ACTIVE MANAGEMENT OF CONCUSSIONS

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School of Physical and Occupational Therapy
The speakers have no financial relationships to disclose in the last 12 months with a commercial interest that manufactures products or provides services that will be discussed in today’s CME Activity.
ACTIVE MANAGEMENT OF CONCUSSIONS

PubMed Keyword Search Results

Number of publications

- Concussion
- mTBI
- CTE

Year's return to football after concussion leads to Reliable way
- mTBI
- CTE

Los Angeles Times

The Denver Post

Child Neurology Society
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Among all age groups, TBI rates were higher for males than for females.

(CDC, 2010)
OVERVIEW
OF THE
PATHOPHYSIOLOGY
OF CONCUSSIONS
MEERYO CHOE
ACTIVE MANAGEMENT OF CONCUSSIONS

Mendez et al. 2005

Coup

Countercoup

ICP

Shear Stress

Mendez et al. 2005
• Injury caused by rotational motion of the cerebral hemispheres in the anterior–posterior plane, around the fulcrum of the fixed in-place upper brain stem
• Alteration of consciousness likely due to disruption of the electrophysiological and subcellular activities of the neurons of the reticular activating system that are situated in the midbrain and diencephalic region, where the maximal rotational forces are exerted
Neurometabolic Cascade of mTBI: Pathophysiology

- Axonal injury
- Energy crisis
- Mitochondrial dysfunction
- Ca^2+ influx
- Protease activation
- Glutamate release

- K^+ influx
- ADP/ATP pump dysfunction
- Altered neurotransmission
- Axonal injury
Time course of acute pathophysiology
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Axonal injury
Energy Crisis
Mito K+
atp
ADP
Pump
K+
Cell Death
Protease activation
Ca2+
Glutamate
Altered neurotransmission

Seeing is Believing:
Imaging mTBI Pathophysiology

MRI
Protease activation
K+
PET, MRS
ADP
Pump
K+
K+
Glutamate
K+

DTI, MEG
MRS
MEG
PET
fMRI
Diffuse Axonal Injury

- Common and devastating result of TBI
  - LOC and PVS
- Unmyelinated axons are more vulnerable to traumatic injury
  - May be implications for injury during childhood
- Certain region-specific changes have been observed

Corpus Callosum
Brain Stem
Frontal and temporal lobes
Basal Ganglia
Thalamus

*Sharp DJ, Nat Rev Neurol 2014*
Nat. Rev. Neurol. doi:10.1038/nrneurol.2013.36
ACTIVE MANAGEMENT OF CONCUSSIONS

THE KEY ELEMENTS OF AN INITIAL CONCUSSION EVALUATION

SHARIEF TARAMAN
Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study

(Kuppermann, Lancet 2009)
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Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study

(Kuppermann, Lancet 2009)
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PECARN Pediatric Head Injury/Trauma Algorithm

Provides the PECARN algorithm for evaluating pediatric head injury.

Note: This only applies to children with GCS scores of 14 or greater.

Age
- <2 Years -1
- ≥2 Years +2

GCS ≤14, Palpable Skull Fracture or Signs of AMS
- AMS: Agitation, somnolence, repetitive questioning, or slow response to verbal communication
- Yes +1, No +2

Occipital, parietal or temporal scalp hematoma; History of LOC ≥5 sec; Not acting normally per parent or Severe Mechanism of Injury?
- Severe Mechanism: (Motor vehicle crash with patient ejection; death of another passenger; or rollover; pedestrian or bicyclist without helmet struck by a motorized vehicle; falls of more than 0.9m/3ft; head struck by a high impact object)
- Yes +1, No +2

PECARN recommends Observation vs CT: 0.9% risk of clinically important Traumatic Brain Injury.

Imaging dependent on:
- Physician Experience,
- Worsening
- Signs/Symptoms During Observation Period, Age <3 Months, Parental Preference, or Multiple vs. Isolated Findings: Patients with certain isolated findings (i.e., with no other findings suggestive of traumatic brain injury), such as isolated LOC, isolated headache, isolated vomiting, and certain types of isolated scalp haematomas in infants older than 3 months have a risk of cTBI substantially lower than 1%.

