VISUAL & VESTIBULAR ABNORMALITIES FOLLOWING CONCUSSION

Anne Mucha PT, DPT, MS, NCS
Coordinator of Vestibular Rehabilitation
UPMC Sports Concussion Program
Centers for Rehab Services, Pittsburgh PA

Learning Objectives:
• Describe the vestibular system and its relationship to recovery following mTBI
• Describe common vestibular system abnormalities following mTBI
• Describe common visual system abnormalities following mTBI
• Understand how to screen for vestibular and ocular motor dysfunction
• Gain knowledge of rehabilitation strategies to treat vestibular and ocular motor deficits

Recovery From Sport-related Concussion: How Long Does it Take?

Most Commonly Reported Symptoms: Athletes post concussion:

<table>
<thead>
<tr>
<th>SYMPTOM</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td># 1 Headache</td>
<td>71</td>
</tr>
<tr>
<td># 2 Feeling slowed down</td>
<td>58</td>
</tr>
<tr>
<td># 3 Difficulty concentrating</td>
<td>57</td>
</tr>
<tr>
<td># 4 Dizziness</td>
<td>55</td>
</tr>
<tr>
<td># 5 Fogginess</td>
<td>53</td>
</tr>
<tr>
<td># 6 Fatigue</td>
<td>50</td>
</tr>
<tr>
<td># 7 Visual blurring/double vision</td>
<td>49</td>
</tr>
<tr>
<td># 8 Light sensitivity</td>
<td>47</td>
</tr>
<tr>
<td># 9 Memory dysfunction</td>
<td>43</td>
</tr>
<tr>
<td># 10 Balance problems</td>
<td>43</td>
</tr>
</tbody>
</table>

Function of Vestibular System:

Vestibulo Ocular Reflex (VOR)
- Most active when vision & somatosensation reduced

Vestibulo Spinal Reflex (VSR)
- Stabilize vision while head moves
- Balance control

Vestibular System Overview

- Peripheral Vestibular System
  - Semicircular Canals
  - Otoliths: Utricle and Saccule
- Vestibular Ganglia
- Vestibular Nerve

- Central Vestibular Projections
  - Vestibular Nuclei
  - Cerebellum
  - Autonomic Nervous System
  - Thalamus
  - Cerebral Cortex

Lovell et al. 2004

N=134 High School Male Football Athletes (Collins et al., 2006, Neurosurgery)
Subjective Complaints w/ Vestibular Dysfunction:
- Dizziness
- Impaired balance (particularly in dark)
- Blurry vision, difficulty focusing
- Motion discomfort, height phobia
- Difficulty in busy visual environments

Common Vestibular Causes of Dizziness p mTBI
Peripheral/Inner Ear
- Benign Paroxysmal Positional Vertigo (BPPV)
- Labyrinthine Concussion
- Perilymphatic Fistula
Central Vestibular/Brain
- Post traumatic migraine
- Brainstem concussion

Common Non-Vestibular Causes of Dizziness:
- Ocular Motor Problems
- Cervicogenic Dizziness
- Autonomic/orthostatic

Screening for Vestibular Abnormalities:
Aural Symptoms:
- May identify labyrinth/inner ear injury. Ask about:
  - Changes in hearing
  - Tinnitus, particularly lateralizing
  - Pressure/fullness in ear(s)
- Significance:
  - Unilateral aural symptoms frequently correlate to co-existing peripheral vestibular pathology (labyrinth)
  - Patients with mixed central and peripheral vestibular dysfunction recover more slowly and incompletely (Brown et al, 2006)
- Warrants referral to Otology or Oto-neurology

Dizziness following Concussion
Benign Paroxysmal Positional Vertigo

Screening for BPPV
Ask about movement-specific dizziness:
- Looking up
- Getting out of bed
- Turning over in bed
- Lying down

Adapted from Furman 2010
Vestibulo-Ocular Dysfunction:

Normal VOR:
- Able to maintain focus on stationary object while moving head without loss of visual focus or dizziness

Screening for VOR function:
Abnormal: Inability to see image clearly with head motion; dizziness

VOR testing:
- **Head Thrust Test** (Head Impulse Test)
  - Most sensitive clinical VOR test
  - Apply low amplitude/high acceleration rotation to head
  - Corrective saccade to maintain fixation = abnormal

VOR testing:
Clinical DVA/Illegible “E” test

Advanced Clinical Methods for Assessing VOR Function

Laboratory Testing: VNG/ENG
Vestibular Dysfunction: Space/Motion Discomfort

Subjectively:
- Bothered by walking in supermarket?
- Avoid heights due to dizziness
- Dizziness in wide-open spaces?

