The “Team” Approach to Concussion Management

Becky Bliss, PT, DPT, cNDT
Concussion or mild traumatic brain injury (MTBI) is a pathophysiological process affecting the brain induced by direct or indirect biomechanical forces.

- Common features include the following:
  - Rapid onset of usually short-lived neurological impairment, which typically resolves spontaneously.
  - Acute clinical symptoms that usually reflect a functional disturbance rather than structural injury.
  - A range of clinical symptoms that may or may not involve loss of consciousness (LOC).
  - Routine neuroimaging studies are typically normal.
Metabolic Crisis

Neuron Following Concussion

Metabolic dysfunction results in ENERGY CRISIS

Massive release of neurotransmitters interferes with cell communications

Nerve cell is extremely vulnerable in this condition, and further injury or stress may cause cell death or serious cell damage.
Pathophysiology

Initial Injury → Axonal Stretching → Disruption of Neural Membranes → Potassium efflux Calcium Influx → Na/K pump works overtime → Increased energy (glucose) required

Increase in Demand + Decrease in ATP (energy) = Metabolic Crisis

Axonal Swelling + Lack of Perfusion = Diffuse Axonal Injury
Concussion Signs and Symptoms

- **Physical**: headache, balance problems, light/noise sensitivity, blurred vision, dizziness, fatigue, nausea, neck pain
- **Cognitive**: mentally foggy, difficulty concentrating, confusion, delayed processing
- **Emotional**: irritability, sadness, nervousness, anxiety, lability
- **Sleep**: drowsy, altered sleep patterns

*Duration of Symptoms is highly variable and may last from several minutes to months or even longer in some cases*
Epidemiology

- Concussions occur commonly in helmeted and non-helmeted sports and account for a significant number of time loss injuries.
- There are up to 3.8 million concussions occurring among participants in sports and recreational activities each year.
- Published reports indicate recognized concussion injuries occur frequently.
- Football, ice hockey, soccer, and lacrosse tend to have the highest concussion incidence rates when calculated by athlete exposure.
Post Concussion Syndrome

- Symptoms include:
  - Chronic persistent Headaches
  - Fatigue/Sleep disturbances
  - "Fogginess"
  - Personality changes (irritability, depression)
  - Sensitivity to light or sounds
  - Dizziness when standing quickly
  - Academic functioning: Short term memory deficits, difficulty with problem solving, concentration, and processing speed.
  - Can be very disabling for the individual and their families

- Typically defined as having concussion symptoms that last for greater than a month after the initial head injury but WHO vs CDC have different criteria currently
Second Impact Syndrome

- Rare fatal phenomenon involving a 2\textsuperscript{nd} head injury before resolution of 1\textsuperscript{st}
- 1\textsuperscript{st} concussion could have been mins, days or weeks prior
- 2\textsuperscript{nd} blow only have to be “minor”
- Sudden collapse and rapid neurological decline
- Results in severe death and/or impairment
- Thought to be caused by subdural hemorrhage and/or dysautoregulation of the cerebral vasculature causing hyperemic brain swelling and elevated ICP
- Adolescents and young adults
1 is Too Many
Role of Athletic Trainers in Concussion Management

- As licensed medical professionals, athletic trainers receive comprehensive didactic and clinical training in concussion management.

- They are typically the first providers to identify and evaluate injured persons and are integral in the post injury management and return-to-play (RTP) decision-making process.
Role of Pre-season Preparation

▪ Risk Factors
▪ Education
▪ Baseline Concussion Testing
▪ Emergency Procedure Protocol

"We have to get to a point where it's not a LUXURY to have an athletic trainer; it's a NECESSITY."
ImPACT Testing
Risk Factors

▪ Several risk factors contribute to an athlete’s concussion recovery.

▪ Assessing the athlete’s concussion history can provide valuable information; specifically, the number of concussions, the severity of each concussion, and how close in time the concussions occurred to each other.

▪ Additionally, assessing concussion symptoms (number, severity, and duration), the age of the athlete, and any pre-existing conditions (e.g., history of migraines, headaches, ADD/ADHD, Learning Disability, Depression, Anxiety) before the season begins can help with managing a concussion if it ever occurs.
Education

- Studies have shown that many athletes do not report concussion symptoms to coaches, parents, and ATC’s because they do not know what the symptoms feel like.

- Athletes who have received concussion education are more likely to tell their coaches when they are feeling symptomatic.

- Education of parents and coaches can help them become familiar with the signs of a concussion.
Baseline Concussion Testing

- A Baseline Concussion Test is usually a computer-based neurocognitive test that measures various aspects of brain functioning, including memory abilities, reaction time, informational processing speed, and impulse control.

- This test is administered at the beginning of the sports season and acts as a measure of what an athlete looks like when they’re healthy.

- If a concussion then occurs throughout the season, the concussion management specialist can administer a similar test and compare the results to that athlete’s performance before they were injured.