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- Pre-Morbid Conditions
- Anxiety or Mood Disturbance
- Vestibular Dysfunction Balance Problems
- Poor Headache Control
- Adjustment Reaction
- Cervical Injury
- Multiple Sequential Hits or Prior Concussion History
- Ocular Dysfunction
- Poor Initial Management
- Sleep Disturbance
- Excessive Removal from Activities
- NSAID overuse
- Assaults & Injuries with Litigation

Prolonged Concussion Recovery
### Symptom Evaluation

**How do you feel?**

*You should score yourself on the following symptoms, based on how you feel now.*

<table>
<thead>
<tr>
<th>Symptom</th>
<th>None</th>
<th>Mid</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Pressure in head</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Neck Pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nausea or vomiting</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Blurred vision</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Balance problems</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling like in a fog</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Don’t feel right</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Fatigue or low energy</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Confusion</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Trouble falling asleep</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>More emotional</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Irritability</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sadness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nervous or Anxious</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total number of symptoms** (Maximum possible 22)

**Symptom severity score** (Maximum possible 132)

<table>
<thead>
<tr>
<th>Do the symptoms get worse with physical activity?</th>
<th>Y</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do the symptoms get worse with mental activity?</td>
<td>Y</td>
<td>N</td>
</tr>
</tbody>
</table>

**Overall rating:** if you know the athlete well prior to the injury, how different is the athlete acting compared to his/her usual self?  
Please circle one response:  
- no different  
- very different  
- unsure  
- N/A

---

### Cognitive Assessment

**Standardized Assessment of Concussion (SAC)**

#### Orientation (1 point for each correct answer)

<table>
<thead>
<tr>
<th>Question</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>What month is it?</td>
<td>0</td>
</tr>
<tr>
<td>What is the date today?</td>
<td>0</td>
</tr>
<tr>
<td>What is the day of the week?</td>
<td>0</td>
</tr>
<tr>
<td>What year is it?</td>
<td>0</td>
</tr>
<tr>
<td>What time is it right now? (within 1 hour)</td>
<td>0</td>
</tr>
</tbody>
</table>

**Orientation score**  
(0-5)

#### Immediate Memory

**List**

- elbow  
- apple  
- carpet  
- saddle  
- bubble  

**Alternative word list**

- candle  
- baby  
- finger  
- paper  
- monkey  
- penny  
- sugar  
- perfume  
- blanket  
- sandwich  
- sunset  
- lemon  
- wagon  
- iron  
- insect

**Immediate memory score total**  
(0-15)

#### Concentration: Digits Backward

**List**

- 4-9-3  
- 3-8-1-4  
- 6-2-9-7-1  
- 7-1-8-4-6-2

**Alternative digit list**

- 6-2-9  
- 3-8-5-2-7  
- 5-3-9-1-4-8  
- 8-3-1-9-6-4  

**Total of 4**  
(0-15)

#### Concentration: Month in Reverse Order (1 pt. for entire sequence correct)

- Dec-Nov-Oct-Sep-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan

**Concentration score**  
(0-5)
### Balance examination
Do one or both of the following tests.
Footwear (shoes, barefoot, braces, tape, etc.)

**Modified Balance Error Scoring System (BESS) testing**
Which foot was tested (i.e. which is the non-dominant foot)
Testing surface (hard floor, field, etc.)

**Condition**
- Double leg stance: 
- Single leg stance (non-dominant foot):
- Tandem stance (non-dominant foot at back):

**And / Or**
- Tandem gait

Time (best of 4 trials): _______ seconds

### Coordination examination
**Upper limb coordination**
Which arm was tested:

**Coordination score**

### SAC Delayed Recall
**Delayed recall score**
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Education Week
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THE ROLE OF COMPUTERIZED NEUROPSYCHOLOGICAL TESTING

JONATHAN ROMAIN
The Cognitive Effects of mTBI

- Cognitive issues immediately following concussion are common.
  - Attention, reaction time, fine motor dexterity, memory.
- Neuropsychological deficits on testing can be seen in the time frame defined as Post Concussive Syndrome (10 days to 3 months).
- It becomes more difficult to use neuropsychological tests to track cognitive recovery in persistent post-concussive syndrome (symptoms extending beyond 3 months).

