Concussion / Mild Traumatic Brain Injury (mTBI) Rehabilitation

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- Permanent Partial Disability Evaluations
- Permanent Impairment Ratings
- Current President International Academy of Neuromusculoskeletal Medicine
- Forensic Analysis of Causation
- Concussion Management / Treatment

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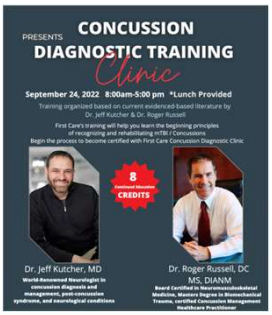

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DISCLOSURES

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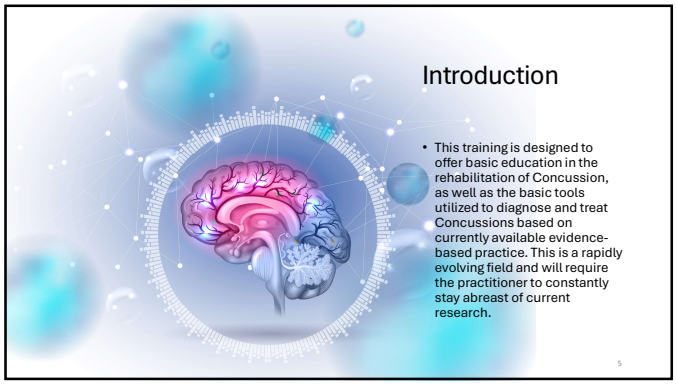
Introduction
• This training is designed to offer basic education in the rehabilitation of Concussion, as well as the basic tools utilized to diagnose and treat Concussions based on currently available evidence-based practice. This is a rapidly evolving field and will require the practitioner to constantly stay abreast of current research.
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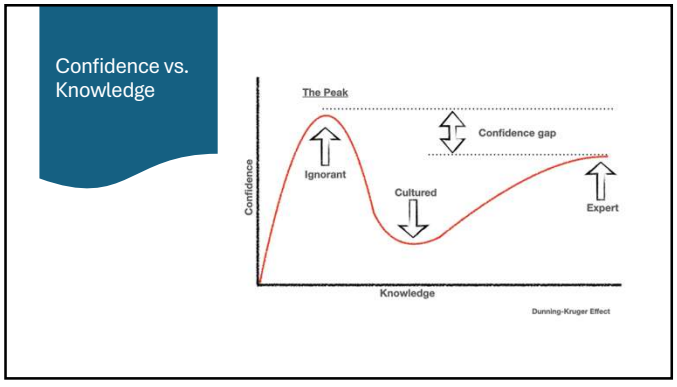
Confidence vs. Knowledge
The Peak
Confidence gap
Ignorant
Cultured
Expert
Confidence
Knowledge
Dunning-Kruger Effect

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Misconceptions

- Permanent Injury
- Gray Matter Bruising
- Rest
- No Exercise
- Not Treatable
- Etc…

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Grading Traumatic Brain Injury

Classification System For Traumatic Brain Injury			
Classification	Duration Of Unconsciousness	Glasgow Coma Scale	Post-Traumatic Amnesia
Mild	<30 Minutes	13-15	<24 Hours
Moderate	30 Minutes-24 Hours	9-12	1-7 Days
Severe	>24 Hours	3-8	>7 Days

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Misdiagnosis

- ER
- Family Physician
- Chiropractor

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Criteria for Diagnosis

1. Mechanism of Injury
2. Temporal Relationship
3. Signs and Symptoms

*****Common Signs and Symptoms of Concussion*****

Physical	Behavioral/Emotional	Cognitive	Sleep
• Headache • Nausea • Vomiting • Blurred or double vision • Seeing stars/lights • Balance problems • Dizziness • Sensitivity to light or noise • Tinnitus	• Drowsiness • Fatigue • Irritability • Depression • Anxiety • Panic • Sadness • More emotional • Nervousness	• Feeling "slow" • Feeling "in a fog" • Feeling "dazed" • Difficulty concentrating • Difficulty remembering • Memory deficits	• Drowsiness • Sleeping more than usual • Sleeping less than usual • Difficulty falling asleep

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Agenda

- Pathophysiology
- Initial Visit / Treatment
- Exertion Testing / Prescription
- Vestibulo-Ocular Exam / Rehab
- Cervicogenic Somatosensory Exam / Rehab

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Pathophysiology

Neurometabolic Cascade

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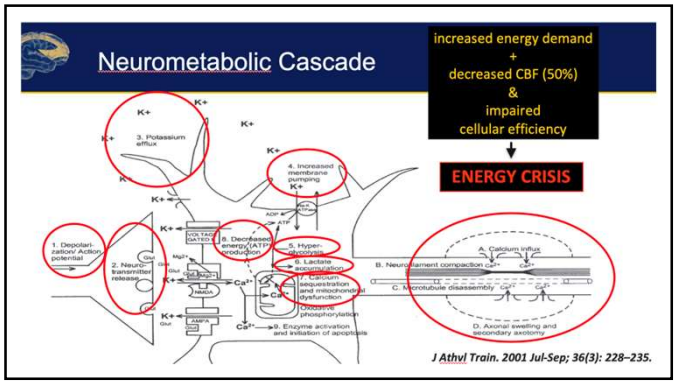

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Neurometabolic Cascade

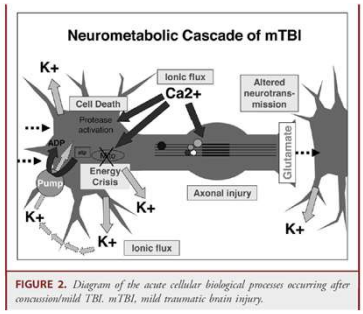

FIGURE 2. *Diagram of the acute cellular biological processes occurring after concussion/mild TBI. mTBI, mild traumatic brain injury.*

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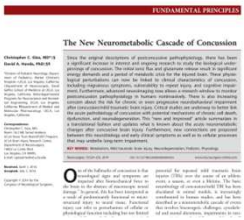
Neurometabolic Cascade: Ionic Imbalance


FUNDAMENTAL PRINCIPLES

The New Neurometabolic Cascade of Concussion

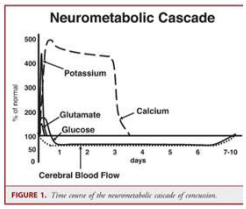


FIGURE 1. *Time course of the neurometabolic cascade of concussion.*

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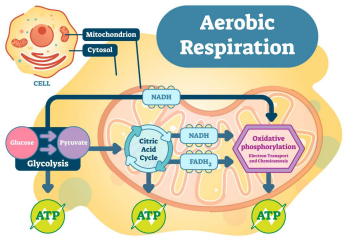
Aerobic Respiration