- If a Baseline Concussion Test was not performed on the athlete, the specialist must rely only on comparisons to the general population.
Emergency Procedure Protocol

- Before the season ever begins, the coaches, ATC’s, and others involved in the athletic and academic pursuits of an athlete should have an emergency procedure ready in the event of a suspected concussion.

- This would involve having an outlined plan for the various stages of concussion management, starting with education and baseline testing before the season, emergency procedures to follow on the sideline in the event of a suspected concussion (e.g., SCAT2 exam, conditions defining when to transport the athlete to an emergency department, procedure to contact parents or family of athlete, etc), and a plan for ongoing evaluation and accommodations for those recovering from a concussion.
Equipment Safety


Missouri was the twenty-fifth state to enact strong youth sports concussion safety legislation since the Washington State's groundbreaking Zackery Lystedt Law was enacted in May 2009.
H.B 300, 334 and 387

- **Immediate removal if concussion suspected:** A youth athlete suspected of having sustained a concussion or brain injury in a practice or game must be immediately removed from competition and not allowed to return for at least 24 hours.

- **No return to play without written clearance.** Once removed from play, a youth athlete may not return to competition until he has been (a) evaluated by a health care provider trained in the evaluation and management of concussion; and (b) receives written clearance to return from that health care provider.

- **Continuing concussion education.** School district must distribute a concussion and brain injury information sheet to each youth athlete participating in its athletic program on a yearly basis, which the athlete's parent or guardian must sign and return to the school district in order for the athlete to be able to participate in interscholastic sports.
State of Missouri Brain Injury Report in HS

- SCS HCS HB 300, 334, and 387 became law in August 2011, and it mandates that an organization with public schools as members must publish and distribute an annual report regarding the impact of student athlete concussions and head injuries which should include efforts that may be made to minimize damages from school sports injuries.

### Conclusion
2012-13 Concussion Survey Results

<table>
<thead>
<tr>
<th></th>
<th>Number of Athletes</th>
<th>Number of Days Sport was Missed</th>
<th>Number of Days Class Time Missed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>2097</td>
<td>22672</td>
<td>2289</td>
</tr>
<tr>
<td>Female</td>
<td>635</td>
<td>7845</td>
<td>760</td>
</tr>
<tr>
<td>Total</td>
<td>2732</td>
<td>30,517</td>
<td>3049</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Number of Students</th>
<th>Number of Days Activity was Missed</th>
<th>Number of Days Class Time Missed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>180</td>
<td>2356</td>
<td>186</td>
</tr>
</tbody>
</table>
How Many Days Missed for Concussion....

- There were a total of 2097 males and 635 females held out of practices and contests due to a head injury, for a total of 22,672 and 7,845 days respectively.
- This means that the male athletes were held out on an average of 10.8 days per incident and females were held out 12.4 days.
- This was up from the previous year when males were on average held out 6.5 days and females 10.4 days.
- This does show a good correlation to the gradual return-to-play guidelines which indicate at a minimum 7-day return rate.

<table>
<thead>
<tr>
<th>Top 7 Head Injury Sports/Activities</th>
<th>Number of Head Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Football</td>
<td>1325</td>
</tr>
<tr>
<td>Wrestling</td>
<td>218</td>
</tr>
<tr>
<td>Basketball (G)</td>
<td>209</td>
</tr>
<tr>
<td>Soccer (G)</td>
<td>198</td>
</tr>
<tr>
<td>Soccer (B)</td>
<td>194</td>
</tr>
<tr>
<td>Basketball (B)</td>
<td>174</td>
</tr>
<tr>
<td>Sideline Cheer</td>
<td>169</td>
</tr>
</tbody>
</table>
Requirements of Schools

▪ All coaches must take a course on the signs, symptoms, and prevention of concussions.

▪ All parents and athletes must receive and sign for the concussion materials as indicated on the MSHSAA Pre-participation Physical Form.

▪ Athletic Directors must keep accurate records of this information and be able to provide it to MSHSAA if asked to do so.
Sideline Assessments

- SCAT 3
- Child SCAT 3
- SCAT 2 (mobile app)
- Sideline Impact Test (mobile app)
- NFL Sideline Tool
- SAC
- King-Devick Test
# Return to Play Protocol

