Rehabilitation Following Concussion
Anne Mucha PT, DPT, MS, NCS
Cara Troutman-Enseki PT, DPT, OCS, SCS
Coordinators, Vestibular & Exertion Rehabilitation
UPMC Centers for Rehab Services & Sports Concussion Program

Morbidity Associated w/ Concussion:
- 225,000 new persons each year show LONG TERM deficits as result of mTBI (Meaney 2011)
- Actual numbers may be 380,000-760,000 – based on CDC estimates of annual concussions

What ON FIELD sign/symptom is most important in predicting recovery?
- 87 Male HS Football Players (mean age 16.2 yrs)
- 13 On-field signs/sxs
  - Determined by ATC/Sports Med Physicians
- Groups divided into:
  - Rapid recovery (< 7 days; n = 56; mean = 4.9 d)
  - Protracted recovery (> 21 days; n = 31; mean = 33.2 d)
  - Post Traumatic Amnesia
  - Retrograde Amnesia
  - Confusion
  - Dizziness
  - Headache
  - Numbness

Concussion Management??

Which On-Field Signs/Symptoms Predict Protracted (>21 d) Recovery?

Direct LR with 3 predictors: $\chi^2(3, 94)= 11.77, p= .008$

Predictors reliably distinguish between rapid and protracted recovery groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Wald</th>
<th>OR</th>
<th>p</th>
<th>95% CI for OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dizziness</td>
<td>5.44</td>
<td>6.34</td>
<td>0.02</td>
<td>1.34 - 29.91</td>
</tr>
<tr>
<td>LOC</td>
<td>2.53</td>
<td>0.27</td>
<td>0.11</td>
<td>0.54 – 1.35</td>
</tr>
<tr>
<td>Vomiting</td>
<td>1.45</td>
<td>0.42</td>
<td>0.23</td>
<td>0.10 – 1.72</td>
</tr>
</tbody>
</table>

(Lau et al. 2011)
Is DIZZINESS due to a VESTIBULAR problem?

If YES, Vestibular Rehab may help!!

**Common Vestibular Causes of Dizziness p mTBI**

Peripheral:
- Benign Paroxysmal Positional Vertigo (BPPV)
- Labyrinthine Concussion
- Perilymphatic Fistula

Central Vestibular:
- Post traumatic migraine
- Brainstem concussion

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

Adapted from Furman 2010

**Common Vestibular Findings after Concussion:**

- Visual Motion Sensitivity
- Vestibular Impairment
- VOR
- Balance

**Benign Paroxysmal Positional Vertigo (BPPV)**

- Otoconia from otolith organs dislodge and travel into semicircular canal, causing vertigo
- Movement-specific dizziness with:
  - Looking up
  - Getting out of bed
  - Turning over in bed
  - Lying down

**Screening for BPPV**

- Presence/absence of post-traumatic dizziness?
- (1) Dizziness with getting out of bed (2) Dizziness with rolling in bed

**Tests:**

- Dix-Hallpike Test
- Roll Test

**Retro chart review; 114 post concussion patients seen for balance/vestibular rehab; Significant improvements in:**

- ABC
- DHI
- Gait Speed
- SOT
- DGI
- FGA
- 5Times Sit to Stand

**RCT; 29 pts following sport-related concussion:**

- Received Vestibular-Cervical Rehab vs Sham; 1x/wk
- Followed until cleared to RTP
- Results: Treatment group w/ > RTP clearance rate @ 8 wks (73% vs 7%)
BPPV Treatment:
- Canalith repositioning maneuvers

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

**Abnormal VOR:**
- Disruption of VOR pathways centrally and/or peripherally
- Difficulty w/ Eye/Head motion, particularly @ FASTER speeds
- Blurry, symptomatic

Impairments in VOR function following Concussion

VOR/Gaze Stability Training:
- Maintain visual focus while moving the head; variations:
  - Speed
  - Duration
  - Size of target
  - Complexity of background
  - Surface
  - Posture
  - Dynamic motion
  - x2 viewing

Visual Motion Sensitivity
- **Heightened awareness of normal visual motion**
- Abnormal sensitivity with visual/vestibular interaction
- "Optokinetic hypersensitivity"

Subjectively dizziness w/:
- Walking in supermarket, school hallways, or other crowded places?
- Heights, wide-open spaces, tunnels/bridges?

