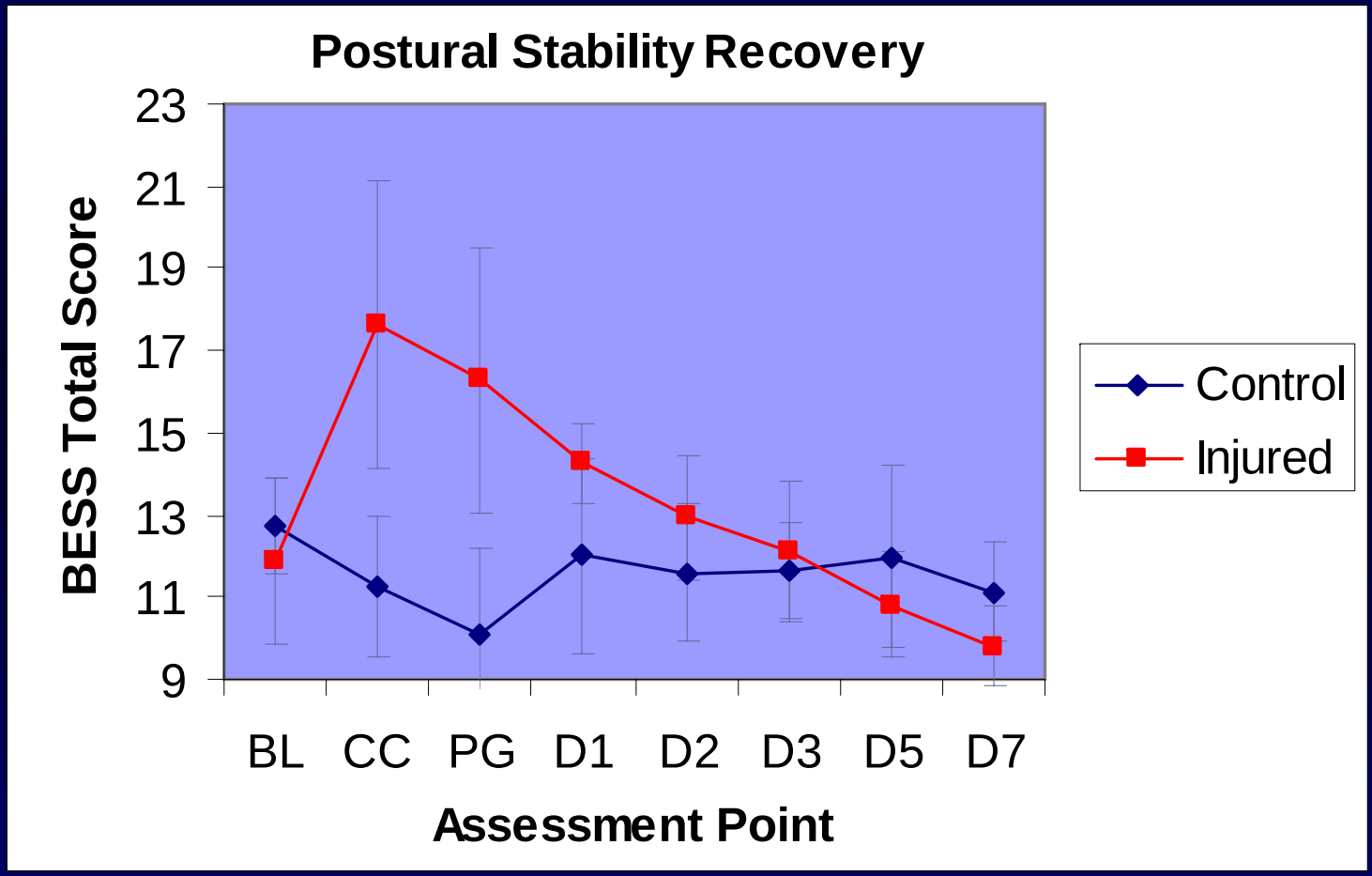
- Hands lifted off iliac crests
- Opening eyes
- Step, stumble, or fall
- Moving into >30 deg. of hip flexion or abduction
- Remaining out of testing position for >5 secs.






Balance Error Scoring System (BESS)

94 Injured & 56 Control NCAA FB players



Repeated measures ANOVA:
Group x Day interaction; $F(7,142) = 7.52$; $p < .0001$
(significant differences through day 1 postinjury)

McCrea et al (JAMA 2003)

SAC

Standardized Assessment of Concussion

FORM A

Name:_____

Age:_____ **Sex:**_____ **Examiner:**_____

Nature of Injury:_____

Date of Exam:_____ **Time:**_____ **Exam No.**____

1) ORIENTATION:

Month: _____	0	1
Date: _____	0	1
Day of week: _____	0	1
Year: _____	0	1
Time (within 1 hr.): _____	0	1

Orientation Total Score _____ / 5

2) IMMEDIATE MEMORY: (all 3 trials are completed regardless of score on trial 1 & 2; score equals sum across all 3 trials)

List	Trial 1	Trial 2	Trial 3
Elbow	0 1	0 1	0 1
Apple	0 1	0 1	0 1
Carpet	0 1	0 1	0 1
Saddle	0 1	0 1	0 1
Bubble	0 1	0 1	0 1
Total			

Immediate Memory Total Score ____ / 15

Note: Do not inform the subject that delayed recall will be tested.