<table>
<thead>
<tr>
<th>Rehabilitation stage</th>
<th>Functional exercise at each stage of rehabilitation</th>
<th>Objective of each stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No activity</td>
<td>Symptom limited physical and cognitive rest</td>
<td>Recovery</td>
</tr>
<tr>
<td>2. Light aerobic exercise</td>
<td>Walking, swimming or stationary cycling keeping intensity &lt;70% maximum permitted heart rate No resistance training</td>
<td>Increase HR</td>
</tr>
<tr>
<td>3. Sport-specific exercise</td>
<td>Skating drills in ice hockey, running drills in soccer. No head impact activities</td>
<td>Add movement</td>
</tr>
<tr>
<td>4. Non-contact training drills</td>
<td>Progression to more complex training drills, eg, passing drills in football and ice hockey May start progressive resistance training</td>
<td>Exercise, coordination and cognitive load</td>
</tr>
<tr>
<td>5. Full-contact practice</td>
<td>Following medical clearance participate in normal training activities</td>
<td>Restore confidence and assess functional skills by coaching staff</td>
</tr>
<tr>
<td>6. Return to play</td>
<td>Normal game play</td>
<td></td>
</tr>
</tbody>
</table>

http://blogs.bmj.com/bjsm/files/2013/11/RTP1.jpg
Typical Recovery

- 85-90% Concussions show signs of recovery in first 7-10 days

- Early identification of impairments aids in return to activity/sport without prolonged sequelae
Predictors of Prolonged Recovery?

Published in the Journal of Pediatrics 2013:

“Symptoms Severity Predicts Prolonged Recovery after Sport-Related Concussion, but Age and Amnesia Do Not”

Boston Children’s and University of Pittsburgh Medical Center studied a total of 182 patients that presented to their clinics within three weeks of injury.

****We need to listen to the initial symptoms (especially headaches, dizziness and fogginess) described versus considering sex, age, loss of consciousness, and amnesia when discussing length of recovery
Symptomatic Recovery Period

- No exercise (24-48 hours only?)
- Decreased school activity/hours (based on symptoms)
- Do not want decompensation
- Role of added stressors?
- Each case is individual, no 2 concussions are the same
- PATIENT EDUCATION!!!
A new study published in the journal *Pediatrics* asserts that when it comes to treatment for concussion, rest is a good thing—but it may be possible for adolescents to get too much of it.

In a paper e-published ahead of print on January 5 (.pdf), researchers report on findings from a study of 88 patients, aged 11 to 22, who reported to a Wisconsin emergency department (ED) and were diagnosed as having experienced concussion. Of that number, 43 were prescribed "usual care" of 1–2 days of rest followed by a gradual return to activity, while the remaining 45 participants were prescribed strict rest for 5 days (no school, work, or physical activity).

Assessments were performed in the ED and at 3 and 10 days after injury. Participants also completed activity diaries that included a 19-symptom Post Concussive Symptoms Scale (PCSS). What researchers found was that while neurocognitive and balance tests showed no significant differences in the groups as they recovered, 50% of the participants assigned to strict rest took an average of 3 days longer to report symptom resolution. Additionally, the strict rest group reported higher PCSS scores than the usual-care group.

"Recommending strict rest from the ED did not improve symptom, neurocognitive, and balance outcomes in youth diagnosed with concussion," authors write. "Surprisingly, adolescents who were recommended strict rest after injury reported more symptoms over the course of this study."

Authors forwarded several possible explanations for the difference in symptom reporting, including the possibility that the more restrictive treatment influenced the patients' perceptions. "The deleterious effects of strict rest may have more to do with emotional distress caused by school and activity restriction," they write. "Missing social interactions and falling behind academically may contribute to situational depression increasing physical and emotional symptoms."
Multidisciplinary Approach

From withdrawal to return to play:

▪ Coach
▪ Athletic Trainer
▪ Sports Medicine Doctor
▪ Neuropsychologist
▪ Neurologist
▪ Vestibular Therapist (PT/OT)
▪ Vision Therapist
▪ Neuro-otologist
▪ Counselor
Conceptual Framework

Concussion

- Ocular
- Post-Traumatic Migraine
- Vestibular
- Cervical
- Anxiety/Mood
- Cognitive/Fatigue
Not a perfect World

- Subtypes RARELY occur in isolation and often overlap
  - The KEY is finding the “driving” subtype(s) to start management
Medical History is Key!

- Migraines
- Prior Concussions
- Visual Impairment
- Cervical Injury/Impairment
- Learning Disabilities
- Mood Disturbances
## Oculomotor Dysfunction Following mTBI

<table>
<thead>
<tr>
<th>Condition</th>
<th>mTBI</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convergence Insufficiency</td>
<td>55%</td>
<td>5%</td>
</tr>
<tr>
<td>Saccadic Impairment</td>
<td>30%</td>
<td>0%</td>
</tr>
<tr>
<td>Pursuit Impairment</td>
<td>60%</td>
<td>0%</td>
</tr>
<tr>
<td>Ocular misalignment</td>
<td>55%</td>
<td>5%</td>
</tr>
<tr>
<td>(vertical phoria)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ocular misalignment</td>
<td>45%</td>
<td>5%</td>
</tr>
<tr>
<td>(horizontal phoria)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accommodative dysfunction</td>
<td>65%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Oculomotor System

- Purpose: to produce eye movements to direct the fovea toward the target of interest