Related terms:
- Space and Motion Discomfort (Jacob et al., 2010)
- "Visual Vertigo" (Bronstein 1985)
- "Chronic Subjective Dizziness" (Staab 2004)
**Balance Impairment:**
- Very common acutely and sub-acute following concussion (Geurts 1996; Guskiewicz 1997; Guskiewicz 2000; Kontos 2012)
- Often related to abnormalities in **Sensory Organization**
- It appears that, in particular, the ability to utilize and process vestibular information needed for balance may be affected in concussed athletes (Peterson 2003; Guskiewicz 2001)

**Balance Training**

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

**Visual System Impairment:**
- Subjective complaints:
  - Blurred vision
  - Double vision
  - Jumping images (oscillopsia)
  - Eye strain
  - Difficulty taking notes in class

*Intervention is often helpful!*

**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 (Vertical Phoria)</td>
<td>55%</td>
<td>5%</td>
<td>0.0012*</td>
</tr>
<tr>
<td>Ocular Misalignment (Horizontal Phoria)</td>
<td>45%</td>
<td>5%</td>
<td>0.0084*</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 Capo-Aponte et. al. Military Medicine 2012

**Pursuits:**
- Eyes follow a slowly moving target

**Saccades:**
- Eyes move quickly between targets

**Common findings:**
- Saccadic pursuits/ intrusions
- Symptom provocation

**ATYPICAL w/ Concussion:**
- Hypometric saccades
- Slowed saccades
- Symptomatic w/ saccadic eye movements

- *overshooting*
- cerebellar disease
Vertergence System Issues

**Convergence:** Ability of eyes to turn inward to focus on a near target

- **Vergence Testing:** Patient fixates on target brought in along the mid-sagittal plane toward the nose
- **Near Point of Convergence:** when target becomes double
- Normal NPC < 6 cm from tip of nose (Scheiman 2003)

Disorders of Vergence:

**Convergence Insufficiency**
- Reduced vergence response (NPC ≥ 6 cm from tip of nose)

**Convergence Spasm**
- Increased vergence response

Courtesy: Suzanne Wickum OD.

Ocular Motor Problems: Misalignments

- Strabismus
- Can be obvious "tropia"
  - wall-eyed or cross-eyed
- Can be subtle "phoria"
- Can be aggravated/pre-existing

Evidence for Treating Ocular Motor Dysfunction following mTBI:


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

Treating Visual Disturbances

*Convergence Insufficiency, Pursuit, Saccade Impairments*

- Visual exercises/vision therapy
- Prism lenses
- Medication (convergence spasm)
- Surgery (rarely)

Screening for Vestibular and Visual Dysfunction
UPMC Vestibular/Ocular Motor Screening (VOMS)

- Brief **5 minute** assessment of the following five domains:
  1. smooth pursuits
  2. horizontal and vertical saccades
  3. convergence
  4. horizontal and vertical vestibular ocular reflex (VOR)
  5. visual motion sensitivity (VMS)

- Following each VOMS assessment, patients rate on a scale of 0 (none) to 10 (severe) symptoms of:
  - headache, dizziness, nausea and fogginess

- Convergence is assessed by both symptom provocation and near point of convergence (NPC) distance
  - Normal = <5cm

- Assessment instructions standardized

Interpreting the VOMS:

- Controls report few symptoms following VOMS and have normal NPC distances (< 5 cm)
- VOMS symptom scores >2 and NPC distance ≥5cm represent clinically useful cut-offs.
- 3 VOMS items (VOR, VMS, NPC distance) resulted in 89% accuracy for identifying patients with concussion.
- The VOMS is a **complementary tool** to balance assessments, neurocognitive testing and symptom inventory; measuring distinct constructs.
- The VOMS may identify Vestibular and Ocular Motor dysfunction following concussion:
  - Guides referral for further evaluation and treatment when issues persist beyond acute stage.
  - Vestibular PT, Neuro-Otology, Optometry, Ophthalmology, etc.

CERVICAL DYSFUNCTION

Musculoskeletal Involvement and Treatment of the Cervical Spine

- **Suboccipital tightness/spasm**
  - Treat with manual therapy techniques: Suboccipital release, manual cervical traction
- **Decreased cervical mobility**
  - Treat with cervical traction, side glides, closing/opening mobilizations
- **Decreased mobility at Cervical-Thoracic Junction**
  - Treat with Grade V Cervical-Thoracic Mobilization
- **Decreased thoracic mobility**
  - Treat with Grade V upper thoracic mobilization
- **Positive ligamentous testing (Sharp Purser, C2 Kick-Test, Odontoid Shear Test)**
  - Refer to MD for imaging

Cervical Evaluation

- Cervical AROM
- Ligamentous Testing: Sharp Purser, C2 Kick Test, Modified Shear Test
- Cervical Mobility Testing
- Thoracic Mobility Testing
- UE Strength Testing
- Upper Motor Neuron Testing
- Reflex Testing
Cervicogenic Dizziness