NEUROLOGICAL SCREENING:

Loss of Consciousness (presence, duration)

Recollection of injury (pre- or post-traumatic amnesia)

Strength:

Sensation:

Coordination:

3) CONCENTRATION:

Digits Backward: (If correct, go to next string length. If incorrect, read trial 2. Stop after incorrect on both trials)

4-9-3	6-2-9	0 1
3-8-1-4	3-2-7-9	0 1
6-2-9-7-1	1-5-2-8-6	0 1
7-1-8-4-6-2	5-3-9-1-4-8	0 1

Months in Reverse Order: (entire reverse sequence correct for 1 pt.)

Dec-Nov-Oct-Sep-Aug-Jul

Jun-May-Apr-Mar-Feb-Jan 0 1

Concentration Total Score _____ / 5

EXERTIONAL MANEUVERS

(when appropriate):

5 jumping jacks **5 push-ups**

5 sit-ups **5 knee-bends**

4) DELAYED RECALL

Elbow	0 1
Apple	0 1
Carpet	0 1
Saddle	0 1
Bubble	0 1

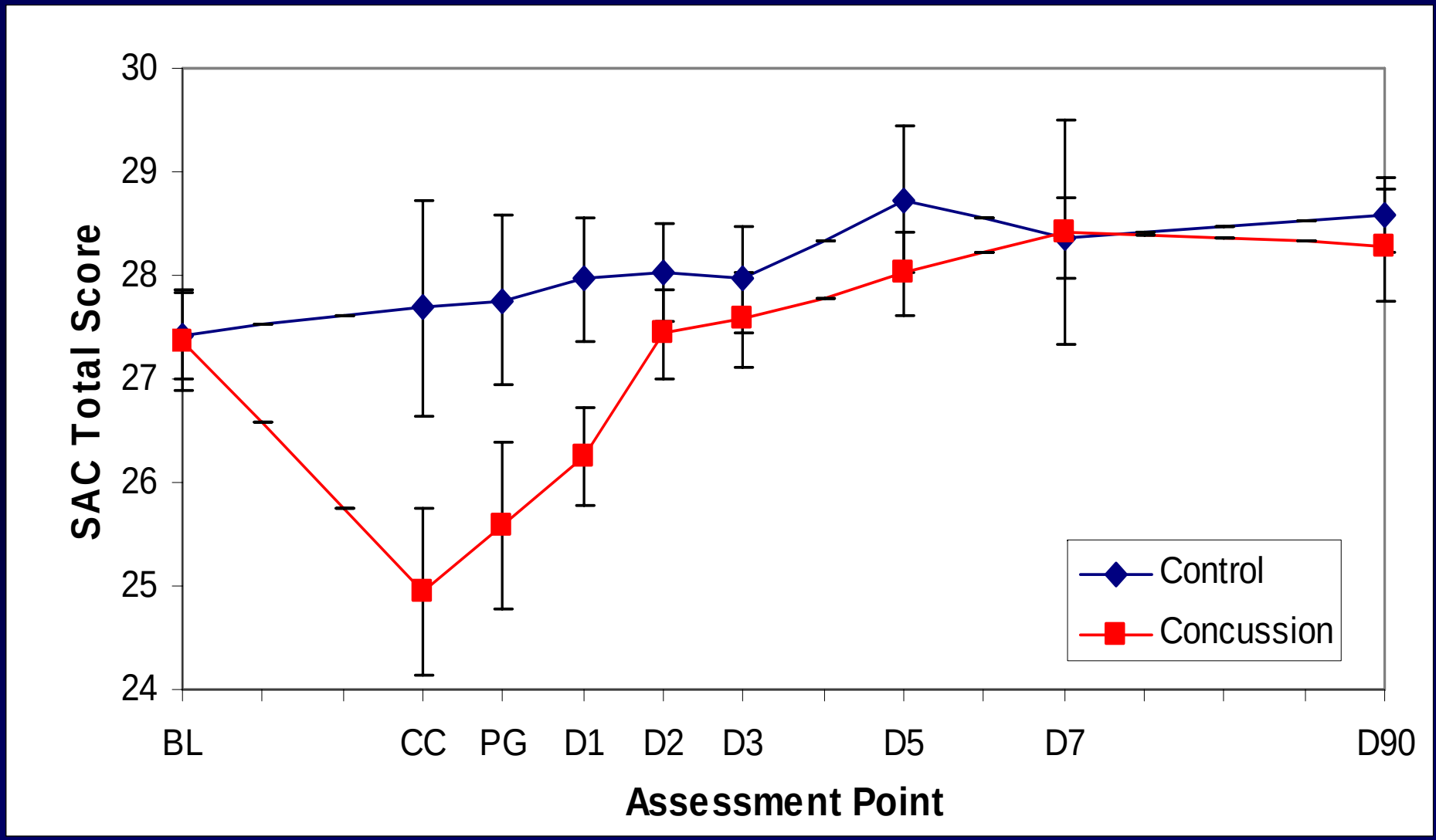
Delayed Recall Total Score _____ / 5

SUMMARY OF TOTAL SCORES:

Orientation	_____ / 5
Immediate Memory	_____ / 15
Concentration	_____ / 5
Delayed Recall	_____ / 5

Overall Total Score _____ / 30

Cognitive Recovery:
Standardized Assessment of Concussion (SAC)



McCrea & Guskiewicz, et al; JAMA: 290(19):2556-

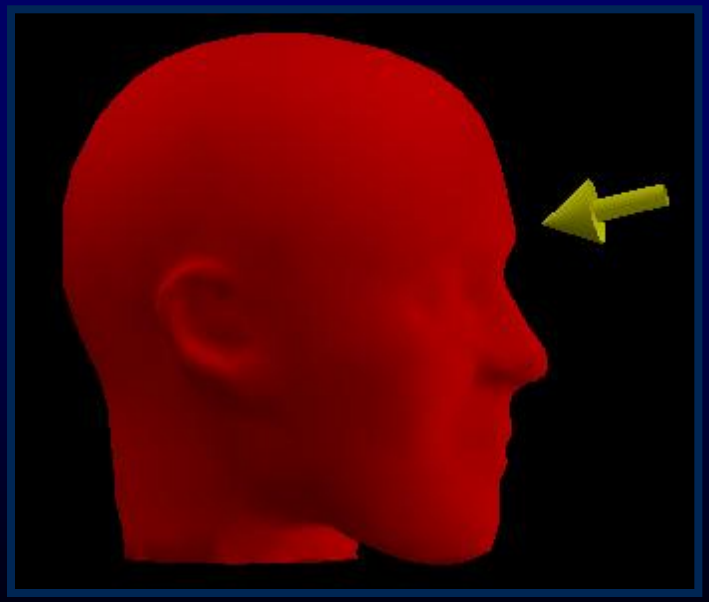
Concussion #1: August 14, 2004
Clinical Findings

- An MRI conducted on postinjury day 2 revealed no abnormalities, so the player was instructed to rest and attend team meetings as tolerated until symptoms resolved.

- Symptoms resolved over the course of 5 days, and he was returned to restricted participation, followed by full participation at postinjury days 6 and 7 respectively.