Symptom resolution should trump cognitive assessment in PCS.
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- There is no gold standard test to assess cognitive functioning following concussion.
- Computerized testing
  
  **Benefits**
  - Cost effective
  - Brief
  - Can be repeated in rapid succession
  
  **Limitations**
  - Sensitive but not specific
  - Questionable reliability
  - Does not fully account for premorbid level of functioning

- Comprehensive neuropsychological testing is reserved for patients with strong suspicion for underlying mental health, developmental, and learning comorbidities.
Baseline Testing

- Baseline testing is a pre-season exam conducted by a trained health care professional to assess an athlete’s balance and brain function (including learning and memory skills, ability to pay attention or concentrate, and processing speed), as well as for the presence of symptoms.
- Results from baseline tests (or pre-injury tests) can be used and compared to a similar exam during the season if an athlete has a suspected concussion.
- Comparison can help raise a red-flag for pre-existing cognitive struggles.
The Challenges of Baseline Testing

- Test-retest reliability is low on many commercially available computer tests (even baselines shift).
- Test taking environments vary.
- Poor effort (sand bagging) has been documented in greater than 11% of high school athletes.
- Large sample studies have failed to demonstrate the incremental value of baseline testing compared to normative group testing.
- Sounds good on paper but empirical support is still lacking.
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THE MENTAL HEALTH ASPECTS OF CONCUSSION

JONATHAN ROMAIN
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• The treatment strategy for managing the emotional and mental health needs of the adolescent concussion patient is dictated by the underlying etiology.

• Symptoms of irritability, short fuse, and frequent crying during the first few days following injury are likely a direct result of neurologic disruption. In these cases, the best treatment is to educate the family that this is a transient neurologic state, while ensuring that the patient is protected from environmental stressors.

• One analogy that parents and patients find helpful is “weathering the storm.”

• The key here is to normalize the recovery process and provide parents with a realistic recovery trajectory.
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• Normalize the experience.
  – This is an injury and not brain damage.
  – Unlike a sprained ankle or the flu, the brain takes time to heal.
  – Most patients return to normal, though some just take longer than others.

• Normalize ADL’s
  – Sleep hygiene is essential to concussion recovery and optimal physical and mental health.
  – Sub-symptomatic physical activity is essential to concussion recovery and optimal physical and mental health. “Active Recovery”
  – Mental activity is essential to concussion recovery and optimal physical and mental health
Mental Health Adages in Concussion

• The more challenging patient is the child whose symptoms persist for weeks or develop over time.
• A common theme in working with TBI patients is that brain injuries tend to exacerbate preexisting conditions.
• Inverse relationship between injury severity and mental health issues.
• Good history taking is the foundation for good mental health management.
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• Knowledge
  – The early provision of information related to concussion diagnosis and possible symptoms, normalization of symptoms, reassurance of positive expectation of recovery, and education on coping strategies.

• Attribution
  – The extent to which one attributes symptoms to concussion versus other causes.

• Self-efficacy
  – The individual’s belief in their ability to overcome adversity, effect change, and reach goals.

Belanger et al. (2013) The Clinical Neuropsychologist
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- Anxiety symptoms can impact cognitive functioning as well as interfere with compliance with treatment recommendations.
- Anxiety can amplify concussion symptoms (autonomic stimulation).
- Anxiety symptoms can prolong recovery.
- Prolonged recovery can lead to increased absences, falling behind academically, and social isolation, which can exacerbate anxiety.
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• Although fairly uncommon in pediatric concussion, the circumstances of a concussion can result in posttraumatic stress disorder (PTSD) or acute stress disorder, particularly when considering that concussions do not have to result in loss of consciousness during the event.

• It is important to at least screen for PTSD in situations in which there is the strong potential for this (in other words, an event that involved threatened death or serious injury to self or other, was the result of an assault, and resulted in intense fear or horror).