- 85% of patients experiencing chronic complaints after cervical injury report dizziness (Oosterveld 1991)
- Often termed “Cervical Vertigo” in the literature, although vertigo is rarely present

Clinical Presentation: Cervicogenic Dizziness

- **Dizziness:** commonly described as:
  - “Off”
  - “Swimming”
  - “Floating”
  - “Detached”
  - Rarely “vertigo”
- Dizziness more pronounced with cervical motion
- Neck pain, stiffness, ROM limitations
- Weak/uncoordinated deep neck flexors
- Balance complaints & impairment

Exertion Testing And Exertion Therapy For Return To Play

Cara Troutman-Enseki PT, DPT, OCS, SCS

Role of Exertion Testing

- Allows the physical therapist to screen the athlete prior to return to play to rule out potential symptom provocation with physical exertion

Research supporting the use of Exertion Testing prior to Return to Play in Athletes

- Research has shown that neurocognitive scores decreased post-exertion following a concussion suggesting that all athletes should be exerted prior to neurocognitive testing (Neal McGrath et al.)

No research exists that details a return to play exertion test following a concussion.
Components to Consider when Designing an Exertion Test

- Balance
- Cardiovascular Activity
- Exercises to Stress the Vestibular System
- Sport-Specific Activity

Balance

- Choose the same balance assessment pre and post exertion to assess for a decline in the patient’s balance ability post exercise.

Cardiovascular Activity

- Can choose from the stationary bike, UBE, elliptical or treadmill
- Consider the cardiovascular activity the patient will be returning to when deciding what cardio equipment to utilize (cross-country runner versus crew)

Movement Screen

- Consider assessing movements that the patient will have to perform in their sport/job/recreational activity
- Examples of movements to screen for: vertical, horizontal, forward, backward, and rotational
- Rational for movement screen: to assess for symptom provocation with activities that stress the vestibular system (VORx1 both vertical and horizontal and visual motion sensitivity)

Functional Screen

- Consider assessing higher level functional movements that they will need to return to sport/job/recreational activity to further stress their vestibular system.
- Incorporate many different planes of dynamic movement to ensure that the patient does not have any lingering symptoms.

Sport-Specific Activity Screen

- Consider testing sport-specific activities to make sure the patient does not become symptomatic. Examples:
  - Dribbling and passing a soccer ball while running up and down the field for a soccer player
  - Stick handling while using the sliding board with resistance cords for a hockey player
  - Have a dancer perform walking handstands, turns, aerials, or their entire dance routine
Role of Exertion Therapy

- When a patient is not able to remain symptom-free with exertion testing, exertion therapy can help to rehabilitate the patient back to physical activity.
- The patient's program is developed based on their individual impairments and the sport that they are returning to.

Exertion Therapy

- Limited research on exertion therapy in patients post-concussion
- Research has shown that student athletes that have engaged in high levels of activity in the weeks following a concussion had increased symptoms, worsened neurocognitive data, and significantly longer recovery times - Majerske et al., 2008

Exertion Therapy

- Research has not shown an impairment based approach to exertion therapy following a concussion.
- Goal is to take the impairments found following exertion testing and create an individual program based on these impairments and the sport the patient is returning to.

Exertion Therapy: When to initiate?

- No specific time table to dictate when to begin exertion therapy following a concussion
- Initiated in athletes with minimal to no symptoms
- Initiated in athletes that are symptomatic but have crossed over to the chronic stage of post-concussion management
- Initiated in anxious/depressed post-concussion patients
- Initiated in migraine suffering post-concussion patients
- Timing of exertion therapy decided by all medical parties involved in the individual athlete’s post-concussion management

Screening for Outside Involvement prior to initiating exertion therapy

- Screen for orthostatic hypotension
- Screen for cervical involvement
- Screen for vestibular ocular impairments

Considerations for exertion therapy when vestibular ocular impairments are present

- Sensitivity to busy environments: Use treatment rooms or have the patient schedule at less busy times of the day.
- VOR impairments: have the patient perform the stationary bicycle over the treadmill, use focusing techniques when performing tasks such as squats and lunges.
- Limit head movements early on and slowly progress the patient to include more dynamic movements.
Exertion Therapy?