- 6 extraocular muscles rotate the eye
  - Divided into 3 pairs with complementary actions

- 3 cranial nerves control the eye muscles
  - CNIII (oculomotor): Medial rectus, superior rectus, inferior rectus and inferior oblique
  - CN IV (Trochlear): Superior oblique
  - CN VI (Abducens): Lateral rectus
Common Symptoms in Ocular Deficits

- Difficulty focusing/ prolonged reading
- Double vision
- Blurry vision
- Eye strain
- Headaches
- Pulling around eyes
- Sensitivity to light
Visual Assessment

- Visual acuity
- Extra-ocular movements
- Pursuit eye movements
- Saccades
- Vergence
- Accommodation
- Gaze holding (nystagmus)
- Ocular alignment
Ocular Motor findings – Post Concussion:

Pursuits:
- “Saccadic” pursuits or “Saccadic Intrusions”
- Symptomatic w/ pursuit movements

Saccades:
- Hypometric Saccades
- Slowed Saccades
- Symptomatic with saccades eye movements

Atypical to Concussions: overshoots!
Abnormal Smooth Pursuits
Fast Speed Smooth Pursuits
Vergence 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)
- Abnormalities in Vergence
  - Convergence Insufficiency = reduced vergence response (≥ 6 cm from tip of nose)
  - Convergence Spasm = Increased vergence response
Convergence
Vergence Dysfunction

- **General Symptoms**
  - Asthenopia when reading
  - **Frontal headaches**
  - Intermittent or constant double vision
  - Squints, closes one eye.
  - Letters will appear to float or move around the page
  - Lack of symptoms but findings persist
    - Suppression, avoidance, or occlusion (pre-existing?)

- **Common Vergence Problems**
  - Convergence Insufficiency
  - Convergence Excess
  - Convergence Spasm
Convergence Insufficiency

- **Symptoms:**
  - “Double” (or blurred) vision at a reading distance
  - Eye strain while reading.
  - Frontal headaches.
  - Pulling around the eyes.

- **Definition:** Sensory and neuromuscular anomaly of the binocular vision system, characterized by an inability of the eyes to turn towards each other or sustain convergence. Also, when there is a tendency of the eyes to deviate outward (exophoria). Not age dependent.

- **Non-TBI Cohort:** prevalence up to 6% in general population. Much greater in mTBI cases.

Convergence
Insufficiency
Difficult Environments
Misalignment Issues

OCULAR MISALIGNMENT

- **Tropia** – overt deviation of the eye
  - Exo – outward (laterally)
  - Eso – inward (medially)
  - Hyper – upward
  - Hypo - downward

- **Phoria** – Ocular deviation occurs when dissociation occurs.
Alternate Cross Cover Test
Misalignment Symptoms:

*If Severe:*
- Diplopia
- Head tilt (vertical misalignment)
- Noticeable eye turn

*If Subtle:*
- Difficulty maintaining focus
- Cosmetically normal
- Ocular soreness
- Headaches
- Mental dullness
Areas Responsible For Binocular Function
Dizziness Post Concussion

Prevalence and Significance

- Dizziness reported in 55% of concussed athletes (Lovell 2004)
- Ocular impairments (blurred vision, diplopia, difficulty reading, etc) seen in 30%
- Dizziness associated with protracted recovery
- Undiagnosed vestibular deficits may delay recovery
Roles of the Vestibular System

▪ Linear and angular motion detection
▪ Postural Stability
▪ Orientation in Space
  ▪ Monitors position of head relative to gravity
▪ Gaze Stability

▪ Am I moving or are surroundings moving?
Causes of Vestibular Dysfunction

<table>
<thead>
<tr>
<th>Type of TBI</th>
<th>Possible Manifestation</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labyrinthine Concussion</td>
<td>Ataxia, imbalance, BPPV may be present</td>
<td>Most common vestibular injury due to TBI</td>
</tr>
<tr>
<td>Skull Fracture</td>
<td>UVL or BVL (partial or complete) Conductive hearing loss May have mixed peripheral and central lesions</td>
<td>Common with blows to the occiput, temporal or parietal regions</td>
</tr>
<tr>
<td>Hemorrhage into Labyrinth</td>
<td>May create post traumatic hydrops (Meniere’s type syndrome) Damage to labyrinth, may create acute vertigo and Unilateral hearing loss</td>
<td>Labyrinthine damage may present with signs and symptoms similar with acute peripheral vestibular damage</td>
</tr>
<tr>
<td>Hemorrhage into brainstem</td>
<td>Oculomotor signs, poor smooth pursuit, vertigo, perception of tilt</td>
<td>Damage to vestibular and oculomotor nuclei</td>
</tr>
<tr>
<td>Increased Intracranial</td>
<td>Fluctuating hearing loss, ataxia, imbalance</td>
<td>May cause peri-lymphatic fistula</td>
</tr>
<tr>
<td>Pressure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Ears and the Brain... Connection

- Head movements are detected by the cupula and transmitted via Vestibular Nerve to the Brain. Which then controls eye movement to stabilize the gaze.