- Very Efficient
- Requires Oxygen
- Produces **32-36 ATP/Glucose**



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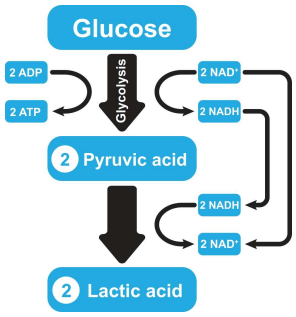

Anaerobic Glycolysis (Respiration)

- Disrupted Mitochondrial Function
- Energy Crisis stimulates Anaerobic Glycolysis
- Much less efficient
- Produces a **net 2 ATP/Glucose**
- 18x Less Efficient

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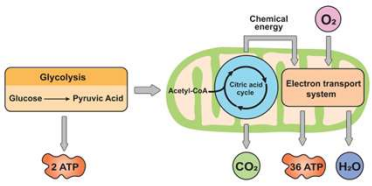
Aerobic vs Anaerobic Respiration



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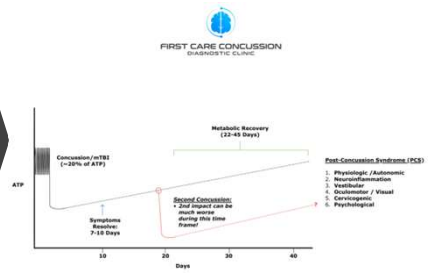
Patient Explanation



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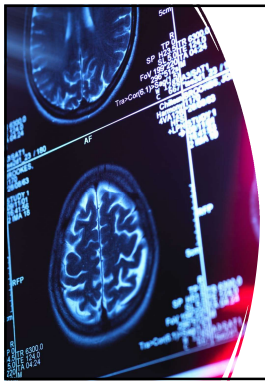

mTBI vs Severe TBI

- Mild = 20% ATP Reduction
  - Mitochondria are not irreversibly damaged.
  - Reversible energy deficit.
- Severe = 50% ATP Reduction
  - Significant alteration in phosphorylating capacity of mitochondria = potentially permanent.
- **2 mTBI's that occur in close temporal proximity can lead to the same irreversible damage seen in severe brain injury.**

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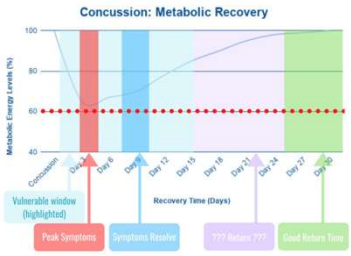

Multiple Concussions

- When delivered within a period of vulnerability, the cognitive effects of multiple concussions are cumulative, persistent, and may be permanent.
- Increasing the time interval between concussions attenuates the effects on cognition.

Meehan III et al. 2012

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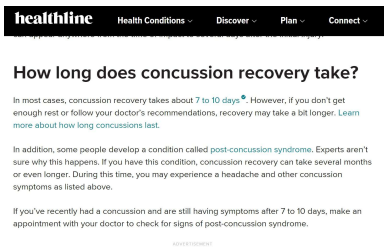
Concussion Recovery Time?

- The literature repeatedly reports Concussion / mTBI spontaneous recovery in 70%-95% of cases.
- Recent Google search on Concussion Recovery Time
  - 7-10 Days!
  - Misinformation!


healthline Health Conditions Discover Plan Connect

How long does concussion recovery take?

In most cases, concussion recovery takes about 7 to 10 days. However, if you don't get enough rest or follow your doctor's recommendations, recovery may take a bit longer. Learn more about how long concussions last.

In addition, some people develop a condition called post-concussion syndrome. Experts aren't sure why this happens. If you have this condition, concussion recovery can take several months or even longer. During this time, you may experience a headache and other concussion symptoms as listed above.

If you've recently had a concussion and are still having symptoms after 7 to 10 days, make an appointment with your doctor to check for signs of post-concussion syndrome.

ADVERTISEMENT

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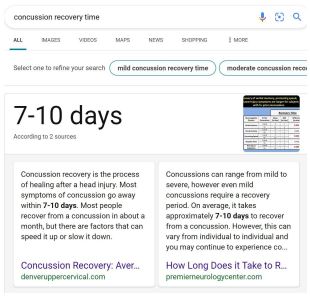
Concussion Recovery Time

- Another Google search on Concussion Recovery Time
  - 7-10 Days!
  - Misinformation!


concussion recovery time

ALL IMAGES VIDEOS MAPS NEWS SHOPPING MORE

Select one to refine your search: mild concussion recovery time | moderate concussion reco

7-10 days

According to 2 sources

Concussion recovery is the process of healing after a head injury. Most symptoms of concussion go away within **7-10 days**. Most people recover from a concussion in about a month, but there are factors that can speed it up or slow it down.

Concussion Recovery: Aver...
denveruppercervical.com

Concussions can range from mild to severe, however even mild concussions require a recovery period. On average, it takes approximately **7-10 days** to recover from a concussion. However, this can vary from individual to individual and you may continue to experience co...

How Long Does it Take to R...
premierneurologycenter.com

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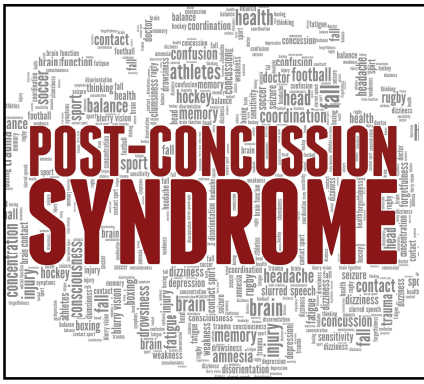

Development of PCS

- **The literature reports that 5%-30% of mTBI's progress to PCS.**
- **This implies that 70%-95% of mTBI's will resolve spontaneously.**
- **The literature is from SRC's:**
  - **Young**
  - **Healthy**
  - **Athlete**
  - **Male (predominately)**

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Development of PCS in Non-SRC

- **What are the 2-week and 6-month outcomes of patients with mTBI who presented to ER with GCS of 15 and negative Head CT scan?**
- **In this cohort study of 991, 27% had functional recovery and 73% had incomplete recovery at 2 weeks.**
- **At 6 months, 44% had functional recovery and 56% had incomplete recovery.**

Madhok et al. 2022


JAMA Network Open.

Original Investigation | Emergency Medicine

Outcomes in Patients With Mild Traumatic Brain Injury Without Acute Intracranial Traumatic Injury

Abstract

Key Points

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Madhok (2022)

Time	Symptoms Resolved	Symptoms Persist
2 Weeks	27%	73%
6 Months	44%	56%

Concussions / mTBI are consistently reported as resolving in 70%-95% regardless of treatment rendered. This is simply false and not applicable to the general population. The above study by Madhok (2022) demonstrates this obvious fallacy.