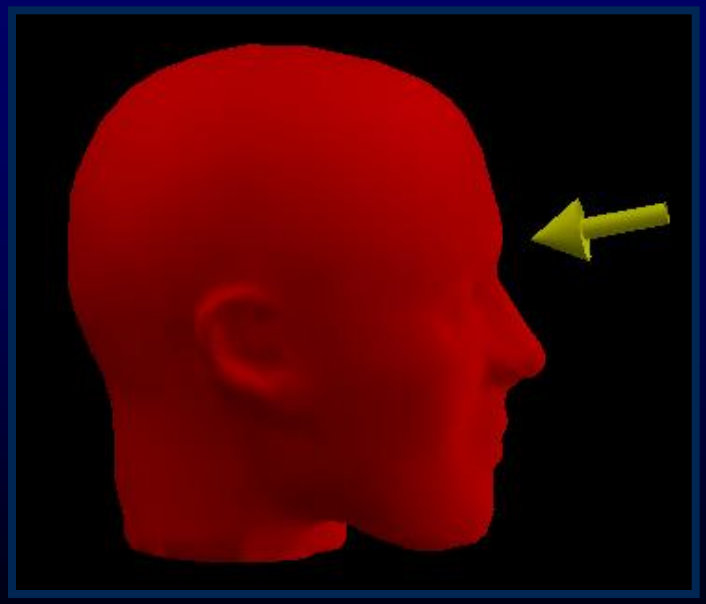
Impact Data: Concussion #1

- First impact
  - 9:55 a.m.
  - 79.18 g acceleration



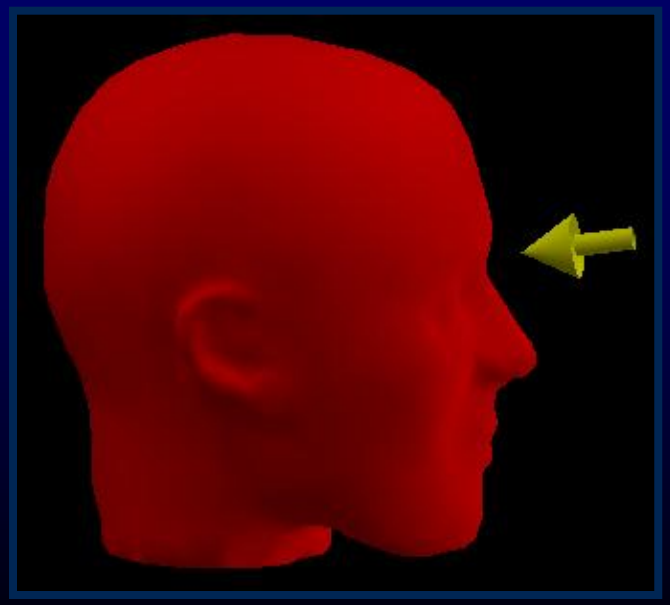
Impact Data: Concussion #1

- Second impact
  - 10:06 a.m.
  - 97.97 g acceleration



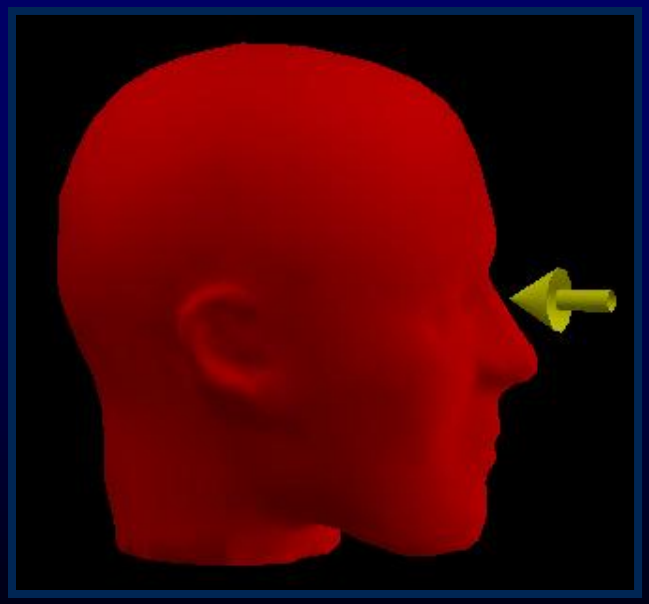
Impact Data: Concussion #1

- Third impact
  - 7:30 p.m.
  - 64.51 g acceleration



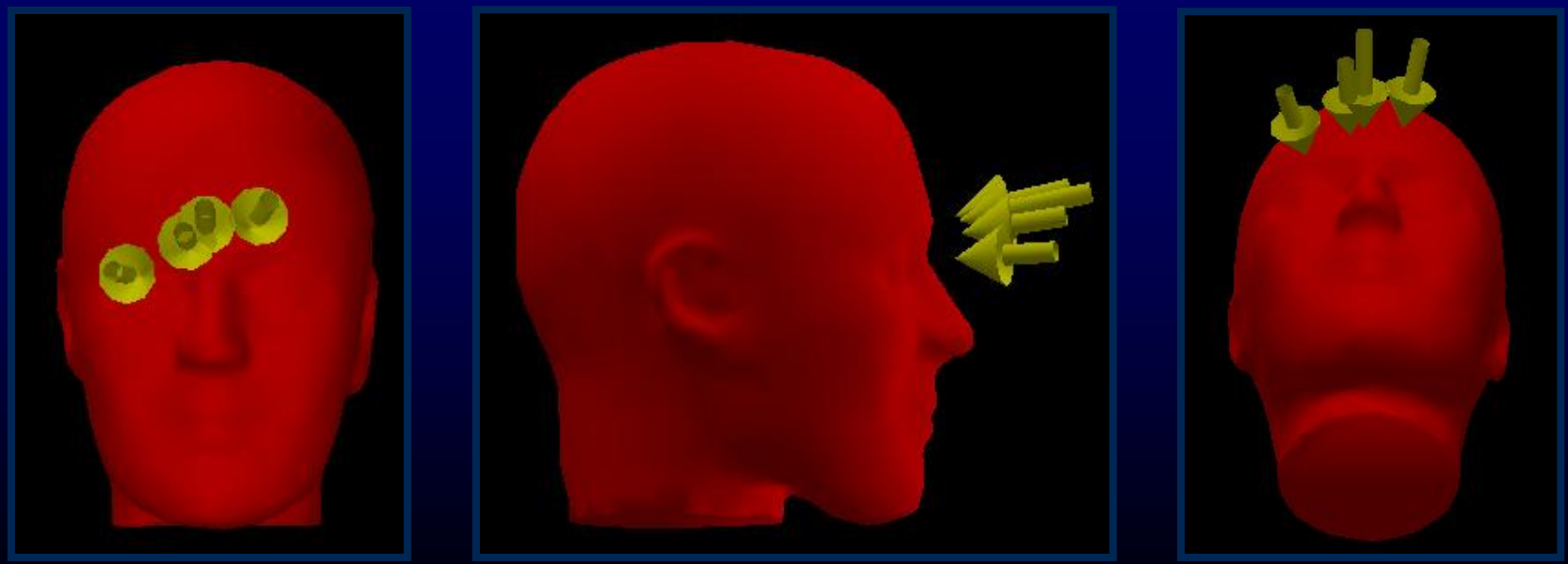
Impact Data: Concussion #1

- Fourth impact
  - 7:33 p.m.
  - 63.95 g acceleration



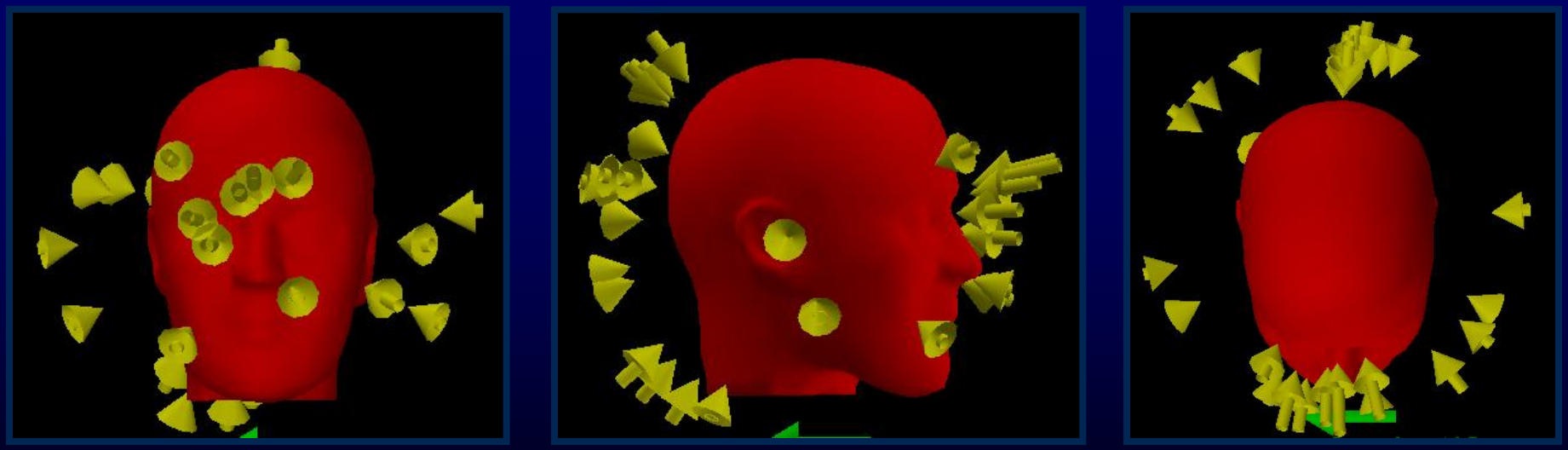
Impact Data: Concussion #1

- All 4 significant impacts
  - 2 in morning session (79.18 & 97.97 g)