- The ratio of eye to head movement (GAIN) should be 1:1. Abnormal gain can cause symptoms of blurry vision or vertigo.
Central Processing Proprioceptive Input

Motor Outputs

- **VOR (Vestibular Ocular Reflex):** generates eye movements, which enables clear vision while head is in motion

- **VSR (Vestibular Spinal Reflex):** generates compensatory body movement in order to maintain head and postural stability, thereby preventing falls
Dynamic Visual Acuity (VOR)

Vestibular/Ocular System Deficits – Present in Concussion

- Disruption of both static and dynamic balance contributing to postural instability
- Symptoms involving visual, vestibular and somatosensory system to include:
  - Dizziness/Vertigo
  - Motion Sensitivity/Height Phobia
  - Tinnitus
  - Lightheadedness
  - Blurred vision/Double vision/Trouble Focusing
  - Photophobia
  - Imbalance (especially in dark)

May be temporary or permanent depending on structures involved and severity of injury = if not cleared in 7-10 days, referral to Vestibular Rehab/Vision Therapy may be warranted
Benign Positional Vertigo

Otoliths become detached from the utricle, floating freely into the semi-circular canals; when the head is moved, the clump of particles moves (as per the red arrow), causing a deflection of the hair cells, which creates the sensation of movement in one ear only, i.e., spinning or vertigo.
Left Dix Hallpike + Left Posterior Canal
Factors that may trigger or exacerbate headaches

▪ Cervical spine injury
▪ Impaired sleep
▪ Higher level cognition
▪ Vision
▪ Hearing sensitivity
▪ Exercise
Physical Therapy Concussion Eval: The Whole Picture

- Subjective Questionnaires: DHI, ABC Scale, NDI, HIT-6
- Complete History of Event – LOC, direction of hit, amnesia, removal from play?, on-field symptoms
- Prior concussion(s), *history of mood disorders / anxiety, ADHD, ADD, migraines, learning disabilities*
- History of visual impairments
- Management since injury? (cognitive rest, days off school/work, medications, testing)
- Full past medical history
- Complete Vestibular/Ocular Evaluation
- Cervical Spine Evaluation
- Exertional Tolerance Exam
Concussion Exam Components

Exam:
- Cervical Range of Motion
- Cervical Ligamentous Integrity
- General Extremity strength screening
- Fine Motor/Coordination Assessment (finger to nose, finger to object etc)
- Joint Position Error Test
- Cranial N. Exam
- Ocular Motor Range of Motion
- Smooth Pursuit Saccades
- Vestibular Ocular Reflex (horizontal and vertical at different speeds)
- Head Thrust Test
- VOR Cancellation
- Convergence
- Ocular Alignment Testing
- Optokinetic Nystagmus
- Spontaneous Nystagmus
- Fixed Gaze Nystagmus

Head Shaking Nystagmus
- Dix Hallpike and Roll Test (rule out BPPV)
- Vertebral Artery Test
- Tragal Pressure/Valsalva for fistula/inner ear tear
- Dynamic Visual Acuity (eye chart)
- Romberg, Sharpened Romberg, Standing Foam (modified CTSIB)
- Dynamic Gait Index or Functional Gait Assessment
- Tandem walking
- Single Leg Stance
- BESS Test if applicable / HiMAT
- Motion Sensitivity Quotient (if complaints of motion evoked dizziness)
  - Modified Balke Protocol/ Buffalo Treadmill Test (determine threshold for aerobic activities) Vestibular Rehab
What does Nystagmus Look Like?
Cranial Nerve Screening

Olfactory (I)
sensory: nose

Intermediate
motor: submaxillary and sublingual gland
sensory: anterior part of tongue and soft palate

Glossopharyngeal (IX)
motor: pharyngeal musculature
sensory: posterior part of tongue, tonsil, pharynx

Vestibulocochlear (VIII)
sensory: inner ear

Vagus (X)
motor: heart, lungs, bronchi, gastrointestinal tract
sensory: heart, lungs, bronchi, trachea, larynx, pharynx, gastrointestinal tract, external ear

Facial (VII)
motor: muscles of the face

Hypoglossal (XII)
motor: muscles of the tongue

Accessory (XI)
motor: sternocleidomastoid and trapezius muscles
Visual acuity (VA) is acuteness or clearness of vision, which is dependent on the sharpness of the retinal focus within the eye and the sensitivity of the interpretative faculty of the brain.

Visual Acuity – Static
Dynamic Visual Acuity - DVA
Computerized DVAT

- *InVision*

- **The Dynamic Visual Acuity (DVA) Test**
  Quantifies the impact of vestibular ocular reflex (VOR) system impairment on a patient's ability to perceive objects accurately while moving the head at a given velocity on a given axis.