In addition, another important aspect of this study demonstrates that a large percentage of the general population does not necessarily follow what has been described as a normal physiologic healing process. In order to recover in 30 days, symptoms are generally resolved or at baseline by Day 7-10. When 73% of the patients in the above study are still symptomatic, the patient is not demonstrating a normal physiologic recovery process.

More concerning is the fact that over half (56%) were still suffering from symptoms at 6 months.

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Initial Visit

Red Flags

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Initial History

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Outcome Measure

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Symptom Severity Score Example

<u>Post Concussion Symptom Severity Score</u>: A concussion is a mild traumatic brain injury (MTBI) that may cause a range of physical and cognitive symptoms. The Concussion Symptom Severity Score is essentially a "current state" measure of the patient's concussive symptoms. The patient is asked to report the "current" experience of symptoms on a scale of 0-6. There are 22 symptoms overall with a possible total score of 132. The scoring allows tracking of symptoms during treatment intervals. The Concussion Symptom Severity Score can be utilized as an outcome measure to demonstrate improvement or lack of improvement.

Date	Symptom Score	# Symptoms
01/19/21	78/132	22/22
01/21/21	57/132	22/22
01/28/21	51/132	21/22
02/04/21	30/132	17/22
02/11/21	23/132	9/22
02/18/21	20/132	8/22
02/25/21	14/132	8/22
03/17/21	10/132	8/22

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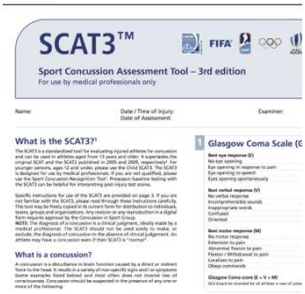
Symptom Severity Score

- Taken from the SCAT3
- Study:
  - Administered 98 healthy non-athlete controls, 118 with head injury, and 46 with orthopedic injury.
  - ID Head Injury if SSS > 7 and HA or Head Pressure (Sensitivity 87%; specificity 80%).

    Zahid et al. 2018 (also Eagle et al. 2020)


SCAT3™

Sport Concussion Assessment Tool – 3rd edition

For use by medical professionals only

Name: Date / Time of Injury: Examiner:

What is the SCAT3?[1]

What is a concussion?

1 Glasgow Coma Scale (G

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High Symptom Severity Scores

- **Be wary of SSS > 50 (after 10-14 days)**
- **Assess for complicating factors and prognostic indicators.**
- **Observe:**
  - **Good Old Days Bias**
  - **Catastrophization**
  - **Individual Factors**
  - **Psychological**

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Work Status

- **Job Description**
  - **Manual Labor**
  - **Sedentary**
  - **Cognitive Requirements**
- **Work Missed?**
- **Why?**

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Red Flags

- Slurred Speech
- Severe/Worsening HA
- Can't Recognize People
- Decreasing Consciousness
- Seizures
- Increasing Confusion / Irritability
- Vomiting x 2 Since Injury
- Signs of Skull Fracture
- Unusual Behavior Change
- GCS < 15

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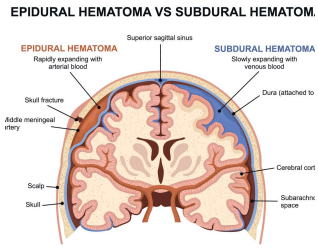

Medications

- Assess for Blood Thinners
  - Anticoagulants (e.g., Heparin, Coumadin)
  - Antiplatelets (e.g., Plavix)
  - *There is increased risk of bleeding even with full GCS and no red flags (Uccella et al. 2017).*

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Scan? HAAGLE Acronym

- **H**eadache that the physician considers significant
- **A**mnesia: Antegrade or retrograde in nature of > 30 minutes
- **A**nticoagulated: This includes warfarin and clopidogrel (Plavix)
- **G**CS of < 15 at any time
- **L**oss of consciousness at any time
- **E**mesis of > 2 episodes

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Complicating Factors

- Behavior Disorders (ADD/ADHD)
- History of Headaches
  - Especially Migraines
- History of Anxiety
- History of Depression
- History of Sleep Disorder
- History of Mental Diagnosis
- History of Prior Concussion

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Exam Sheet

CLINICAL EXAMINATION

Observation	
Laceration / Contusion / Erythema	No ☐ Yes ☐
Speech	
Dysphagia (difficulty with speech):	No ☐ Yes ☐
Dysphonia (inaudible to normal tone/volume):	
Dysarthria (words not formed properly):	
Mental Status	
Alert & Oriented x 4	No ☐ Yes ☐
Skull Fracture Signs	
Battle Sign / Raccoon Eyes	No ☐ Yes ☐
CSR (Otorrhea or Rhinorrhea)	
Hemotympanum	
Palpation (Focal Tenderness)	No ☐ Yes ☐
Cranial Nerves	
Olfactory	Normal ☐ Abnormal ☐
Optic	
Visual Acuity:	Normal ☐ Changed ☐
Confrontation:	Normal ☐ Abnormal ☐
Oculomotor: PERRL	Normal ☐ Abnormal ☐
Accommodation	Right _____ (mm) Left _____ (mm)
Convergence	NPC _____ (cm)
Cardinal Planes of Gaze (III, IV, and VI)	
Smooth Pursuits	Normal ☐ Abnormal ☐ Saccades ☐
Trigeminal	Normal ☐ Abnormal ☐
Facial	Normal ☐ Abnormal ☐
Vestibulocochlear (Hearing)	Normal ☐ Abnormal ☐
IX and X	Normal ☐ Abnormal ☐
Spinal Accessory	Normal ☐ Abnormal ☐
Hypoglossal	Normal ☐ Abnormal ☐
Pyramidal Tract	
Pronator Drift	Normal ☐ Abnormal ☐
Hoffman's	Present ☐ Absent ☐
Cerebellar	
Finger-Nose	Normal ☐ Abnormal ☐
Finger-Finger	Normal ☐ Abnormal ☐
Rosnberg's	Normal ☐ Abnormal ☐
Tandem Gait	Normal ☐ Abnormal ☐
Coordination	Normal ☐ Abnormal ☐
Rapid Alternating	Normal ☐ Abnormal ☐

Doctor's Notes:

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Vitals

- **Height**
- **Weight**
- **Orthostatic Intolerance**
  - **Supine (2 Min): BP and HR**
  - **Standing (1 Min): BP and HR**
    - **Assess for Dizziness and/or Lightheadedness**
  - **Why?**

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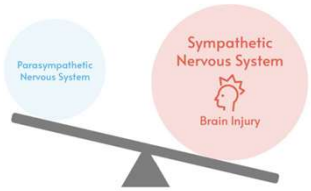
Autonomic Nervous System Dysfunction



- Autonomic dysregulation is common after a head injury and may present with symptoms of:
  - Orthostatic Hypotension (OH)
  - Dizziness or Vestibular Dysfunction
  - Postural Orthostatic Tachycardia Syndrome (POTS)
  - …or altered HR and BP responses at rest and during exercises.

