Role of Vestibular Rehabilitation in Concussion Management

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Objectives

• Attain a more clear understanding of the impact of concussion on the vestibular system.
• Assist in early identification of patients that may benefit from vestibular therapy to improve healing time.
• Understand the components being examined during a vestibular assessment.
• Understand and utilize a newer tool for assessment following concussion to identify patients that need to have vestibular treatment.
Concussion

- **According to the CDC:** A concussion is a type of traumatic brain injury (TBI) caused by a bump, blow, or jolt to the head that can change the way your brain normally works. Concussions can also occur from a fall or a blow to the body that causes the head and brain to move quickly back and forth.
## Concussion Signs and Symptoms

<table>
<thead>
<tr>
<th>Migraine (Physical Sx)</th>
<th>Cognitive Symptoms</th>
<th>Neuro-psychiatric</th>
<th>Sleep Disturbance</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Headaches</td>
<td>• Attention Problems</td>
<td>• More emotional</td>
<td>• Difficulty falling asleep</td>
</tr>
<tr>
<td>• Visual Problems</td>
<td>• Memory dysfunction</td>
<td>• Sadness</td>
<td>• Sleeping less than usual</td>
</tr>
<tr>
<td>• Dizziness</td>
<td>• “Fogginess”</td>
<td>• Nervousness</td>
<td></td>
</tr>
<tr>
<td>• Noise/Light Sensitivity</td>
<td>• Fatigue</td>
<td>• Irritability</td>
<td></td>
</tr>
<tr>
<td>• Nausea</td>
<td>• Cognitive slowing</td>
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</tr>
</tbody>
</table>

(Pardini, Lovell, Collins et al. 2004)
Information about acute concussion

- **LOC** - Approximately 90% of concussions do **NOT** result in loss of consciousness.

- **Amnesia** - Typically have amnesia for event and may have retrograde or anterograde amnesia.

- **MRI and CT** - Typically **not** helpful because it is not a structural change. There are changes at the neurometabolic level.

- **85%** - Typically resolve without needing therapeutic intervention.
Recent Study

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!!!
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

****Assessment for Vestibular Therapy warranted
According to the APTA

The American Physical Therapy Association recognizes that physical therapists are part of the multidisciplinary team of licensed health care providers that provides concussion management, which includes:

- Education
- Examination and evaluation to establish a diagnosis

An individual suspected of having a head injury and/or who has signs, symptoms, and behaviors of concussion should be immediately assessed for concussion by a licensed health care provider who is trained in the evaluation and management of concussion, and, if applicable, the individual should be immediately removed from participation in organized activity.

- Withdrawn from sports
- Withdrawn from other recommended activities
A school athlete suspected of having suffered a concussion or other head injury during a competition or practice shall be immediately removed from the competition or practice. Such school athlete may not return to competition or practice until he or she is evaluated by and receives written clearance from a health care provider.

A youth athlete suspected of sustaining a concussion or brain injury in a practice or game shall be removed from competition at that time and for no less than twenty-four hours. Such youth athlete may not return to competition until the athlete is evaluated by and receives written clearance from a licensed health care provider trained in the evaluation and management of concussions.
Healthcare Provider

Kansas
  • Defined as a physician

Missouri
  • Licensed health care provider trained in the evaluation and management of concussions
Multidisciplinary Approach

From withdrawal to return to play:

- Coach
- Athletic Trainer
- Sports Medicine Doctor
- Neuropsychologist
- Neurologist
- Vestibular Therapist (PT/OT)
- Neurotologist
- Counselor
History of Vestibular Therapy

- Dr. Timothy Hain – “The Dizzy Doctor” 1984 first publication on the vestibular system.
- He connected with Susan Herdman in 1994 for their first study completed together “Characteristics of postural stability in patients with gentamicin toxicity.”
- This was the year the first Vestibular Therapy Textbook was released by Susan Herdman.
- Competency course in Vestibular Rehab has been recognized through the APTA for adult treatment for 17 years.
- Certifications have been recognized through the APTA for pediatric treatment 4 years ago.
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
Postural Stability

- Central Nervous System (CNS) provides feedback mechanism critical for maintaining postural equilibrium.
- CNS processes input from visual, vestibular and somatosensory system to execute adequate and coordinated musculoskeletal responses.

Vestibular System Role:
- Maintain fixed gaze stabilization during head and body movement.
- Maintain balance in conjunction with additional info from visual and proprioceptive inputs.
Maintaining Upright Posture

- Sensory Organization: Involves the complex processes that determine appropriate timing, direction and amplitude of corrective postural actions from incoming information from our Visual, Vestibular and Somatosensory System

- How do we assess this in concussion management?
  - Advanced Technology VS. Low Level

**Advanced**
- NeuroCom SOT/VSR Sport
- Biodex mCTSIB
- Virtual Reality Head Rehab
- Dynavision2

**Simple**
- Romberg
- BESS
- mCTSIB
- HiMAT
- DGI
- FGA

Role of Baseline Testing!
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.
Function of Vestibular System

Vestibular Ocular Reflex (VOR)
Vestibular Spinal Reflex (VSR)