- **Gaze Stabilization Test (GST)**
  Quantifies the range of head movement velocities on a given axis over which a patient is able to maintain an acceptable level of visual acuity.
Balance and Gait Assessment

▪ Romberg, Sharpened Romberg, Single Leg Stance
▪ Sensory Organization Test (Balance Master)
▪ Modified CTSIB
▪ BESS Test
▪ Dynamic Gait Index
▪ Functional Gait Assessment
▪ HiMAT (relatively new for higher level TBI)
▪ Computerized Posturography…. Neurocom
Modified CTSIB

- 4 Positions
  - 1. Eyes open Solid Surface
  - 2. Eyes closed solid surface
  - 3. Eyes open compliant surface
  - 4. Eyes closed Compliant surface
- Hold each position for 30 secs
- Rate Quality of Balance
The Balance Error Scoring System (BESS) provides a portable, cost-effective and objective method of assessing static postural stability. The BESS can be used to assess the effects of mild head injury on static postural stability. Information obtained from this clinical balance tool can be used to assist clinicians in making return to play decisions following mild head injury. The BESS can be performed in nearly any environment and takes approximately 10 minutes to conduct.

The balance-testing regime consists of three stances on two different surfaces. The three stances are double leg stance, single leg stance and tandem stance. The two different surfaces include both a firm (ground) and foam surface. Athletes’ stance should consist of the hands on the iliac crests, eyes closed and a consistent foot position depending on the stance. Shoes should not be worn.

In the double leg stance, the feet are flat on the testing surface approximately pelvic width apart.

In the single leg stance position, the athlete is to stand on the non-dominant leg with the contralateral limb held in approximately 20° of hip flexion, 45° of knee flexion and neutral position in the frontal plane.

In the tandem stance testing position, one foot is placed in front of the other with heel of the anterior foot touching the toe of the posterior foot. The athlete’s non-dominant leg is in the posterior position. Leg dominance should be determined by the athlete’s kicking preference.

**Administering the BESS**: Establish baseline score prior to the start of the athletic season. After a concussive injury, re-assess the athlete and compare to baseline score. Only consider return to activity if scores are comparable to baseline score. Use with Standardized Symptom Scale Checklist.

**Scoring the BESS**: Each of the trials is 20 seconds. Count the number of errors (deviations) from the proper stance. The examiner should begin counting errors only after the individual has assumed the proper testing position.

![Images of different stances]

**B.E.S.S. SCORECARD**

<table>
<thead>
<tr>
<th>Errors</th>
<th>Firm Surface</th>
<th>Foam Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moving the hands off the hips</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening the eyes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step, stumble or fall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abduction or flexion of the hip beyond 30°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifting the forefoot or heel off of the testing surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remaining out of the proper testing position for greater than 5 seconds</td>
<td></td>
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</table>

The maximum total number of errors for any single condition is 10.

If a subject commits multiple errors simultaneously, only one error is recorded.

**B.E.S.S. TOTAL:**

(Annex™ Foam Balance Pads available at www.power-systems.com or through most sporting goods stores)
What We’ve Learned......

- It is more than just balance
- Vestibular/Ocular Component is missing Link
- On Field Markers that Predict Complicated Recovery?
- Outcomes are highly variable
- Vestibular-related symptoms (dizziness/fogginess) and migraine history/symptoms best predict protracted recoveries
- Effective sideline management is key-removal from play a must when symptoms occur
- Return to play prior to full recovery from concussion will result in worse outcome and less force causing re-injury.
- Neurocognitive testing is an effective tool to help quantify the injury and guide the management and RTP process.
- The “mild” injuries may become complicated and the “severe” injuries may become mild
- Proper Clinical management is best form of prevention

- Targeted clinical pathways for treatment and rehabilitation are being established
Role of Vestibular/Ocular Rehab Return to Play/Activity

▪ Does the patient have skewed/blurred vision while body in motion/head turning?
▪ Do they have continued headaches?
▪ Do visual tasks increase their symptoms?
  ▪ Critical missing link of full sensory integration of visual / vestibular / somatosensory system?
You Have To Train All Systems!