Pertab 2018

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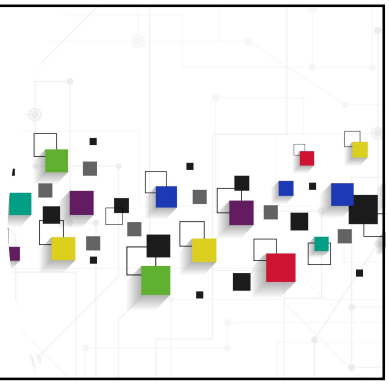
Orthostatic Intolerance (OI)

Autonomic Nervous System Dysregulation



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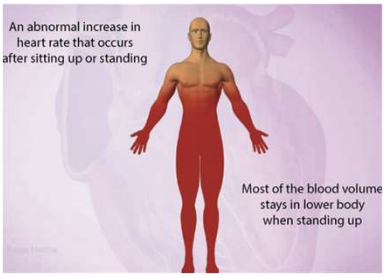
POTS Pathophysiology

- Mechanisms
  - Sympathetic Hyperactivity
  - Sympathetic Hypoactivity
  - Hypovolemia
  - Deconditioning
- Can be associated with autoimmune diseases or diabetes.
- Population
  - Typically, females and adolescents



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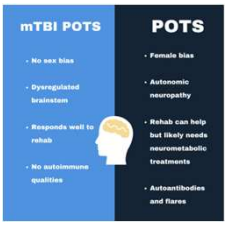
Post-Concussion Orthostatic Tachycardia




Original Research Article

Post-Concussive Orthostatic Tachycardia is Distinct from Postural Orthostatic Tachycardia Syndrome (POTS) in Children and Adolescents

Rachel Pearson, MD[1,2,3], Christopher A. Sheridan, CSCS[1,4], Kaylee Kang[1], Anne Brown[1], Michael Baham[1,4], Robert Asarnow, PhD[5], Christopher C. Giza, MD[1,2], and Meeryo C. Choe, MD[1,2]

Abstract

Background: Orthostatic tachycardia (OT) affects some patients after concussion/mild traumatic brain injury (mTBI). In this study, we sought to identify the factors associated with increased risk for OT in patients with mTBI. **Methods:** We conducted a retrospective review of 268 patients (8-25 years) with mTBI/concussion to determine the prevalence of OT, defined as orthostatic heart rate change ≥40 bpm for those ≤19 years of age and ≥30 bpm on active standing test for those >19 years of age. **Results:** Among the study population, 7% (n = 19) exhibited post-concussive OT. The only significant difference between OT and non-OT groups was that history of prior concussion was more prevalent in the OT group. **Conclusion:** A substantial subset (7%) of concussion-clinic patients exhibit OT. While POTS literature describes female and adolescent predominance, post-concussive OT had similar prevalence across age and gender groups in this study, suggesting that it may be distinct from POTS.

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Orthostatic Intolerance

- Post-Concussive Orthostatic Tachycardia (PCOT)
  - History of TBI
  - Heart Rate ≥ 30 bpm > 19 years
  - Heart Rate ≥ 40 bpm ≤ 19 years
  - Absence of Orthostatic Hypotension
  - Associated dizziness and/or lightheadedness
- Post-Concussive Orthostatic Hypotension (PCOT)
  - History of TBI
  - Dizziness, lightheadedness, or syncope with change in position.
  - Decreased Systolic ≥ 20 mmHg
  - Decreased Diastolic ≥ 10 mmHg
  - Symptoms relieved by lying down or returning to seated position.
  - No medications that could account for symptoms.

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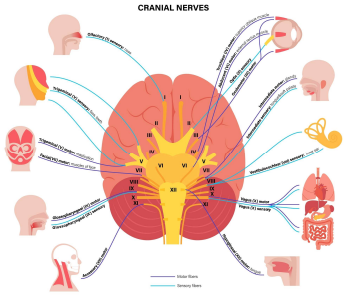
Cranial Nerves



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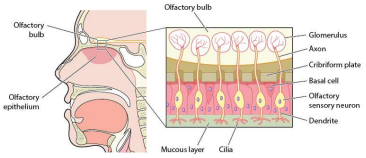
CN I Olfactory

- Any changes in smell or taste?
- Test:
  - One nostril at a time.
  - Common smell, e.g., isopropyl alcohol, coffee.
- Singh et al (2018)
  - Mild TBI = 9.55%
  - Mod TBI = 20.01%
  - Severe TBI = 43.5%



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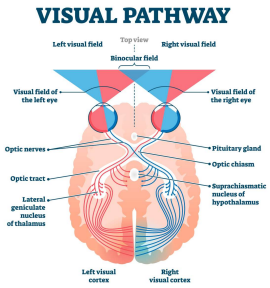
CN II Optic



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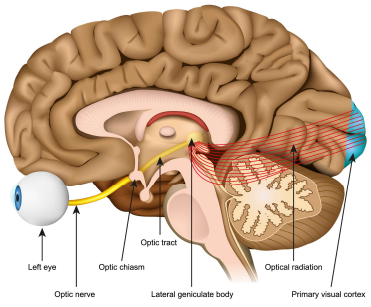
CN II Optic

- Any changes in vision?
- Test:
  - Visual Acuity
    - Snellen (Distance Vision)
    - Jaeger (Near Vision)
  - Confrontation (Peripheral Vision)
  - Color (rarely affected)



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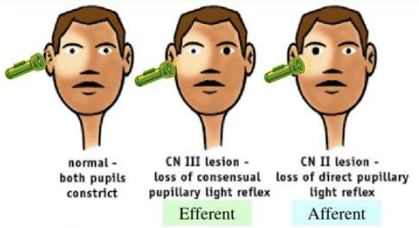
Pupillary Reflex



Consensual reflex: Both pupils should constrict at the same time [13]

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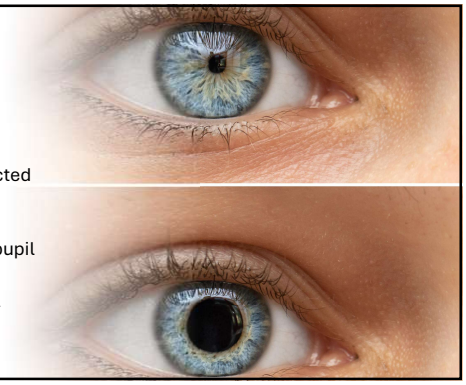
CN III Oculomotor (Pupils)

- **Miosis**
  - Small constricted pupil.
- **Mydriasis**
  - Dilated large pupil
- **Anisocoria**
  - Unequal pupil

