Concussion: Visuo-vestibular Rehab

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Sports Medicine: Physical Therapy
I have no financial relationship with any commercial entity producing health-care related products and/or services.
Who benefits from Concussion rehab

- Type of athlete?
  - Cervical spine sx
  - Visual sx
  - Vestibular sx
  - Balance dysfunction – unresolving
  - Gender and Age not a factor

- When do you begin treatment?

- Duration of rehabilitation

(Alsalaheen B, JNPT 2010)
OUTLINE:
Physical Therapy Assessment and Management

- Taking a good history
- Multi-System Approach: Assess and Treat
  - Medical (will not be addressed in this lecture)
  - Musculoskeletal
  - Balance
  - Visual/Ocular Disturbance
  - Vestibular Dysfunction
  - Exertion and Sport Specific Training
History:
Let their story guide your exam

Basics of the injury:
- Sport, position played and MOI?
- On-field sx (Dizzy? HA? Vision? Aural?)
- Removal from play?
- Management since injury?

Current symptoms:
- MSK: Neck pain?
- Disequilibrium? Imbalance?
- Visual disturbances?
- Vestibular+ (Describe your dizziness!)
  - lightheadedness
  - spinning/head moving
  - motion sickness
  - disequilibrium vs sensation in head
- Aural: fullness/pressure/tinnitus/loss?
- Emotional: mood changes? Parents, do you see changes in your child?
Multi-System Approach: Assess and Treat

- **MSK: Cervicogenic**
- Balance
- Visual/Ocular Disturbance
- Vestibular Dysfunction
- Exertion and Sport Specific Training
Sports Concussion Exam: MSK Cervicogenic Dysfunction

- MOI and structures involved (whiplash, facet, fx-fall onto head)
- R/o more complex c-spine injuries
- Assess basic core strength: periscapular, lumbopelvic and other MSK injuries involved in incident

**Assess for Cervicogenic dysfunction**
- Cervicogenic HA
- Cervicogenic Dizziness
Sports Concussion Exam: MSK Cervicogenic Dysfunction

- Diagnosis of exclusion (difficult to treat)
- Can be stand alone dx and/or in combination with concussion sx
- Head/neck injury with HA and dizziness when all other causes of HA and dizziness are ruled out

- Patient description
  - Occipital, headband (oculo-frontal-temporal)
  - Typically generalized pressure, aching,
  - Limitations in cervical ROM (flex, ext, rot),
  - Typically unilateral

- If full ROM and no neck pain but + for HA…likely not cervicogenic

(Hall, 2010)
Referred pain:

- Brain itself is not sensitive to pain (‘pain sensitive’ structures: meninges, vessels and extracranial structures: neck, eyes, TMJ)
- C1-C2 refers pain to oculo-fronto-temporal regions
- C2 nerve root compression vs irritation contributes to suboccipital aching and dysesthesias radiating to posterior scalp and ear
- C2 n. root undergoes most stretch/strain d/t ↑ rotation at C1-C2
  - C2 nerve root isn’t protected by facets and pedicles like other spinal nerves (it lies exposed on vertebral arch)
  - Synapses with trigeminal nerve, so pain pathway from C2 nerve irritation can travel along the trigeminal nerve

(Thurnberg, 2001)
Trigeminocervical nucleus:
- Convergence of cervical and trigeminal nociceptive afferents
- Structures include:
  - Articular, muscular and neural structures of c-spine from C0-C3
  - Upper portion of vertebral artery
  - TMJ
  - CN V, VII, IX, X

Pain from trigeminal nerve may be interpreted as coming from neck and vise versa
Sports Concussion Exam: MSK Cervicogenic Dysfunction

Examine

- Muscle Palpation
  - Suboccipitals: palpate while rotating
  - Splenius Capitis: palpate just posterior mastoid and resist ipsilateral rotation

- Upper cervical mobility (C1-2) Flex/Rotation test
  - Cervicogenic HA and C1-2 dysfunction correlate
  - Nml 45 deg B; <33 deg = C1-2 hypo

- Proprioception/Head position
  - Patient sits 35” from target with head mounted laser
  - Find target with EO, then close eyes and move head maximally
  - Patient attempts to return head toward center target

(Thurnberg, 2001)
Sports Concussion Exam: MSK Cervicogenic Dizziness:

- Upper c-spine: complex proprioceptive system with connections to visual and vestibular systems
- Doesn’t send appropriate signals d/t damaged muscle spindles
- Can be mechanoreceptor dysfunction or posttraumatic vertebro-basilar circulatory insufficiency
- Diagnosis of exclusion (difficult to treat)
  - Head/neck injury with dizziness when all other causes of dizziness are ruled out
  - Swivel chair test
Multi-System Approach: Assess and Treat

- Musculoskeletal
- **Balance**
- Visual/Ocular Disturbance
- Vestibular Dysfunction
- Exertion and Sport Specific Training
Sports Concussion PT Intervention: MSK C-Spine and Balance

