Post-Concussion Balance Deficits – Are Athletic Trainers Missing Lingering Impairments?

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Balance
- Impaired balance is a cardinal post-concussion symptom.
- What is Balance?
  - Coordination of multiple neurological systems
    - Motor System
    - Sensory System
      - Visual, Vestibular, Somatosensory
    - Cognitive Processing

Balance Assessment by ATCs
- Limitations....
  - Fatigue
  - Functional Ankle Instability
  - Practice Effect
  - Scoring (MDC’s)
  - Dehydration
  - Environment
  - Known Unknowns
    - Lull, MO, Verone, Stagner, Kaffka, Kaffka, Kaffka, & others

<table>
<thead>
<tr>
<th>Table 2: Concussion-Assessment Practice Patterns, % (Re,Total)</th>
</tr>
</thead>
</table>
| Concussion-Management Practice Patterns of National Collegiate Athletic Association Division II and III Athletic Trainers: How the Other Half Lives
Journal of Athletic Training 2015;50(1):300-305
<p>|</p>
<table>
<thead>
<tr>
<th>Table 4: Sensitivity (k) and specificity (g) for detecting athletes with or without TBI</th>
</tr>
</thead>
</table>
| Standard Clinical Recovery
|  
| Standard diagnostic methods for measuring recovery after spine-related concussion
Journal of the International Neuropsychological Society 2005;11:79-84 |
**BESS Results**

**BESS Recovery**

Acute Effects and Recovery Time Following Concussion in Collegiate Football Players
The NCAA Concussion Study

**Experimental Evidence of Lingering Impairments**

**Static Postural Control**

- Gait Initiation Videos
S1 A/P
HYA: 4.7cm
HOA: 3.54cm
PD: 2.94cm

S1 A/P
HYA: 5.42cm
mTBI: 2.29cm

* * *

Cohen's d vs Baseline

Baseline Day

GI COP Displacement

Cohen's d vs Baseline

Baseline Day

Day 1

BESS

RTP Day

d = 1.99

* d = 1.48

* d = 0.78
• Gait Termination Video

Post-Concussion Balance Deficits – Are Athletic Trainers Missing Lingering Impairments?
The Role of Dual-Tasks

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The Micheli Center for Sports Injury Prevention
Division of Sports Medicine, Boston Children’s Hospital

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Conflict of Interest
No disclosures or conflicts of interest to report related to the topic of this presentation
Concussion

Cortex

Sub-Cortical Structures

Frontal Lobe

Temporal Lobe

Parietal Lobe

Hypothalamus

Basal Ganglia

Cerebellum

Cognition

Memory

Complex functioning

Thermoregulation

BP control

Sleep patterns

Sexual function

Diabetes insipidus

Headache

Facial Pain

Balance/Posture

Sensory-Motor

Adapted from E. Toledo et al., *Neurosci Biobehav Rev* (2012)

Topics

1) How long do deficits last after concussion?

2) How can we accurately monitor recovery to determine appropriate RTP timing?

3) What factors (+/-) affect recovery?

Initial Evaluation

Video

Evaluation of Recovery

Varied levels of subjectivity/objectivity for each tool:

Symptom Resolution


Howell et al., *Arch Phys Med Rehab*, 2013; Data from 40 adolescents (20 with concussion)
Cognitive Deficits

Video

ImPACT

Motor Deficits

Isolated motor deficits (BESS) resolve within a week of injury

Broglio et al., JAT, 2009; Murray et al., JAT, 2014

Static vs. Dynamic Balance

A weak relationship exists between mBESS performance (static stability) and average gait speed (dynamic stability).

Cognitive-Motor Interaction

Stroop tasks (congruent/incongruent stimuli)
Conflict Resolution
Frontal Lobe:
Anterior cingulate gyrus, prefrontal cortex

Mental Status Examination
(spelling backwards, arithmetic)
Temporal/Parietal/Frontal Lobes
Fusiform gyrus, lingual gyrus, thalamus

Motor Cortex ➔ Internal Capsule ➔ Spinal Cord ➔ Muscle Control
Dual-Task Video

Poor Gait Balance Control Video

Total COM M-L Displacement

Stroop Accuracy Rates

Total Displacement (m) Worse

Worse

Subject Testing Timeline

Howell et al., Arch Phys Med Rehabil, 2013: Data from 40 adolescents (20 with concussion)

Howell et al., Arch Phys Med Rehabil, 2013: Data from 40 adolescents (20 with concussion)

Topics

1) How long do deficits last for after concussion?

2) How can we accurately monitor recovery to determine appropriate RTP timing?