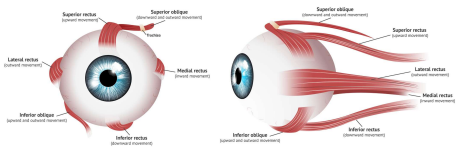


50

Occulomotor

- Levator Palpebrae Superioris
- Superior Rectus
- Medial Rectus
- Inferior Rectus

Muscles of the Human Eye



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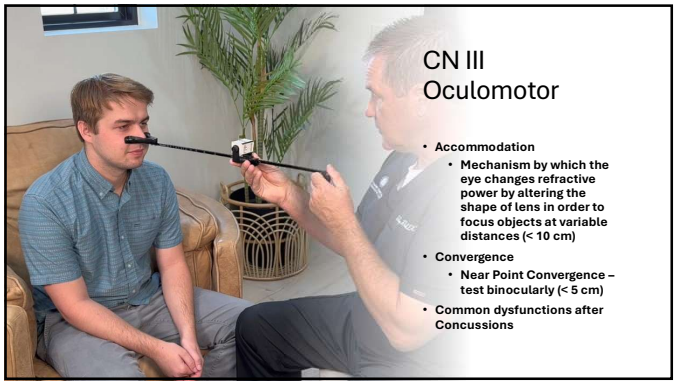

CN III Oculomotor

- **Accommodation**
  - **Mechanism by which the eye changes refractive power by altering the shape of lens in order to focus objects at variable distances (< 10 cm)**
- **Convergence**
  - **Near Point Convergence – test binocularly (< 5 cm)**
- **Common dysfunctions after Concussions**

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Convergence Insufficiency (CI)

- **Common in general population.**
- **CI commonly occurs with mTBI.**
  - **Common symptoms blurred vision, near sighted discomfort, frontal headaches, pulling sensation in eyes, sleepiness, loss of concentration, nausea, eye discomfort, and general fatigue.**
  - **Symptoms typically worsen with reading, computer use, or visually demanding environment.**
  - **Prognostic indicator!**

Convergence Insufficiency Identifies Athletes at Risk of Prolonged Recovery From Sport-Related Concussion

Kevin M. DuPrey,*† DO, David Webner,† MD, Adam Lyons,‡ MD, Crystal H. Kucuk,§ BS, Jeffrey T. Ellis,† ATC, and Peter F. Cronholm,‖¶ MD
Investigation performed at the Healthplex Sports Medicine Institute, Crozer-Keystone Health System, Springfield, Pennsylvania, USA

Background: Sensitive and specific screening methods are needed to identify athletes at risk of prolonged recovery after sport-related concussion (SRC). Convergence insufficiency (CI) is a common finding in concussed athletes.

Purpose: To assess the relationship between CI and recovery after SRC at the initial office visit.

Study Design: Case-control study; Level of evidence, 3.

Methods: In this retrospective cohort study, 270 athletes (147 male, 123 female), mean ± SD age 14.7 ± 2.0 years (range, 10-21 years), with the diagnosis of SRC who presented for initial office visit between January 2014 and January 2016 were evaluated for near point of convergence (NPC). The athletes were categorized into 2 groups: normal near point of convergence (NPC ≤6 cm), and convergence insufficiency (NPC >6 cm). These athletes were then followed to determine recovery time.

Results: Athletes presented for initial office visit at a mean of 5.2 ± 4.2 days (range, 1-21 days) after SRC. Half of the athletes had CI after SRC (50.4%; n = 136). Athletes with CI (NPC 12.3 ± 4.7 cm) took significantly longer to recover after SRC, requiring 51.6 ± 53.9 days, compared with athletes with normal NPC (4.1 ± 1.3 cm), who required 19.2 ± 14.7 days (P < .001). After controlling for potential confounding variables, CI significantly increased the odds of prolonged recovery (>28 days from injury) by 12.3-fold (P < .001; 95% confidence interval, 6.6-23.0). CI screening correctly classified 75.2% of our sample with 84.2% sensitivity and 70.0% specificity. The positive predictive value for CI and prolonged recovery was 62.5%, and the negative predictive value was 88.1%.

Conclusion: CI at the initial office visit identified athletes at increased risk of prolonged recovery after SCR. Clinicians should consider measuring NPC in concussed athletes as a quick and inexpensive prognostic screening method.

Keywords: head injuries/concussion; eye injuries; clinical assessment/grading scales; pediatric sports medicine

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Convergence Insufficiency

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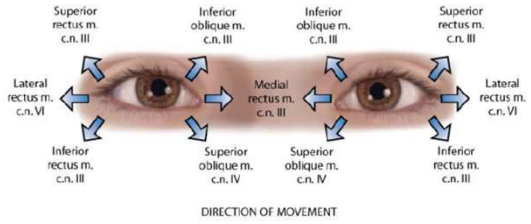
CN III, IV, and VI



55

CN III, IV, and VI

- Cardinal Planes of Gaze
  - H-Pattern
    - If diplopia present at a certain position, make note of that position.
    - Then cover one eye. True diplopia will disappear.
    - If not, rule out detached retina (unilateral diplopia).
  - Look for nystagmus (slight nystagmus at extremes is normal)
  - Smooth Pursuit
    - 18"-24" away; slow smooth motion with finger.
    - Look for "Catch-Up Saccades" / "Re-fixation Saccades"
    - Inquire about dizziness, headaches, or blurred vision.
    - More on this with VOMS testing.

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Disconjugate Gaze

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Feature	Catch-Up Saccades	Refixation Saccades
Function	Correct tracking errors	Shift gaze to a new target
Trigger	Failure of smooth pursuit	Voluntary or reflexive shift of gaze
Associated Movements	Interspersed with smooth pursuit	Standalone movement
Clinical Indications	Vestibular disorders, cerebellar dysfunction	Ataxia, Parkinson's, stroke

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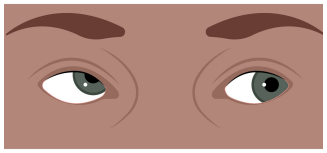
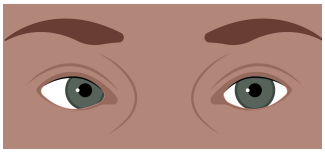
$SO_4\ LR_6$

RIGHT 4th NERVE PALSY



RIGHT 6th NERVE PALSY



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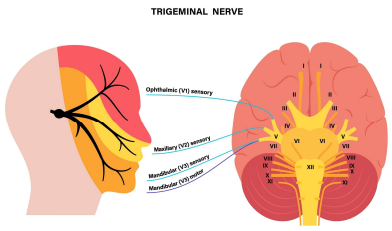
CN V Trigeminal

- Facial Sensation
- Muscles of Mastication
- Corneal Reflex
  - Trigeminal is afferent (sensory)
  - Facial is efferent (motor)



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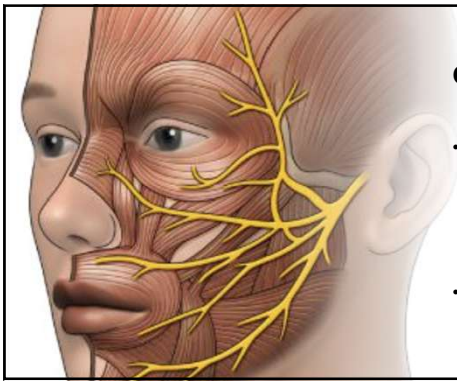

CN VII Facial

- Motor to Facial Expression
  - Note wrinkle in forehead while raising eyebrows.
  - Note nasolabial fold while smiling
- Taste
  - Rarely tested

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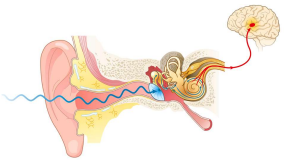
CN VIII Vestibulocochlear Nerve

Fingers Rubbing

If deficit, determine if conductive or sensorineural.