↓ balance from afferent, efferent or integration malfunction

- If any *afferent* signal is altered, (cervical pain and reduced range of motion can impair signal due to poor proprioception)
- Concussions disrupt the BS ability to *integrate* and interpret the afferent signals
- *Efferent* signal problems may occur due to delay from poor central integration or from VS tract dysfunction, resulting in untimely, ineffective balance reactions
Sports Concussion PT Intervention: MSK C-Spine and Balance

Challenge the somatosensory system

- Most people are visually dominant for balance with an overreliance on vision and under-utilization of somatosensory and vestibular inputs for balance

- Train by downplaying visual reliance
  - Posturography = most accurate way to measure and affect visual dependency ($$$)
  - Virtual reality may prove to do this as well
  - Use unstable surfaces to increase challenge
  - Cheap, effective clinical way to limit vision
    - Eyes closed
    - Dark room
    - Vaseline over glasses
Multi-System Approach: Assess and Treat

- Musculoskeletal
- Balance

**Visual/Ocular Disturbance**

- Vestibular Dysfunction
- Exertion and Sport Specific Training
Sports Concussion Exam: Visual Disturbance

- Ocular issues after concussion are common (poor eye tracking)
- Characteristics: HA, eye strain, blurriness, diplopia, oscillopsia, frontal HA, difficulty attending

- Vision therapy goals:
  - Improve brains ability to control eye alignment, movement, focus and visual processing
  - Visual skills are reinforced through repetition and integrated with cognitive/motor skills until automatic
Sports Concussion Exam: Visual Disturbance: Oculomotor Control

- Concussions can directly impair oculomotor function
- The 3 nerves (CN III, IV and VI) that innervate the eye muscles, exit the brain stem, travel along base of skull, join behind the eye and enter orbit.
- The nerves are susceptible to injury anywhere along the route from BS to eye muscles
Sports Concussion Exam: Visual Disturbance

- Observation (head tilt? ptosis? Ocular misalignment?)
- Observe initial head position but correct to neutral to perform exam

- Visual Fields
- EOMs/Smooth pursuits (H-test)/Gaze Holding
- Saccades (vertical and horizontal)
- Antisaccades (voluntary, top-down cognitive control)

- Static visual acuity (Snellen eye chart: monocular, binocular)
- Convergence and Accommodation
Sports Concussion Exam: Visual Disturbance: Acuity, Accommodation and Vergence

- **Static Visual Acuity**
  - Measure each eye individually, then together…distance and near
  - Variability between distance and near may indicate accommodative dysf
  - If acuity better monocularly than binocularly, likely accommodative dysf
  - Ensure binocular vision compensates for monocular difference

- **Accommodative dysfunction**
  - Difficult for eyes to shift focus between near/far targets
  - Lag between stimulus to accommodation and accommodative response
  - Can simply be fatigue of repeated accommodative stimulation…*daily life*

- **Vergence dysfunction**
  - Disconjugate eye movements resulting in inability of eyes to accurately fixate and stabilize retinal image
  - Convergence Insufficiency is higher in children with ADHD…
Sports Concussion Exam: Visual Disturbance: Convergence

- Single image viewing with 2 eyes
- Perform 3x and record (14 pt font):
  - Provides depth perception
- Near Point
  - Nml NPC <10cm
  - Athlete <6 cm
Sports Concussion Exam: Visual Disturbance: Convergence

- Exophoria
- Practice effect
Sports Concussion PT Intervention: Vision Exercises

- Visual Behavioral Exercises
- 2-10 visits with excellent prognosis
- Smart phone apps, HTS online (www.visiontherapysolutions.net) good resources for home program
- Referral to neuro-optometrist or neuro-opthamologist if needed
Sports Concussion PT Intervention: Vision Exercises

- Exercises to strengthen and ↑ endurance of eye muscles and improve speed, coordination and accuracy

- Accommodation/Convergence
  - Hart Chart, Five Fingers
  - Brocks Strings, Two Fingers

- Pursuits/Saccades
  - Patterns, mazes
  - Self targets, progress by increasing space between targets
Multi-System Approach: Assess and Treat

- Musculoskeletal
- Balance
- Visual/Ocular Disturbance
- **Vestibular Dysfunction**
- Exertion and Sport Specific Training
Sports Concussion Exam: Vestibular Disturbance

- Subjective Sx-Self Reports (DHI, PCSS)
- Balance (included with)
  - BESS/Tandem Gait
  - Computerized Dynamic Posturography
- Vestibular
  - Dynamic Visual Acuity (compared to static-Snellen)
  - Gaze stability (VOR viewing)
  - Fukuda step test
  - VORc (Space and Motion Discomfort)
  - .....or VOMS!
New Data Validating Visuo-Vestibular Screening: UPMC “VOMS”