• Some symptoms to look for include intense psychological distress, recurrent distressing recollection, and frequent nightmares of the event, flashbacks, hypervigilance, and exaggerated startle response, and feelings of detachment from others.

• If these symptoms are present, a mental health evaluation and treatment would be the next logical step.

*This slide was not included in presentation due to time constraints*
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RETURN TO LEARN
JONATHAN ROMAIN
“Patients in our strict rest group reported more symptoms over the course of the study. Modeling revealed that group assignment was associated with high physical symptoms early and emotional symptoms throughout the study.”
# Active Management of Concussions

<table>
<thead>
<tr>
<th>Stage</th>
<th>Home Activity</th>
<th>School Activity</th>
<th>Physical Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brain Rest</strong></td>
<td>• Rest quietly, nap and sleep as much as needed.</td>
<td>• No school.</td>
<td>• Walking short distances to get around is okay.</td>
</tr>
<tr>
<td></td>
<td>• Avoid bright light if bothersome.</td>
<td>• No homework or take-home tests.</td>
<td>• No exercise of any kind.</td>
</tr>
<tr>
<td></td>
<td>• Drink plenty of fluids and eat healthy foods every 3-4 hours.</td>
<td>• Avoid reading and studying.</td>
<td>• No driving.</td>
</tr>
<tr>
<td></td>
<td>• Avoid “screen time” (text, computer, cell phone, TV, video games).</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Restful Home</strong></td>
<td><strong>Activity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Set a regular bedtime/wake up schedule.</td>
<td>• No school.</td>
<td>• Light physical activity, like walking.</td>
</tr>
<tr>
<td></td>
<td>• Allow at least 8-10 hours of sleep and naps if needed.</td>
<td>• May begin easy tasks at home (drawing, baking, cooking).</td>
<td>• No strenuous physical activity or contact sports.</td>
</tr>
<tr>
<td></td>
<td>• Drink lots of fluids and eat healthy foods every 3-4 hours.</td>
<td>• Soft music and ‘books on tape’ ok.</td>
<td>• No driving.</td>
</tr>
<tr>
<td></td>
<td>• Limit “screen time” to less than 30 minutes a day.</td>
<td>• Once your child can complete 60-90 minutes of light mental activity without a worsening of symptoms he/she may go to the next step.</td>
<td></td>
</tr>
</tbody>
</table>

*Progress to the next stage when your child starts to improve, but s/he may still have some symptoms.*

*Progress to the next stage when your child starts to improve and s/he has fewer symptoms.*
# Active Management of Concussions

**Return to School - Partial Day**
- Gradually return to school.
- Start with a few hours/half-day.
- Take breaks in the nurse's office or a quiet room every 2 hours or as needed.
- Avoid loud areas (music, band, choir, shop class, locker room, cafeteria, loud hallway and gym).
- Use sunglasses/earplugs as needed. Sit in front of class.
- Use preprinted large font (18) class notes.
- Complete necessary assignments only.
- No tests or quizzes.
- Limit homework time.
- Multiple choice or verbal assignments better than lots of long writing.
- Tutoring or help as needed.
- Stop work if symptoms increase.
- Light physical activity, like walking, and as instructed by physician.
- No strenuous physical activity or contact sports.
- No driving.

**Progress to the next stage when your child can complete the above activities without symptoms.**

**Return to School - Full Day**
- Allow 8-10 hours of sleep per night.
- Avoid napping.
- Drink lots of fluids and eat healthy foods every 3-4 hours.
- "Screen time" less than 1 hour a day.
- Spend limited social time with friends outside of school.
- Progress to attending core classes for full days of school.
- Add in electives when tolerated.
- No more than 1 test or quiz per day.
- Give extra time or untimed homework/tests.
- Tutoring or help as needed.
- Stop work if symptoms increase.
- Light physical activity, like walking, and as instructed by physician.
- No strenuous physical activity or contact sports.
- No driving.