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Concussion Occurs 72 hrs 1 week 2 weeks 1 month 2 months

Return-to-activity day:               7      10     13  14  15    18              22 23 24            28     30   32            36 56    57

# of subjects for each RTA day: 1       2      1     2    1      1                1   1   1              1        1    1     3                                                                              1       1

Concussion Events

RTA day: 1st day participation was allowed by attending physician
Pre RTA Post RTA

Clinical decisions made using conventional methods
Pre RTA Post RTA

Independent from study-related data
Pre RTA Post RTA
The role of physical activity

Return to unrestricted PA may negatively affect dual-task balance control

But, too much inactivity for athletes may lead to concussive symptoms

Physical activity level and symptom resolution time are not associated (Howell et al., AJSM, 2015, In Press)

### Topics

1) How long do deficits last for after concussion?

2) How can we accurately monitor recovery to determine appropriate RTP timing?

3) What factors (+/-) affect recovery?

### Some physical activity may not be harmful during recovery

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hazard Ratio</th>
<th>SE</th>
<th>95% C.I.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.0013</td>
<td>0.0351</td>
<td>0.9683 - 1.0341</td>
<td>.712</td>
</tr>
<tr>
<td>Sex*</td>
<td>1.3695</td>
<td>0.2003</td>
<td>1.0282 - 1.8242</td>
<td>.032</td>
</tr>
<tr>
<td>Total score: initial PCSS*</td>
<td>0.9830</td>
<td>0.0046</td>
<td>0.9740 - 0.9920</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Number of previous concussions</td>
<td>0.8748</td>
<td>0.0669</td>
<td>0.7530 - 1.0163</td>
<td>.081</td>
</tr>
<tr>
<td>LOC at time of injury</td>
<td>0.9160</td>
<td>0.1882</td>
<td>0.6124 - 1.3702</td>
<td>.669</td>
</tr>
<tr>
<td>Amnesia at time of injury</td>
<td>0.7890</td>
<td>0.2054</td>
<td>0.4737 - 1.3140</td>
<td>.362</td>
</tr>
<tr>
<td>Prior treatment for headaches</td>
<td>0.7064</td>
<td>0.1875</td>
<td>0.4199 - 1.1884</td>
<td>.190</td>
</tr>
<tr>
<td>Initial period of physical rest</td>
<td>0.7935</td>
<td>0.1345</td>
<td>0.5692 - 1.1062</td>
<td>.172</td>
</tr>
<tr>
<td>Physical activity level</td>
<td>1.0008</td>
<td>0.0007</td>
<td>0.9994 - 1.0021</td>
<td>.261</td>
</tr>
</tbody>
</table>

Multivariate Cox Regression Model: Outcome variable = Symptom Duration (days)

Howell et al., AJSM In Press, 2015; Data from 364 adolescents/young adults with concussion (mean age = 15.0 years)
Long-term effects of early RTP

When is the optimal timing to return to sport and academic activities?

Easy answer: it is multifaceted

The appropriate timing and dosage of physical activity during each recovery stage remains unknown

Likely based on many factors

Clinical Implications

Some physical activity is not harmful to time required for symptom resolution

However, balance deficits undetectable through current assessment paradigms may exist after RTP

Lingering balance control deficits may lead to increased risk of subsequent injury

Lynall et al., MSSE, 2015; Cross et al., BJSM, 2015

Conclusions

1) Deficits after concussion persist from days-months, depending on the testing battery employed

2) Dynamic dual-task assessments provide functional information about concussion recovery

3) Physical activity may not be detrimental to recovery of symptoms

• But, unrestricted RTA may provoke balance altered balance problems undetectable through other exams

Consequences of Prolonged Postural Control Deficits

THANK YOU!
Subsequent Injuries

- **So What?**
  - Well established concussion dose response (↑3 – 6x)
  - Other Injuries?
  - Long Term?

Complications of Prolonged Deficits Subsequent Injuries?

- **Professional Soccer (UEFA) Champions League**
  - Soccer players who suffer concussions are more likely to suffer another injury both in the year following (2.2x) and year prior (2.0x) a concussion.

- **Rugby**
  - ↑60% elevated risk of subsequent injury in the same season as compared to players without a concussion.


Clinically Feasible Balance Tests

- Tandem ST & DT Gait Videos

Clinically Feasible Balance Tests

- BESS & SAC DT Video
Emergence of a “Posture-First” Strategy

Clinically Feasible Balance Tests

- Instrumented measures of postural control can identify lingering and persistent balance deficits often missed with clinical examination.
- Dual-tasks can assess concussion recovery on functions potentially associated with risk of subsequent injury.

Concluding Thoughts

- Instrumented measures of postural control can identify lingering and persistent balance deficits often missed with clinical examination.
- Dual-tasks can assess concussion recovery on functions potentially associated with risk of subsequent injury.
- Challenges
  - Clinically feasible, yet sensitive, measures of post-concussion postural control need to be developed
  - Cause and Effect relationship between lingering balance deficit and subsequent injury