Space and Motion Discomfort
- Jacob et al, 1993
- Uneasiness created by situational stimuli, eg: Moving crowds, supermarkets, busy patterns, spiral staircases, heights, etc
- Heightened awareness of normal motion
- “Optokinetic hypersensitivity”

Related terms:
- “Visual Vertigo” (Bronstein 1995)
- “Chronic Subjective Dizziness” (Staab 2004)

Management: Space/Motion Discomfort
- Coexists frequently with Migraine and/or Anxiety
  - Migraine-Related Dizziness (MRD)
  - Migraine-Anxiety Related Dizziness (MARD)
- Appears to be responsive to combined approach using Medication, Vestibular Physical Therapy, & Behavioral Therapy (Whitney et al, 2005; Jacob et al, 2001)

Migraine and Vestibular dysfunction:
- Meta-analysis (Furman et al, 2003) - 534 migraineurs:
  - Unilateral caloric reduction - 25%
  - Spontaneous nystagmus 10%
  - Positional nystagmus - 20%
  - Directional preponderance - 50%
  - Abnormal postural stability - approx 30%
- Migraine-related dizziness may be the most common disorder presenting to specialty clinics for dizziness, vertigo and disequilibrium (Neuhauser et al, 2009)
- Hypersensitivity of the Vestibular System speculated (Jeong et al, 2010)

How does PTM compare to No Headache and Headache groups in predicting Protracted (>21 days) Recovery from Sports Concussion? (N= 97)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Wald</th>
<th>p</th>
<th>Odds Ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTM v. No Headache</td>
<td>7.60</td>
<td>.006</td>
<td>7.29</td>
<td>1.80-29.91</td>
</tr>
<tr>
<td>Headache v. No Headache</td>
<td>2.20</td>
<td>.14</td>
<td>2.83</td>
<td>0.72-11.20</td>
</tr>
<tr>
<td>PTM v. Headache</td>
<td>3.93</td>
<td>.04</td>
<td>2.57</td>
<td>1.10-6.54</td>
</tr>
</tbody>
</table>

Kontos AP, Elson RJ, Niewicky S, French J, Collins MW; In review.

Migraines: Sometimes you have to dig!
Is Rehab an option??

- 114 consecutive post concussive patients who were referred for balance/vestibular rehabilitation
- Significant improvements achieved in following standardized outcome measures of balance/vestibular function:
  - Activity-Specific Balance Confidence Scale
  - Dizziness Handicap Inventory
  - Gait Speed
  - Computerized Dynamic Posturography - Sensory Organization Test
  - Dynamic Gait Index
  - Functional Gait Assessment
  - 5Times Sit to Stand (Alsalaheen 2010)

Efficacy of Vestibular Rehab


Management of BPPV

Canalith repositioning maneuver


Training VOR Function:

Training VOR function:
Space and Motion Discomfort Training

Training Space and Motion Discomfort

Ocular Motor problems following Concussion

Ocular Motor Dysfunction following mTBI*

<table>
<thead>
<tr>
<th></th>
<th>% mTBI n = 20</th>
<th>% Controls n = 20</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocular Misalignments</td>
<td>55%</td>
<td>5%</td>
<td>0.0012*</td>
</tr>
<tr>
<td>(Vertical Phoria)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ocular Misalignment</td>
<td>45%</td>
<td>5%</td>
<td>0.0084*</td>
</tr>
<tr>
<td>(Horizontal Phoria)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accommodative Dysfunction</td>
<td>65%</td>
<td>15%</td>
<td>0.0031*</td>
</tr>
<tr>
<td>Convergence Insufficiency</td>
<td>55%</td>
<td>5%</td>
<td>0.0012*</td>
</tr>
<tr>
<td>Saccadic impairment</td>
<td>30%</td>
<td>0%</td>
<td>0.0202*</td>
</tr>
<tr>
<td>Pursuit impairment</td>
<td>60%</td>
<td>0%</td>
<td>&lt;0.0001*</td>
</tr>
</tbody>
</table>