Stabilizes Vision When Head Moves
Balance Control
What does the patient feel?
Dynamic Visual Acuity (VOR)

Role of Vestibular Rehab - Return to Play

- Critical missing link of full sensory integration of visual / vestibular / somatosensory system?
- Does that player have skewed/blurred vision while body in motion/head turning?
- Do they have continued headaches?
- Do visual tasks increase their symptoms?
Role of VOR/VSR

- Are these being assessed before return to play?
  - Dynamic Visual Acuity Testing (DVA)
  - Dynamic Gait Index (DGI)
  - Functional Gait Assessment (FGA)
  - BESS Test
  - VOMs

***Role of vestibular rehab to insure player is safe in gaze stabilization prior to return to play if symptoms occur***
Vestibular 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
Dizziness Post Concussion

- Common Vestibular Causes of Dizziness:
  - **Peripheral:**
    - Benign Paroxysmal Positional Vertigo
    - Labyrinthine Concussion
    - Perilymphatic Fistula
  - **Central:**
    - Post traumatic migraine
    - Brainstem concussion
- Common Non Vestibular Causes
  - Ocular Motor Problems
  - Autonomic/orthostatic
  - Cervicogenic Dizziness
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 Evaluation
Concussion Exam Components

Vestibular Rehab Exam:
Cervical Range of Motion
Cervical Ligamentous Integrity
General Extremity strength screening
Fine Motor/Coordination Assessment (finger to nose, finger to object etc)
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
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)
Ocular Motor findings – after 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!
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
Role of Vergence?
Videos
Difficult Environments
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.

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**Errors**:  
- Moving the hands off the hips  
- Opening the eyes  
- Step, stumble or fall  
- Abduction or flexion of the hip beyond 30°  
- Lifting the foot or heel off of the testing surface  
- Remaining out of the proper testing position for greater than 5 seconds

*The maximum total number of errors for any single condition is 10.*  
If a subject commits multiple errors simultaneously, only one error is recorded.

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

<table>
<thead>
<tr>
<th></th>
<th>Firm Surface</th>
<th>Foam Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Double Leg Stance</strong></td>
<td>FIRM</td>
<td>FIRM</td>
</tr>
<tr>
<td>(feet together)</td>
<td>Surface</td>
<td>Surface</td>
</tr>
<tr>
<td><strong>Single Leg Stance</strong></td>
<td>FIRM</td>
<td>FIRM</td>
</tr>
<tr>
<td>(non-dominant foot)</td>
<td>Surface</td>
<td>Surface</td>
</tr>
<tr>
<td><strong>Tandem Stance</strong></td>
<td>FIRM</td>
<td>FIRM</td>
</tr>
<tr>
<td>(non-dominant foot in back)</td>
<td>Surface</td>
<td>Surface</td>
</tr>
</tbody>
</table>

**TOTAL SCORES:**

<table>
<thead>
<tr>
<th></th>
<th>FIRM</th>
<th>Foam</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Firm+Foam total)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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*Airex® Foam Balance Pads available at [www.power-systems.com](http://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
Screening Tool for Clinicians

- 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 assessment tools.
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
Smooth Pursuits

- Ocular Motor
- Pursuits: H-Test
  - Stand 1 yard away from the patient.
  - Patient keeps head still during the test.
  - Practitioner slowly and steadily moves an object in an “H” motion within field of vision.
- Positive test:
  - ____Nystagmus
  - ____Symptoms (dizziness, blurriness, headache, fogginess, etc)
Saccades

• Saccades: **Horizontal**
  - Stand 1 yard away from the patient.
  - Patient keeps head still during the test.
  - Practitioner holds 2 fingers 6 inches apart in a horizontal fashion.
  - Patient will look back and forth with the eyes only (not moving his or her head) between the 2 fingers for 20 seconds. The visual movement should be smooth and stop directly at the fingers.

• Positive test:
  - ____Eyes over- or undershoot stationary fingers
  - ____Symptoms (dizziness, blurriness, headache, fogginess, etc)

• Saccades: **Vertical**
  - Stand 1 yard away from the patient.
  - Patient keeps head still during the test.
  - Practitioner holds 2 fingers 6 inches apart in a vertical fashion.
  - Patient will look back and forth with the eyes only (not moving his or her head) between the 2 fingers for 20 seconds. The visual movement should be smooth and stop directly at the fingers.