  - 2 in evening session (64.51 & 63.95 g)

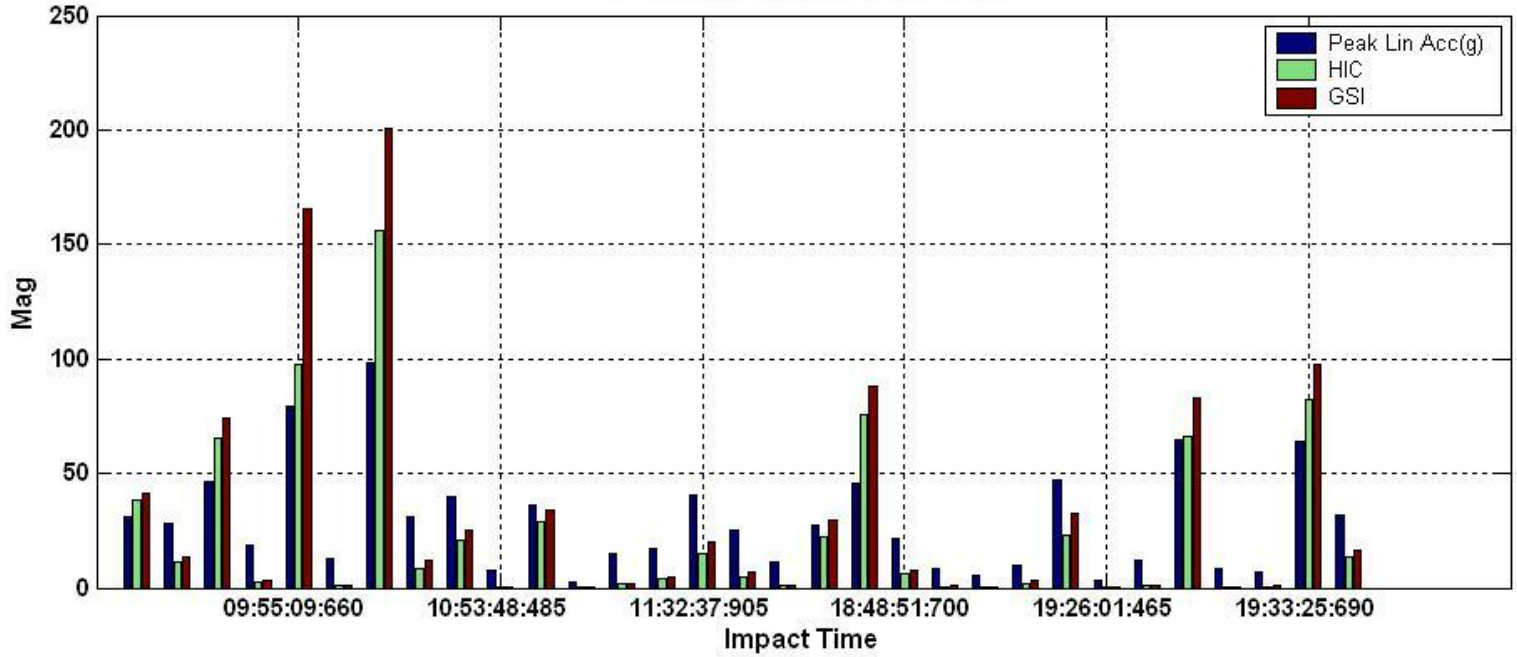


Impact Data: Concussion #1

- 31 total impacts for both sessions
- Between 2.87 g to 97.97 g (mean = 28.95 g)



Cumulative Effects: Concussion #1



Concussion #2: October 16, 2004

Clinical Findings

- Reported 13 of 18 concussion symptoms at the time of injury. Symptoms lingered for 10 days, with drowsiness, fatigue, and dizziness being the most persistent symptoms.
- Sideline SAC and BESS scores were again moderately depressed, however, serial assessments of NP and PS tests were significantly depressed during the initial 4 days postinjury.