- VOMS (Vestibular Oculomotor Screen)
- 85 pts, 85 controls (12-18yr old)
- 6 days post injury +/- 5d
- $\alpha .91$ internal consistency/reliability
- VOR, VORc and NPC most sensitive for predicting concussed group vs control

(Mucha, Collins, Elbin. AJSM. In press)
New Data Validating Visuo-Vestibular Screening: UPMC “VOMS”

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(Mucha, Collins, Elbin. AJSM. In press)
Sports Concussion PT Intervention: Vestibular

Goals of vestibular PT:
- Remediate dizziness and disequilibrium
- Increase accuracy of sensory inputs
- Desensitization to provocative stimuli
Sports Concussion PT Intervention: Vestibular Exercises

Adaptation:
- Gaze stabilization/VOR
- Computerized DVA

Habituation:
- Desensitization
- SMD
- Not for true vestibular system impairments

Canalith repositioning
- BPPV
- Epley, Libertory Maneuver
Zurich 2012 updated guidelines include visuo-vestibular

Military: Blast induced head trauma:
- DVA, Target Acquisition/Following, Perception Time
- Improves to normative values after 4 weeks PT

Elderly: with vestibular pathology
- Great evidence showing effective for improving vestibular pathology
- Decreasing fall risk

Athletic Concussions:
- ↓ sx/dizziness provoked by head movement, busy environ
- ↑ balance function

Limitations in studies: retrospective nature of data collection, no control group, chronicity of concussion sx, absence of standardized vestibular function test battery (*BUT WAIT!*)

Lacking Level 1 evidence, however…
Adaptation

- VOR x 1 viewing ("steady-cam" feature of brain)
- Turn head 40° to R and 40° to L while eyes fixate on target
- Head moves 180bpm

\[\text{---------}(\text{slower to maintain clarity})\]  

- 10-20 repetitions, 2x/day
  - Preferably glasses off
  - Horizontal and vertical
Sports Concussion PT Intervention: Vestibular Exercises: SMD

Habituation: Gradual exposure to provocative stimuli

- Down-regulate vision – decrease visual dependency
- Mixture of gaze-stabilization protocol (VORx1) and balance exercise protocol – greater emphasis on suppressing abnormal visual input

- Create a visual anchor (non-moving target) AND a visually dynamic target/destabilizing input; helps recalibrate pt’s oversensitivity to optic flow
Sports Concussion PT Intervention: Vestibular Exercises

Adaptation:
Gaze stability/VORx1 exercises with progressions including SMD (habituation)

Gaze Stability VOR Exercises with progressions
Multi-System Approach: Assess and Treat

- Musculoskeletal
- Balance
- Visual/Ocular Disturbance
- Vestibular Dysfunction

- Exertion and Sport Specific Training
*Ensure all visuo-vestibular sx are gone before initiating activities with head/eye movement (elliptical/jogging)

- Threshold:
  - HDR to exercise? (elevated RHR common after concussion)
  - Symptomatic response to exercise?
  - Progression should be symptoms dependent, sub-sx threshold

- Timing is everything
  - Acutely exercising can decrease cognitive performance and the number/performance of BDNP nt
  - Exercise delayed until acute healing has occurred can increase neurogenesis, neuroplasticity and visual processing, can improve cerebral blood flow and increase parasympathetic activity NO evidence shows rest >3wks is beneficial

- Consider cost of abrupt ending to years of extreme exercise

(Vidal et al, 2012)
Exertion and Sport Specific Training: A Sample Protocol

Relative cognitive and physical rest

Light aerobic exercise (15’ low intensity)

Moderate aerobic activity:
30’ bike at 75% MHR

Heavy aerobic activity:
30’ bike at 75% MHR w/30” intervals at max effort at 10’, 15’, 20’

Sport specific aerobic activity:
15’ low intensity (minimally distracting environment)

Sport specific activity:
30’ mod intensity w/30” intervals at max effort 10’, 15’ and 20’

Non contact activity:
regular warm up and high intensity, agility, coordination activity

*once cleared by physician:*
Full contact: practice followed by games
Sports Concussion PT Intervention: Exertion and Sport Specific Exercises

- Functional/sport specific ways to incorporate vestibular, vision therapy and traditional PT into concussion rehab
- Ensure athlete can succeed with challenges to multiple sensory, motor and cognitive systems
- Examples from the military
  - “SALUTE”, “Run, roll, aim”, “Illinois Agility Test”, “CQ duty”
  - Tasks which challenge executive function, gaze stability, pursuit tracking, dynamic stability, exertion, etc.

(Moore et al, 2013)
Thank you


Shaw NA. The neurophysiology of concussion. Prog Neurobiol 2002; 67:281-244.


http://www.neuropt.org/special-interest-groups/vestibular-rehabilitation/resources

Times, KR. Vestibular Disorders Association. [http://vestibular.org](http://vestibular.org)