Humming	Weber	Rinne



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Interpretation of Weber and Rinne Tests

	Normal	Conductive Loss	Partial Sensorineural Loss
Weber	Equal in Both	Deaf Ear > Good Ear	Good Ear > Deaf Ear
Rinne	Air > Bone Conduction	Bone > Air Conduction	Air > Bone Conduction

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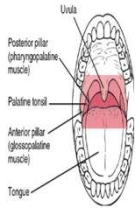
CN IX and X

- Often Tested Together
- Can also have patient say "AH" and then swallow.

CN IX- GLOSSOPHARYNGEAL and CN X - VAGUS

and X considered jointly, actions are seldom compared separately; ways tested together.

- **POSSITIVE FINDINGS-**
- Evaluate voice quality (hoarseness or dysarthria)
- Ask patient to open mouth, say "ah", observe for elevation of soft palate, midline position of uvula.
- Gag reflex, bilaterally
- Swallowing
- Taste (bitter) posterior one-third tongue



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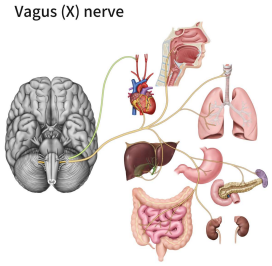
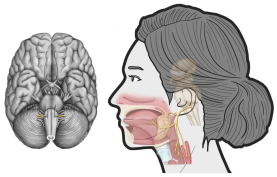
Vagus (X) nerve



Glossopharyngeal (IX) Nerve

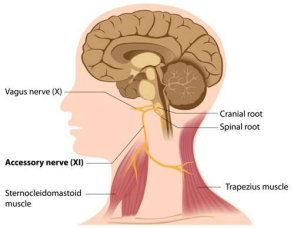


65

CN XI Spinal Accessory Nerve

- Key Test: Shoulder Shrug
  - Can also test Head Rotation
- Rarely involved in mTBI

Accessory Nerve



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Efficient Cranial Nerve Exam

CN	Function	Test
I	Olfaction	Smell
II	Visual Acuity; Peripheral Vision	Any Change in Vision; Confrontation
III, IV, VI	Ocular Movement	Cardinal Planes of Gaze / Smooth Pursuit
III	Pupillary Reflexes	Direct / Consensual Reflexes
IX, X, XII	Uvula / Tonsillar Pillars Elevation; Soft Palate Movement; Tongue	Say "ahh" Stick out Tongue Swallow
V	Facial Sensation Mastication	Facial Sensation V1, V2, V3 Muscles of Mastication
VII	Facial Musculature	Smile; Wrinkle Forehead
VIII	Hearing	Finger Rub; Humming
XI	Shoulder Elevation; Head Rot	Shoulder Shrug

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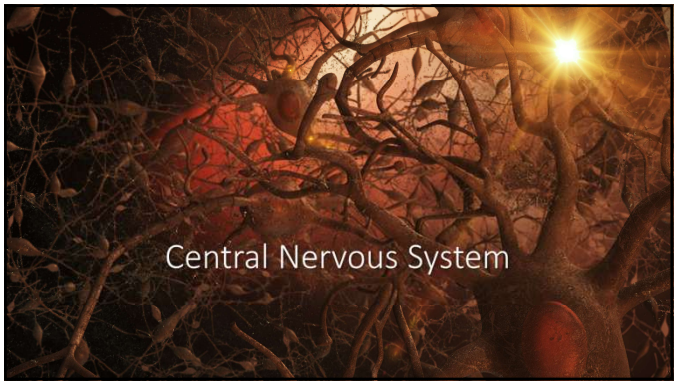

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Pronator Drift

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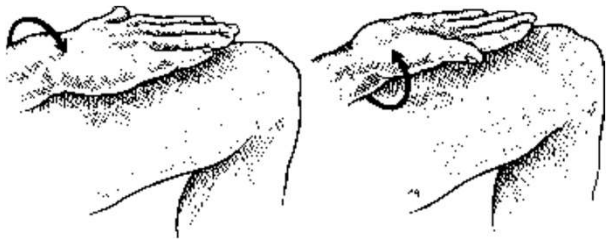
Rapid Alternating Movements



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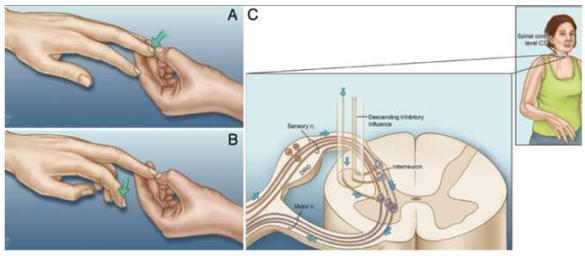
Hoffman's Pathologic Reflex



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Finger-Nose / Finger-Nose-Finger

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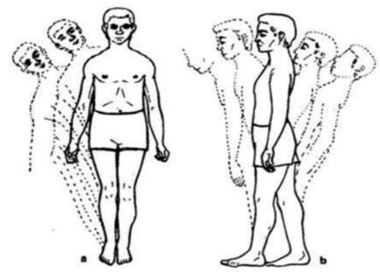
Romberg / Tandem Gait



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Neurological Exam

- Deep Tendon Reflexes
- Sensory
  - Light Touch
  - Pain
  - Joint Position Sense
- Motor
- Pathological Reflexes
  - Babinski's
  - Hoffman's

Upper & Lower Motor Neuron Lesions

CHARACTERISTICS
UPPER & LOWER MOTOR NEURON LESIONS

LESION CHARACTER	UMNL Upper Motor Neuron Lesion	LMNL Lower Motor Neuron Lesion
Paralysis	Spastic	Flaccid
DTR's	Hyperactive	Hypoactive or absent
Superficial Reflexes	Absent	Absent
Muscle tone	Increased	Decreased
Pathological Reflexes	Present	Absent
Clonus	Present	Absent
Atrophy	Absent	Present
Fasciculations	Absent	Present
Reaction of Degeneration	Absent	Present