Concussion #2: October 16, 2004

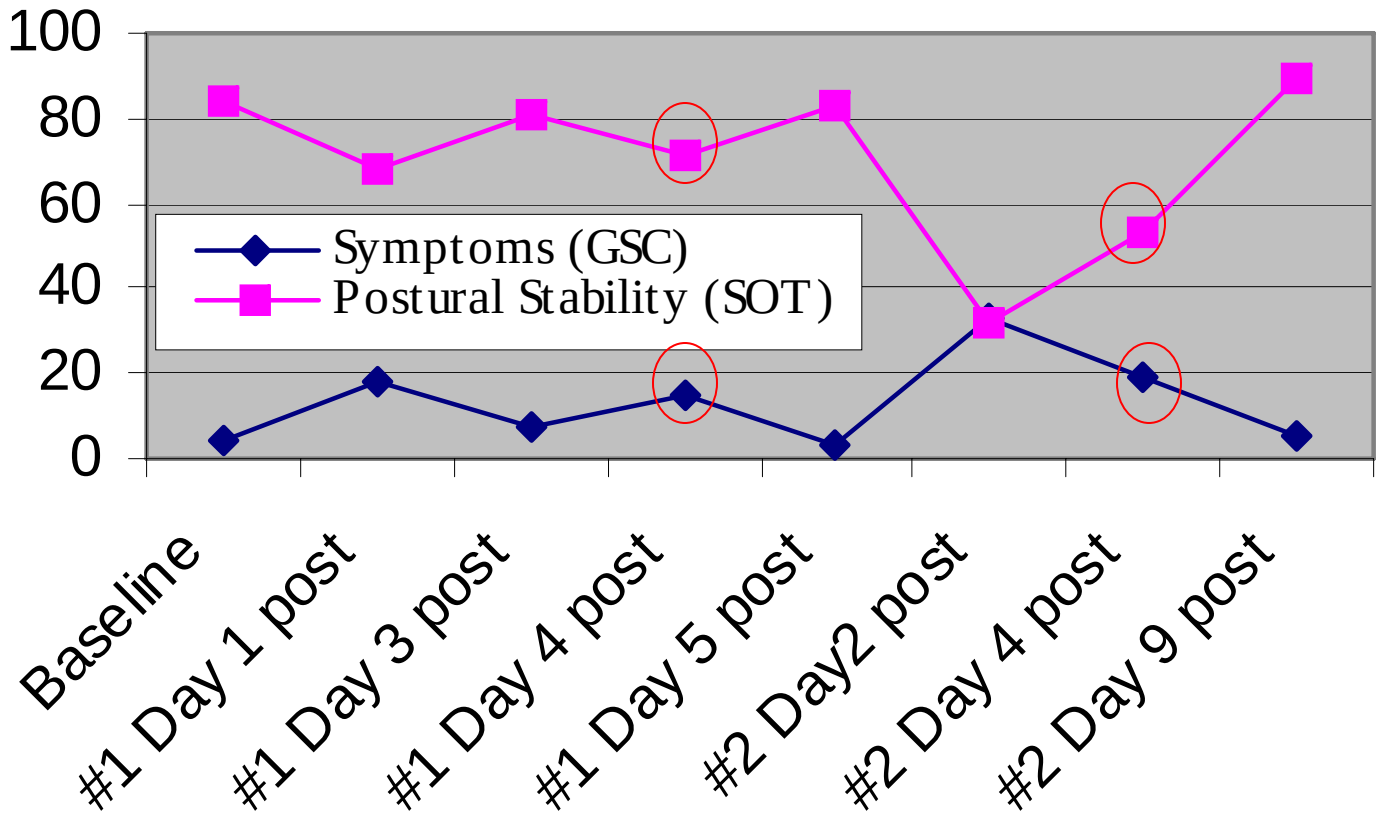
Clinical Findings

- An MRI was not conducted as part of the treatment, however, the player was evaluated by the team physician daily to insure detection of any neurological deterioration.

- Player withheld for 15 days before being permitted to return to full participation.