• Positive test:
  - ____Eyes over- or undershoot stationary fingers
  - ____Symptoms (dizziness, blurriness, headache, fogginess, etc)
Gaze Stability

- Gaze Stability: Horizontal
  - Stand 1 yard away from the patient.
  - Patient keeps eyes fixated on an object 1 foot away from the patient in the center of visual field.
  - Patient moves his or her head back and forth in a horizontal fashion for 20 seconds.
  - Positive test:
    - ____Any hang time or slowed eye movement
    - ____Nystagmus
    - ____Symptoms (dizziness, blurriness, headache, fogginess, etc)

- Gaze Stability: Vertical
  - Stand 1 yard away from the patient.
  - Patient keeps the eyes fixated on an object 1 foot away from the patient in the center of visual field.
  - Patient moves his or her head back and forth in a vertical fashion for 20 seconds.
  - Positive test:
    - ____Any hang time or slow in movement
    - ____Nystagmus
    - ____Symptoms (dizziness, blurriness, headache, fogginess, etc)
Convergence

- Convergence insufficiency (this test is performed with both eyes open):
  - Patient will focus on an object.
  - Practitioner will slowly move the object closer to the patient’s eyes.
  - Patient will indicate to practitioner when a single object becomes 2 (eg, “double vision”)
  - Patient will hold the object at the point of vision change and the practitioner will measure distance.
- Positive test:
  - ___6 cm indicates convergence insufficiency (this often resolves with time/rest).
- Possible restrictions: limited or no geometry, no math, no computers, no texting.
- Consider neuro-ophthalmology or neuro-optometry referral if symptoms do not resolve within 3 to 4 weeks or are persistently 20 cm.
Balance Screen

- Patient stands with feet together with shoes on and arms folded for 30 seconds.
- Eyes open
  - Stable surface
  - Foam surface
- Eyes closed
  - Stable surface
  - Foam surface
- Positive test:
  - ____Patient cannot sustain position for 30 seconds
  - ____Excessive sway
  - ____Symptoms
Factors that may trigger or exacerbate headaches

- Cervical spine injury
- Impaired sleep
- Higher level cognition
- Vision
- Hearing sensitivity
- Exercise
Case Study (1of8)

History: 14 y/o female who was referred due to three concussions that occurred in 2013.

- **First:** In May 2013, she was hit in the head with a discus during track. Symptoms were headache, dizziness, and difficulty thinking. School was not missed, but she was out of sports 1-2 months. Headaches never resolved. Never assessed by a vestibular therapist. Returned to full activity fall of 2013.
Second: Hit in the head during football in PE at the start of the school year. 1-2 hours of amnesia. Symptoms were headache, dizziness, and difficulty thinking. These symptoms remained present three weeks. School was not missed. Never assessed by a vestibular therapist. She was returned to sports when she only endorsed headaches from the first concussion.

Third: October 2013, she hit her head with another swimmer while doing laps. Symptoms were fogginess, an increase in headaches, dizziness, and difficulty thinking. Three weeks later, in choir class, she had a presyncopal symptoms as well as challenges with her balance. She was seen in the ER December 6th and referred to Sports Medicine. She was seen December 9th and referred to vestibular therapy.
Case Study (3of8)

- **PMH**: Fall at age 4-5 down stairs hurting neck. Diagnosed with posttraumatic torticollis. Treated with physical therapy at that time and symptoms fully resolved. Otherwise unremarkable.
Evaluation:

- Musculoskeletal exam: all findings WNL except trigger points that were palpable along her cervical region (C1-C3) and bilateral upper traps right worse than left.
- Gait/Mobility: Able to complete tandem stance without problems. SLS on the right 15 seconds, on the left increased struggles and loss of balance within several seconds.
Case Study (5of8)

Visual Exam:

- Patient wears glasses.
- Acuity = 20/20  Dynamic Visual Acuity (DVA) 20/32 indicating results are WNL and patient has accommodated to visual changes from vestibular injury.
- Smooth pursuit - jumps noted moving eyes up and left.
- Saccadic Pursuit 3 jumps to locate target vertically – up and horizontally to the left.
- Convergence: Right eye adducts following target. Left eye deviates with fatigue.
- Nystagmus present and asymmetrical at end ranges of visual field.
- Eyes movement was conjugate.
Case Study  (6of8)

More specific tests:

- **Modified CTSIB**: Left deviation in all of the tests indicated weakness of her left vestibular system. Her balance was improved when her eyes were closed indicating that her visual input is contributing to her poor balance.
- **Dix-Hallpike**: no increase in subjective symptoms. Nystagmus observed with completion to the left.
- **Motion Sensitivity Quotient = 12** indicating moderate sensitivity to motion.
- **ImPACT testing**: Revealed decreased visual motor speed and reaction time during testing.
Case Study  (7of8)

- Neurologist chose to start a muscle relaxant.
- Muscle soreness/trigger points were addressed during that session.
- Gaze stabilization exercises were initiated as a part of her home exercise program.
- Vestibular maneuver completed to address left vestibular weakness observed in her exam.
**Case Study** (8of8)

**Conclusion:**
- Six sessions over a two month period
- Two headaches over the last two weeks – one due to an emotional meltdown and the other when she bumped her head
- Dizziness resolved
- Only a slight nystagmus in her left visual field remains
- She is able to converge and hold the position for 1 second
- Doing well in school. Returned to conditioning at moderate intensity for the start of her soccer season.
- Due to duration of symptoms, counselling has started to assist with her final healing and return to full contact sports.
Vestibular Exercises (1of2)
Vestibular Exercises (1 of 2)
References

11. Mucha, Collins, Elbin, Furman, Troutman-Enseki, DeWolf, Marchetti, Kontos. (in review)
References


References