* Blast-related mTBI

Disorders of Vergence:
Convergence Insufficiency

Normal: Diplopia at < 6 cm

Courtesy: Suzanne Wickum OD
### Disorders of Vergence: Convergence Spasm

- Trouble reading, focusing
- Trouble focusing from far to near (e.g., taking notes in class)
- Blurred vision
- Headaches
- Eye strain
- Sensitivity to light (with excessive vergence response)
- Pulling sensation around eyes
- Avoidance of reading
- Comprehension deficits over time

*From: Scheiman 2002*

---

### Symptoms of Vergence system deficits:

- Trouble reading, focusing
- Trouble focusing from far to near (e.g., taking notes in class)
- Blurred vision
- Headaches
- Eye strain
- Sensitivity to light (with excessive vergence response)
- Pulling sensation around eyes
- Avoidance of reading
- Comprehension deficits over time

*From: Scheiman 2002*

---

### Accommodative Insufficiency

- Inability to maintain visual focus on near target
- Not due to presbyopia (normal loss of lens elasticity with aging)
- Frequently accompanies convergence insufficiency; but may exist independently
- Measured monocularly
- Norms based on age

---

### Ocular Motor Problems: Misalignments

- Strabismus
- Can be obvious “tropia”
  - Wall-eyed or cross-eyed
- Can be subtle “phoria”
- Can be aggravated/pre-existing

---

### Ocular Motor Problems: Impaired Saccades

Abnormal Findings: Hypometric saccades, slowed saccades, symptomatic saccades. Rarely: hypermetric saccades

---

### Ocular Motor Problems: Impaired Pursuit Movements

Abnormal Findings: Saccadic pursuits, symptom provocation, limited EOM
Training Ocular Motor & Convergence Problems

Treating Ocular Motor Problems

Ocular Motor Exercise

Evidence for Treating Ocular Motor Dysfunction


Vision therapy/Orthoptics resources
- www.covd.org
- www.nora.cc

Balance/Postural Control Impairments following Concussion

Balance: Sensory Organization

- Ability of the balance system to utilize sensory inputs appropriately to maintain postural control
- 3 Sensory Inputs:
  - Vision
  - Somatosensation
  - Vestibular
Objective Testing for Abnormal Sensory Organization

- Computerized Dynamic Posturography
  - Gold Standard
  - Nashner L, 1982
- Clinical Test for Sensory Interaction in Balance
  - Shumway-Cook, Horak 1986
- Balance Error Scoring System
  - Guskiewicz K, 2001

Clinical Test for Sensory Interaction in Balance

- CTSIB
  - 6 Conditions
- Firm / Foam Surface
  - Eyes Open
  - Eyes Closed
  - 30 seconds
  - 2 or more falls/3 trials
  - Shumway-Cook A., Horak F. 1986

Balance Error Scoring System

- BESS Test (6 items)
  - 3 Postures
    - Standing feet together
    - Single-limb Stance
    - Tandem Stance
  - Firm / Foam Surface
  - Eyes Closed
  - 20 seconds
  - Scored by number of errors committed
  - Guskiewicz K. University of North Carolina Sports Medicine Research Laboratory

Balance Testing as Measure of Recovery:

Detecting Concussion:
- Postural control assessment should be combined with other evaluative measures to gain the highest sensitivity to concussive injuries (Broglio 2008)

Recovery from Concussion:
- May resolve more quickly than other symptoms following concussion (Catena 2011)

Training Balance
To find a Vestibular Therapist

- www.neuropt.org:
  - Special Interest Group tab
  - Vestibular Rehabilitation SIG
  - Vestibular Rehab Providers

- May still need additional exposure to concussion-specific issues

Thank You!