**Progress to the next stage when your child has returned to full school and is able to complete all assignments/tests without symptoms.**
Cognitive Adjustments

- Adjust the students’ schedule as needed to avoid fatigue, such as a shorter school day, reduced course load or holding the most challenging classes earlier in the day.
- Adjust the environment to reduce distractions or protect the student from irritations like bright lights, talkative peers, & loud places. Move the student closer to the teacher.
- Give the student extra time to finish classwork & take tests.
- Help the student create a to-do list or get organized.
- Give the student assistance: assign a peer to take notes for the student and/or allow the student to record classes.
- Break down assignments into smaller chunks & offer recognition cues.
- Provide alternate methods for the student to show mastery of a subject, such as allowing multiple-choice or verbal test vs. essay exam.
- Focus on what the student does well & expand the curriculum to more challenging content as symptoms subside.
- Adjust school load to prevent “piling-up” of assignments.
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**Behavioral/Social/Emotional Adjustments**

- If the student is frustrated with failure in one area, redirect him or her to other curriculum areas where he or she can succeed.
- Reinforce positive behavior & academic success.
- Set reasonable expectations.
- Provide structure & consistency; make sure all teachers use same strategies.
- Remove student from a problem situation, but don’t characterize it as a punishment.
- Involve the family in any behavior management plan.
- Acknowledge that the student may be having a hard time. Be empathetic, encouraging, & patient.
- Have the student work with you to make decisions about schedule changes or prioritizing tasks.
- Irritability, low frustration tolerance or “short fuse” are common. Approach student in a non-judgmental way.

*This slide was not included in presentation due to time constraints*
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REHABILITATION AND
RETURN TO PHYSICAL ACTIVITY

ISABELLE GAGNON
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• Activity management / exercise-based rehab
• Visual symptoms
• Vestibular/balance symptoms
• Neck injury
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Activity Management rather than rest

Early Treatment

Restriction not complete removal
- allowed walking, light swimming, etc
- protection from second injury
- Return to school gradually

Symptom-limited

3-4 weeks post-injury: refer to specialized program for rehabilitation

Active Rehabilitation

Pushing beyond symptoms
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**Return to play**

<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>

Can extend duration of this step

McCrary 2013
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Exercise-based rehabilitation

Two models: both require supervision of exercise prescription
Visual problems

- Common problems are convergence and saccades
- Initiate simple exercises
- Refer to specialized team if problems persist
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Convergence

Convergence exercises

• Pencil “push-ups”

• Strings and beads (Brock String)
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Saccades

- Dot page

- Hart charts

```
O F N P V D T C E
Y B A K O E Z L R X
E T H W F M B K A P
B X F R T O S M V C
R A D V S X P E T O
M P O E A N C B K F
C R G D B K E P M A
F X P S M A R D L G
T M U A X S O G P B
H O S N C T K U Z L
```
Dizziness/vestibular problems

If complains of:

- Dizziness, lightheadedness
- Increased symptoms when walking
  (eg. in crowded corridor at school or in mall)
- Nausea
- Blurred vision, difficulty reading
- Balance problems
Objectives:
- Develop vestibular treatment strategies to reduce:
  - Dizziness
  - Gaze instability
  - Imbalance

In conjunction with active rehabilitation intervention for slow to recover patients
Vestibular Treatment Strategies

- 3 principals of vestibular rehabilitation
  - **Adaptation**
    Increase the capability of the vestibular system to make changes in neuronal response to stimulus (i.e. head/body movement)
  - **Substitution**
    Alternative strategies to replace lost or compromised function
  - **Habituation**
    Long term decrease of response to noxious stimulus by repeated exposure
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Neck / Cervical-thoracic spine involvement

- If complaints of neck pain are present
- If suspect a cervicogenic nature to the headaches
- Orthopedic physiotherapy could be indicated
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Case Presentations
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Andrew

16 year old male who fell and hit to the head while wakeboarding
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Left blank intentionally
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Alexandra

16 year old female who sustained concussion while playing basketball. Elbowed to right temple by another player.
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Left blank intentionally
ACTIVE MANAGEMENT OF CONCUSSIONS

Danielle

15 year old female who sustained concussion while playing waterpolo. Struck her head on the pool wall.
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Left blank intentionally