- TEAM EFFORT!
- Conjugate movement (EOM movement, SACCADES and PURSUIT), disconjugate movements (CONVERGENCE and DIVERGENCE), the FIXATION system, accommodation and VOR control the position of an image on the fovea.
Vestibular Rehab Focus

- Fine Motor Deficits/Reaction Time
- Vision
- Eye head coordination
- Headaches
- Fatigue
- Balance/Coordination
- Dual task performance
- Body Mechanics and Posture
- Safe return to activity
Convergence Exercises

- Pencil Push Ups
- Brock String
- Arrow Chart/Dot Card
Motor Control Exercises
Cervical Stabilization with Visual Feedback
Compensation

▪ Response to permanent vestibular lesion
  ▪ Increase response of remaining vestibular system
  ▪ Central nervous system changes to optimize function
▪ Goals of compensation:
  ▪ Approximate normal gaze stability and postural control
  ▪ Under head stationary and head moving conditions
  ▪ Reprogramming of eye movements and postural responses to movement
  ▪ Requires movements and exposure to stimuli that challenge the system
  ▪ Requires an error signal (Brain has to know something is wrong to correct)
Adaptation Exercises

▪ VOR x 1 and x 2 viewing exercises
  ▪ Progression:
    ▪ Duration, goal up to 2 minutes continuous
    ▪ Velocity
    ▪ Patterned/Busy backgrounds
    ▪ Position
    ▪ Target Distance
Vestibular Exercises
Vestibular Exercises
Substitution

- Substitution of other strategies to replace the lost or impaired function
  - Eye tracking
  - Oculomotor Exercises
  - Saccades
  - Eye head coordination exercises
  - Remembered Targets
Cheap Dynavision……
Substitution Exercises

Using laser, eyes first then head, how accurate, add compliant surface
Cervical Proprioception with Oculomotor Component
Saccades with Balance and Cervical Proprioception
Cervical Proprioceptive Exercises

- Head Laser with Targets
- Combine with Saccades
- Eyes Closed awareness

Treatment Strategy
Cervical Proprioception – Target Practice

INTERVENTIONS:
- Started seated on a firm surface
- Progress to a swiss ball, standing, tandem stance, single limb stance
- Couple with audible breathing exercises to ensure diaphragmatic breathing
- Trace circles clockwise and counter clockwise – palpate and observe muscle recruitment and breathing pattern.

Courtesy of Rob Landel, PT, PhD, www.skillworks.biz
Vestibular Rehab Concussion
More exercise ideas
Agility Drills
Progression

- Adaptation (if there is something to adapt)
- Substitution
- Habitation
- Add balance component into all of above or separately
High Functioning Athlete
What About Visual Motion Sensitivity?
ATC and Vestibular PT Relationship

- 3/7/15: Softball player dove for a ball, struck head on ground. No initial S & S, started to feel “foggy” 30-60 mins later
- Fogginess, Dizzines and Headache in weeks following
- Poor scores on ImPACT
- 3/16/15: VOMs administered by ATC and forwarded to PT
- 3/19/15: Vestibular/Ocular Eval
Evaluation Showed

- Abnormal Smooth Pursuits
- + Head Thrust Test
- NPC 4cm, but causes increased headache/eye strain
- Cover/Uncover Test: + Exophoria at near/far vision
- Computerized DVAT Test: normal
- Computerized GST: slow speeds 130/150 degrees per second
- Limits of Stability: abnormal reaction time and movement in the forward direction
Collaborative Effort for Treatment...

- Comprehensive HEP given:
  - Pencil Pushups
  - Brock String
  - Heart Chart
  - Dot Chart
  - VOR x 1, VOR x 2 higher speeds
  - Visual Reaction Time

- ATC insured daily performance in training room, added aerobic training and RTP…player back on field with no symptoms in < 2 weeks!
What about the Non-Vestibular Practitioner?

- Vestibular Ocular/Motor Screening
- Designed for those not specially trained in Vestibular Assessment
- Allows for recognition of need for vestibular referral
- Brief 5 min tool designed to identify ocular/motor impairment following concussion
- Use in conjunction with all assessments tools.
A Brief Vestibular/Ocular Motor Screening (VOMS) Assessment to Evaluate Concussions
Preliminary Findings

**Background:** Vestibular and ocular motor impairments and symptoms have been documented in patients with sport-related concussions. However, there is no current brief clinical screen to assess and monitor these issues.

**Purpose:** To describe and provide initial data for the internal consistency and validity of a brief clinical screening tool for vestibular and ocular motor impairments and symptoms after sport-related concussions.

**Study Design:** Cross-sectional study; Level of evidence, 2.

**Methods:** Sixty-four patients, aged 13.9 ± 2.5 years and seen approximately 5.5 ± 4.0 days after a sport-related concussion, and 78 controls were administered the Vestibular/Ocular Motor Screening (VOMS) assessment, which included 5 domains: (1) smooth pursuit, (2) horizontal and vertical saccades, (3) near point of convergence (NPC) distance, (4) horizontal vestibular ocular reflex (VOR), and (5) visual motion sensitivity (VMS). Participants were also administered the Post-Concussion Symptom Scale (PCSS).

**Results:** Sixty-one percent of patients reported symptom provocation after at least 1 VOMS item. All VOMS items were positively correlated to the PCSS total symptom score. The VOR (odds ratio [OR], 3.89; P < .001) and VMS (OR, 3.37; P < .01) components of the VOMS were most predictive of being in the concussed group. An NPC distance 5 cm and any VOMS item symptom score 2 resulted in an increase in the probability of correctly identifying concussed patients of 38% and 50%, respectively. Receiver operating characteristic curves supported a model including the VOR, VMS, NPC distance, and ln (age) that resulted in a high predicted probability (area under the curve = 0.89) for identifying concussed patients.