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Initial Diagnoses / Plan

DIAGNOSES (ICD-10)

Concussion W/O LOC (Initial Visit)	☐ S06.0X0A
Concussion W/ LOC < 30 Min (Initial Visit)	☐ S06.0X1A
Concussion W/ LOC Unspecified Duration (Initial Visit)	☐ S06.0X9A
Persistent Concussive Symptoms (PCS) AKA Post-Concussion Syndrome	☐ F07.81
Additional Diagnoses:	
Convergence / Accommodation Insufficiency Dizziness BPPV	☐ H51.11 ☐ R42 ☐ H81.10

PLAN / RECOMMENDATIONS

Schedule:	☐ Neurocognitive Testing / Neurologic Co-Manage ☐ Physiologic Testing (BCTT / BCBT) ☐ Vestibulo-Ocular Eval ☐ Cervicogenic Eval ☐ BESS Testing
Prescribed:	☐ Concussion Diet ☐ Sleep Hygiene Instructions ☐ Accommodation / Convergence Insufficiency
Notation: At 48 hours after the incident, I instructed the patient to increase resting heart rate 10 bpm for 15-20 minutes each day (then 15-20 bpm if tolerated). Patient instructed to discontinue the exercise if symptoms significantly worsen.	☐
Psychological Complicating Factors Present	No ☐ Yes ☐
Time: Today, I spent time reviewing the patient's current status, outcome measures, performing an MTBI neurologic evaluation, discussing my recommendations, documenting my findings and completing the chart note. The patient indicated an understanding of our discussion, and we will implement the above treatment plan.	☐ 99203 (New Patient; 30-44 Min) ☐ 99204 (New Patient; 45-59 Min) ☐ 99205 (New Patient; 60-74 Min) ☐ 99213 (Est Patient; 20-29 Min) ☐ 99214 (Est Patient; 30-39 Min) ☐ 99215 (Est Patient; 40-54 Min) ☐ 97112 (Neuromuscular Re-education)

Doctor's Notes:

Provider Signature: ______________________ **Date:** ______________________

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Initial Visit Prescriptions

- Calculated Sub-Symptom Threshold
- Convergence Insufficiency
- Sleep Hygiene
- Concussion Diet

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Sub-Symptom Threshold Exercise

220 – [Age] = HRmax

HRmax x 50% = Calculated Sub-Symptom Threshold

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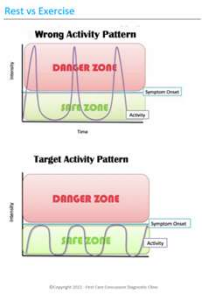
Sub-Symptom Threshold Exercise



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Convergence Insufficiency

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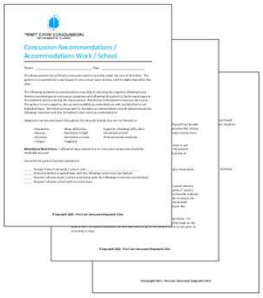
Work / School Accommodations



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Concussion Diet Recommendations

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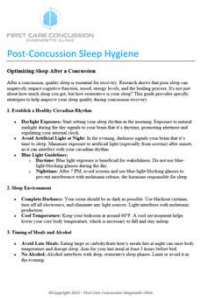
Sleep Hygiene Handout



Post-Concussion Sleep Hygiene

Optimizing Sleep After a Concussion

1. Establish a Healthy Circadian Rhythm

- **Daylight Exposure:** Start setting your sleep rhythm as the morning. Exposure to natural sunlight during the day signals to your brain that it's daytime, promoting alertness and regulating your internal clock.
- **Avoid Artificial Light at Night:** In the evening, darkness signals your brain that it's time to sleep. Minimize exposure to artificial light (especially from screens) after sunset, as it can disrupt the production of your circadian rhythm.
- **Blue Light Guidelines:**
  - **Daytime:** Blue light exposure is beneficial for wakefulness. Do not use blue-light-blocking glasses during the day.
  - **Nighttime:** After 7 PM, avoid screens and use blue-light-blocking glasses to prevent interference with melatonin release, the hormone responsible for sleep.

2. Sleep Environment

- **Complete Darkness:** Your room should be as dark as possible. Use blackout curtains, turn off all electronics, and eliminate any light sources. Light interferes with melatonin production.
- **Cool Temperature:** Keep your bedroom at around 65°F. A cool environment helps lower your core body temperature, which is necessary to fall and stay asleep.

3. Timing of Meals and Alcohol

- **Avoid Late Meals:** Eating large or carbohydrate-heavy meals late at night can raise body temperature and disrupt sleep. Aim for your last meal at least 3 hours before bed.
- **No Alcohol:** Alcohol interferes with deep, restorative sleep phases. Limit or avoid it in the evening.

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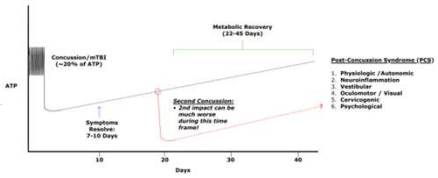
Patient Education

FIRST CARE CONCUSSION
DIAGNOSTIC CLINIC



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Break-Out Groups

- Practice taking history
- Rule out Red Flags
- Perform Exam
- Patient Education
- Prescribe Calculated Sub-Symptom Threshold Exercise
- Prescribe Convergence Insufficiency Rehab
- Discuss Handouts

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Concussion vs. PCS (PSaC)

Understand Time Frames

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PCS Time Frame

- **DSM-IV**
  - **3 Months**
- **ICD-10**
  - **30 Days**
  - **I utilize 30 days in conjunction with ICD-10.**
  - **This is the average physiologic recovery time-frame.**
  - **We utilize ICD-10 for billing.**

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Acute Concussion

- **Treat as Acute if seen within first 10-14 days**
  - Bill as Concussion for first 30 days.
- **Concussion ICD-10 Codes**
  - S06.0X1A - Concussion w LOC 30 min or less, initial encounter
  - S06.0X1D – Concussion w LOC 30 min or less, subsequent encounter
  - S06.0X0A – Concussion w/out LOC, initial encounter
  - S06.0X0D – Concussion w/out LOC, subsequent encounter

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Post-Concussion Syndrome (PCS)

- **Treat as PCS beyond 14 days**
  - Bill as PCS after 30 days.
- **PCS ICD-10 Codes**
  - S06.0X1S – Concussion w LOC 30 min or less, sequela
  - S06.0X0S – Concussion w/out LOC, sequela
  - F07.81 – Postconcussion syndrome

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Neurologic Comanagement

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Neurocognitive Testing

- Cognivue
  - Adaptivity
  - Standardization
  - Brief Administration (10 min)
  - Objective Scoring
    - Memory
    - Executive Function / Attention
    - Discrimination
    - Visuospatial
    - Reaction Time
    - Speed Processing

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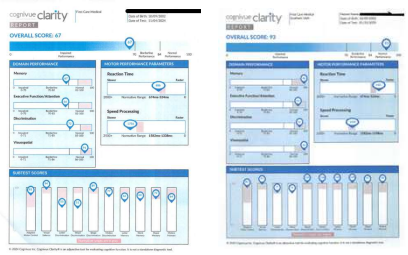
Cognivue Example



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RightEye

- RightEye Sensorimotor system records, views, and analyzes indiscernible eye movements.
- Important in objectifying findings during oculomotor testing.