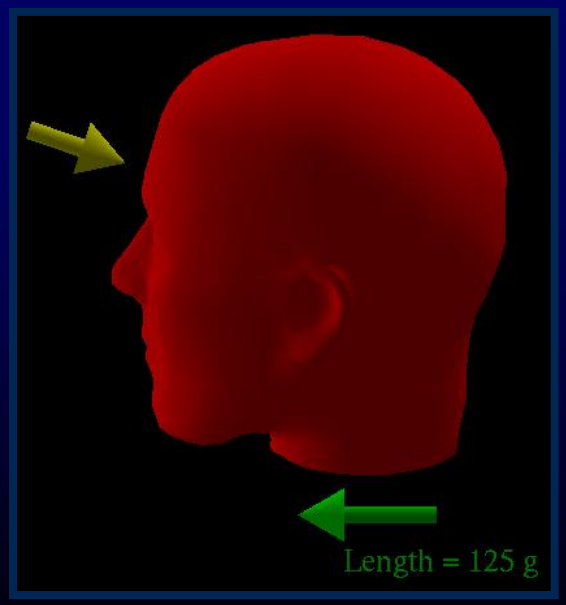
Case Study con't

Relationship Between Concussion Symptoms and Postural Stability



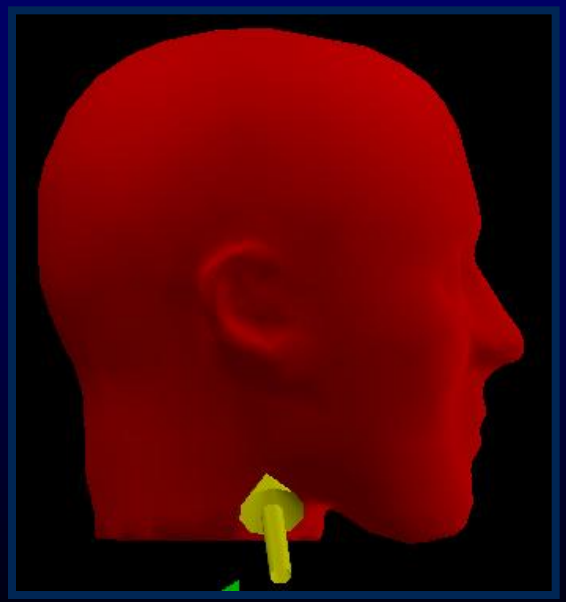
Impact Data: Concussion #2

- Impact in warm-up
  - 9:35 p.m.
  - 76.13 g acceleration



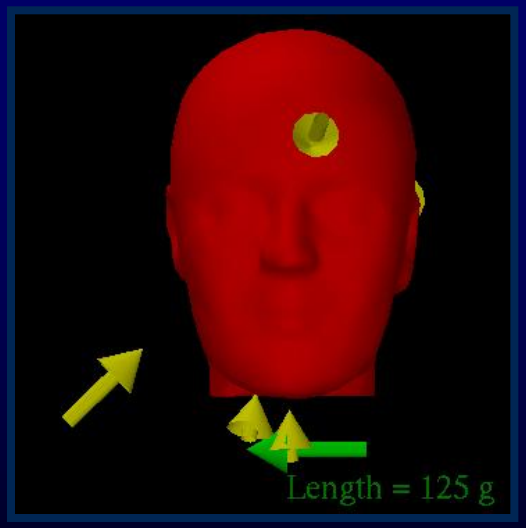
Impact Data: Concussion #2

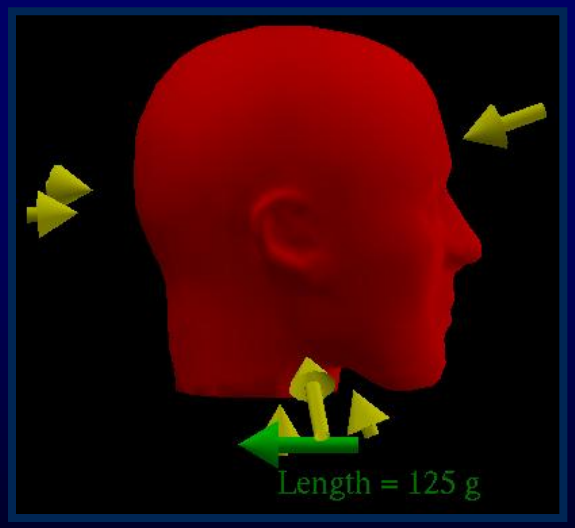
- Impact in game
  - 10:08 p.m.
  - 102.39 g acceleration

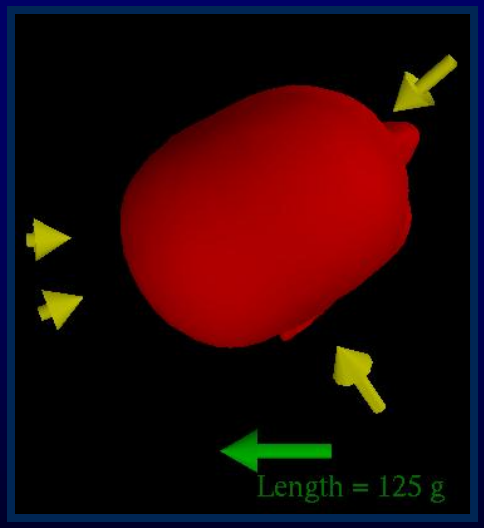


Impact Data: Concussion #2

- 6 total impacts
- Between 13.10 g to 102.39 g (mean = 40.78 g)