**Conclusion:** The VOMS demonstrated internal consistency as well as sensitivity in identifying patients with concussions. The current findings provide preliminary support for the utility of the VOMS as a brief vestibular/ocular motor screen after sport-related concussions. The VOMS may augment current assessment tools and may serve as a single component of a comprehensive approach to the assessment of concussions.
UPMC Vestibular Ocular Motor Screening Tool

- Assessments in 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

*Mucha, Collins, Elbin, Furman, Troutman-Enseki, DeWolf, Marchetti, Kontos. (in review)*
<table>
<thead>
<tr>
<th>Vestibular/Ocular Motor Test:</th>
<th>Not tested:</th>
<th>Headache 0-10</th>
<th>Dizziness 0-10</th>
<th>Nausea 0-10</th>
<th>Fogginess 0-10</th>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (pre VOMS) symptoms</td>
<td>N/A</td>
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<tr>
<td>Smooth Pursuits</td>
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<tr>
<td>Saccades - Horizontal</td>
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<td>Saccades - Vertical</td>
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<td>VOR - Horizontal</td>
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<td>VOR - Vertical</td>
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<td>Visual Motor Sensitivity Test</td>
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<td>Convergence</td>
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Near Point
- cm
- cm
- cm
Return to Play Progression

- **Stage 1** Complete physical and cognitive rest
- **Stage 2** Light aerobic exercise (Monitored vital signs, <70% maximum predicted HR, no resistance training)
- **Stage 3** Sport Specific exercise (running/agility) **no head impact activity**
- **Stage 4** Non Contact Training Drills (dual task, passing ball, obstacles, may attempt resistance training)
- **Stage 5** Full Contact Practice after medical clearance form received
- **Stage 6** Normal Game Play
UPMC SPORTS MEDICINE CONCUSSION PROGRAM GUIDELINES FOR
POST-CONCUSSION EXERTION REHABILITATION
Micky Collins, Ph.D., Mark Lovell, Ph.D., Cara Troutman-Ensek, DPT et al. (updated 3/10/13)

<table>
<thead>
<tr>
<th>Stage of Rehabilitation</th>
<th>Physical Therapy Program: Autonomic Dysfunction</th>
<th>Physical Therapy Program: Vestibular Dysfunction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STAGE 1</strong> Recommendations: exercise in quiet area, no impact activities, balance and vestibular treatment by specialist (pt); limit head movement/position change; limit concentration activities</td>
<td><strong>Target Heart Rate:</strong> 30-40% of maximum exertion <em>(Max HR-Rest HR x 0.3) + Rest. HR</em></td>
<td>• Stationary aerobic conditioning: bike, UBE • Static balance activities • Exercises that limit head movements (weight machines, squats/lunges with focusing) • Core exercises without head movements</td>
</tr>
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<td><strong>STAGE 2</strong> Recommendations: exercise in gym areas recommended, use various exercise equipment, allow some positional changes and head movement, low level concentration activities (counting repetitions)</td>
<td><strong>Target Heart Rate:</strong> 40-60% of maximum exertion <em>(Max HR-Rest HR x 0.40) + Rest. HR</em></td>
<td>• More progressive dynamic aerobic conditioning: elliptical, treadmill walking, progress to treadmill jogging • 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 (e.g. side planks with arm/leg lift, bicycle, Russian twists)</td>
</tr>
<tr>
<td><strong>STAGE 3</strong> Recommendations: any environment ok for exercise (indoor, outdoor); integrate strength, conditioning, and balance/proprioceptive exercises, can incorporate concentration challenges (counting exercises, visual games)</td>
<td><strong>Target Heart Rate:</strong> 60-80% of maximum exertion <em>(Max HR-Rest HR x 0.80) + Rest. HR</em></td>
<td>• 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 (80% max hr)</td>
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<td><strong>STAGE 4</strong> Recommendations: continue to avoid contact activity, but resume aggressive training in all environments</td>
<td><strong>Target Heart Rate:</strong> 80% of maximum exertion <em>(Max HR-Rest HR x 0.80) + Rest. HR</em></td>
<td>• 80% max exertion sport-specific activities avoiding contact</td>
</tr>
<tr>
<td><strong>STAGE 5</strong> Recommendations: initiate contact activities as appropriate to sport activity, full exertion activities for sport activities</td>
<td><strong>Target Heart Rate:</strong> 100% of maximum exertion with contact <em>(Max HR-Rest HR x 1) + Rest. HR</em></td>
<td>• Full physical training activities with contact</td>
</tr>
</tbody>
</table>
Questions?
References


References


References