- **Old Model**: Stages vary by heart rate max with each stage progressing the amount of exertion
- **New Model**: Stages vary by movement/vestibular impairments with each stage progressing into more dynamic movements and more physical exertion

**Post Concussion 5 Stages of Exertion Therapy**

**Stage 1**
- **Exertion Therapy**: light aerobic conditioning, balance activities, exercises that limit head movements (weight machines, squats/lunges with focusing), core exercises without head movements
- **Recommendations**: exercise in quiet area (treatment rooms recommended); no impact activities; balance and vestibular treatment by specialist (prn); limit head movement/position change; limit concentration activities

**Stage 2**
- **Exertion Therapy**: light to moderate aerobic conditioning, balance activities with head movements, resistance exercises with head movements (example: lateral squats with head movement), low intensity sport specific activities, core exercises with head movements (ex: side planks with arm/head turn)
- **Recommendations**: exercise in gym areas recommended; use various equipment; allow positional changes and head movement; low level concentration activities (counting repetitions)

**Stage 3**
- **Exertion Therapy**: moderately aggressive aerobic exercise (intervals, pyramids, stair running), all forms of strength exercises, dynamic warm-ups, impact activities (running, plyometrics), challenge positional changes (burpees, mountain climbers), more aggressive sport-specific activities
- **Recommendations**: any environment ok for exercise (indoor, outdoor); integrate strength, conditioning, and balance/propioreceptive exercise; can incorporate concentration challenges (counting exercises, MRS equipment/visual games)

**Stage 4**
- **Exertion Therapy**: max exertion sport-specific activities avoiding contact. Have the athlete participate in a noncontact practice.
- **Recommendations**: continue to avoid contact activity, but resume aggressive training in all environments
Stage 5

- **Exertion Therapy:** full physical training activities with contact
- **Recommendations:** initiate contact and full exertion activities as appropriate to sport

Taking an athlete through the 5 stages of exertion

Sport-Specific Example

Stage 1: Exertion for a Figure Skater

- Stage 1: Performed 2-3 days/week in quiet environment
- Light cardio warm up: Stationary bicycle or UBE
- Stretches

Stage 1: Exertion for a Figure Skater

- **Strengthening**

Stage 1: Exertion for a Figure Skater

- **Adductor Stretch**
- **Gastroc Stretch**
- **Soleus Stretch**

Stage 1: Exertion for a Figure Skater

- **Hip Flexor Stretch**
- **Quad Stretch**
- **Piriformis Stretch**
- **Cross Body Stretch**
Stage 1: Exertion for a Figure Skater
- Balance

Stage 2: Exertion for a Figure Skater
- 3-4 Days a week in a gym
- Warm up: 20-25 minutes bike, elliptical, UBE
- Stretches

Stage 2: Exertion for a Figure Skater
- Strengthening
- Core
Stage 2: Exertion for a Figure Skater
- Balance

Stage 3: Exertion for a Figure Skater
- 4-5 Days a week in any environment
- Cardio warm up: 10 minutes Jump rope, or 25-30 minutes treadmill, elliptical, bike
- Stretches

Stage 3: Exertion for a Figure Skater
- Plyometrics

Stage 3: Exertion for a Figure Skater
- Forward Leaps
- Power Skips

Stage 3: Exertion for a Figure Skater
- Agility

Stage 3: Exertion for a Figure Skater
- Core
Stage 3: Exertion for a Figure Skater

- Balance

Stage 4: Exertion for a Figure Skater

- 5 Days a week in any Environment
- Skater may return to ice to complete forward stroking, forward/back crossovers, cross strokes, power pulls, spiral sequence, footwork to maintain endurance on ice
- Cardio Warm up: 10 min. Jump rope w/ double loop, 30 min. treadmill, elliptical, outdoor run

Stage 5: Exertion for a Figure Skater

- Once the patient is given doctor’s clearance to return to sport, the skater should return to full program run-throughs multiple times throughout practice sessions to build endurance. Off ice stretching, high intensity cardio and core exercise should be continued

Summary

- An exertion test prior to return to play following a concussion can be helpful in ruling out potential symptom provocation with physical activity.
- When designing an exertion test consider movements that will challenge the cardiovascular system, balance, the vestibular system, dynamic and functional movements, and sport-specific activities.
- When monitored by a trained professional, exertion therapy can help the patient return to their prior level of physical activity.
- An impairment based approach can help rehabilitate the patient so that they will not be symptomatic with return to play.
- More research is needed to determine the best approach to exertion testing and exertion therapy.

Rehab - What’s Different??

- Include systematic monitoring throughout sessions of: HA, Dizziness, Nausea, Fogginess, Fatigue
- Incorporate ocular motor training when needed and/or make referrals
- In acute & sub-acute phase of injury, proceed at much slower rate than with peripheral injuries (energy crisis!)
  “LESS IS MORE”
- Be aware of migraine provocation
  - May need to modify environment and stimuli!
- In very early stages, may need to limit exercise and/or daily activities; however look for ways to introduce activity ASAP
- Monitor for sleep issues, emergence of migraine & mood changes – make recommendations if problems identified
Thank You!