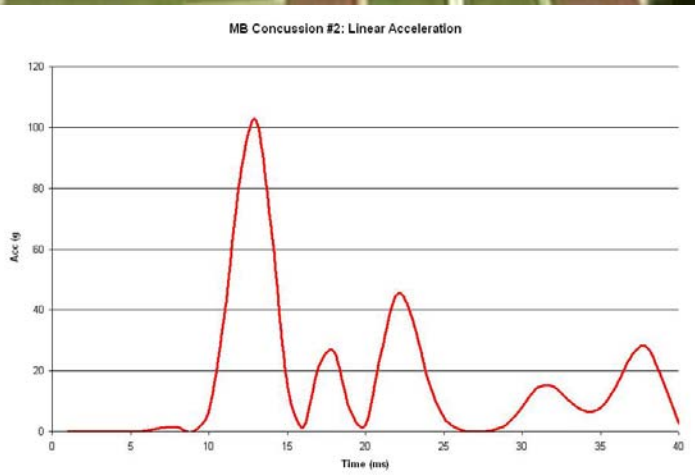






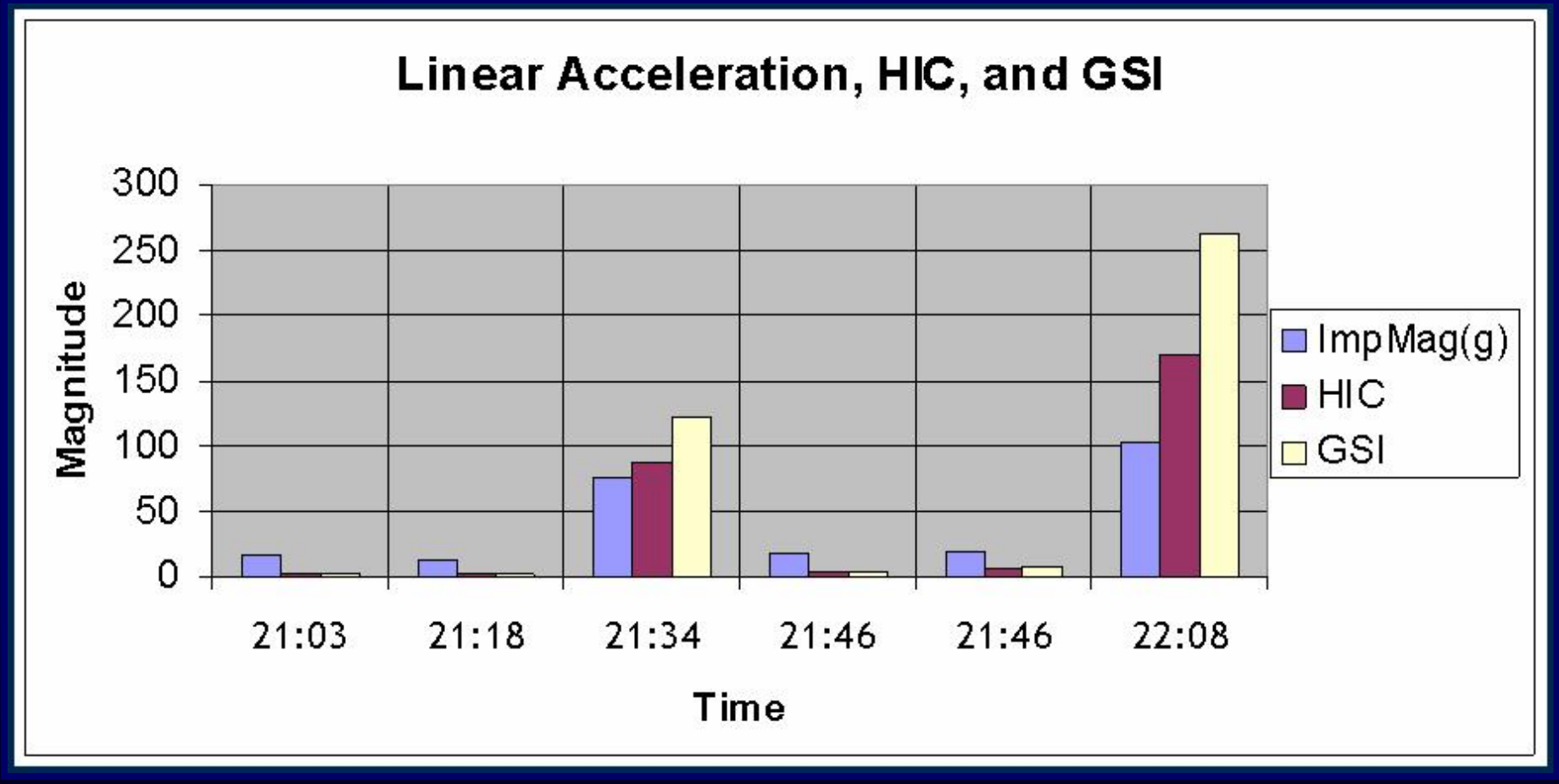
The Play

The Data



SPORTS MEDICINE RESEARCH LABORATORY

Cumulative Effects: Concussion #2



Conclusions

Raises several intriguing questions with respect to sport-related concussion:

1) was there a cumulative effect on the initial injury day, since there were two significant impacts during the morning practice?

2) could the threshold for injury be lowered because of these repetitive loads to the brain? ***"Acute cumulative effect of sub-concussive impacts"***

3) was the delayed symptom recovery and depressed NP and PS scores following the repeat concussion a result of a more chronic cumulative effect, or simply a result of the increased magnitude (102 g)?