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RightEye Example

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Prior PIR

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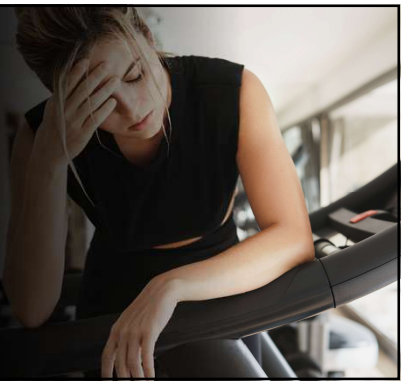
Visit 2

Sub-Symptom Threshold Exercise



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Cocoon Therapy

- Rest has been prescribed as “Concussion Treatment” for decades.
- Many physicians are still prescribing complete rest.

96

Worsening Outcomes?

- "Activity restriction itself may contribute to protracted recovery and other complications."
- "Williamson's Activity Restriction Model of Depression, formulated more than 20 years ago, is central to this hypothesis."
- …"activity restriction cascade" can unfold.

Original Article

Prolonged Activity Restriction After Concussion: Are We Worsening Outcomes?

Clinical Pediatrics
1–9
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DOI: 10.1177/0009922815589914
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Marc DiFazio, MD[1], Noah D. Silverberg, PhD[2,3], Michael W. Kirkwood, PhD[4,5], Raquel Bernier, MD[1], and Grant L. Iverson, PhD[6,7,8,9]

Abstract

The current treatment of concussion or mild traumatic brain injury (mTBI) is primarily based on expert consensus. Most clinical practice guidelines advise cognitive and physical rest after injury including withdrawal from normal life activities such as school attendance, sports participation, and technology use until symptoms resolve. Some individuals who sustain an mTBI experience persistent physical, cognitive, and mental health problems. Activity restriction itself may contribute to protracted recovery and other complications. Williamson's Activity Restriction Model of Depression, formulated more than 20 years ago, is central to this hypothesis. We review research evidence for potential harms of prolonged activity restriction and report an mTBI case as an example of how an "activity restriction cascade" can unfold. According to this model, psychological consequences of removal from valid/acting life activities, combined with physical deconditioning, contribute to the development and persistence of postconcussive symptoms after mTBI in some youth. A modification to mTBI guidelines that emphasizes prompt reengagement in life activities as tolerated is encouraged.

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Prior Rationale for Rest…

- Rest is one of the most widely implemented interventions for MTBI / Concussion. The rationale for rest involves three parts (DiFazio et al. 2015):
  - Brain is in a state of neurometabolic crisis following injury.
  - A second injury during recovery can result in magnified pathophysiological and behavioral deficits.
  - Animals exercising too soon after injury do not show the expected exercise-induced increases in molecular markers of neuroplasticity.

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"Possible Harmful Effects of Rest"

- **Anxiety, Expectations, and the Nocebo Effect:**
  - Being told to stay at home and that a "text message" can damage your brain is quite alarming to patients.
  - The Nocebo Effect is typically iatrogenically induced, meaning that with negative expectations of the patient regarding a treatment cause the treatment to have a more negative effect than it otherwise would have.
- **Depression and Other Psychological Complications:**
  - Removal from normal life after injury can have significant psychological effects (depression).
- **Physical De-Conditioning:**
  - Bed rest results in physiologic alterations in as little as 2-3 days.

DiFazio et al. 2015

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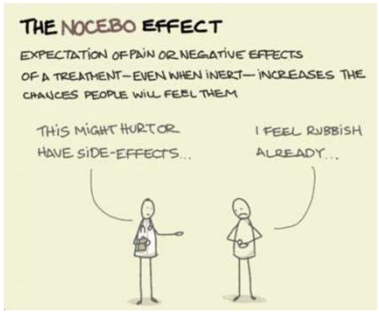

Nocebo Effect

- Placebo Effects Evil Twin
  - Just as expectations of a treatments' effectiveness can influence the reaction to a placebo, an expectation of side effects or future adverse issues can lead to a fulfillment of the prophecy (nocebo), particularly when made by a person in authority (physician).

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Finasteride 5 mg and sexual side effects: how many of these are related to a nocebo phenomenon?

Abstract

Nocebo Example

- Study on Finasteride
  - Sexual side effects = 15%
- Group A
  - Not informed = 15.3%
- Group B
  - Informed = 43.6%

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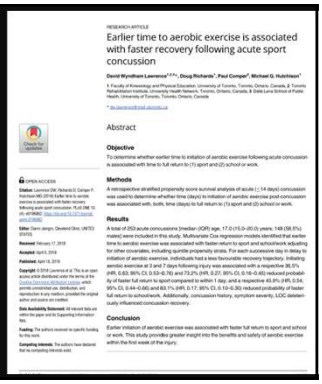
Exercise

- 253 acute concussions
- Initiation of aerobic exercise at 3 and 7 days following injury was associated with a respective 36.5% and 73.2% reduced probability of faster full return to sport compared to within 1 day; and a respective 45.9% reduced probability of faster full return to school/work.
- Conclusion: Earlier initiation of aerobic exercise was associated with faster full return to sport and school or work.

Lawrence et al (2018)



RESEARCH ARTICLE

Earlier time to aerobic exercise is associated with faster recovery following acute sport concussion

Abstract

Objective

Methods

Results

Conclusion

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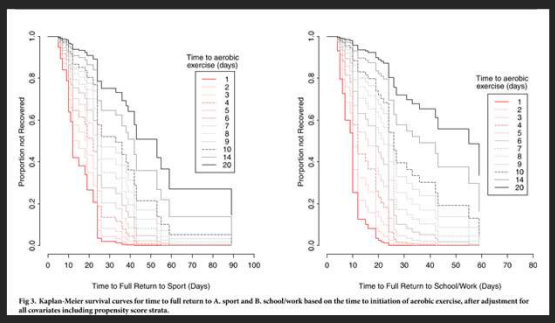

Fig 3. Kaplan-Meier survival curves for time to full return to A. sport and B. school/work based on the time to initiation of aerobic exercise, after adjustment for all covariates including propensity score strata.

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Recovery Trajectory (Lawrence 2018)

Initiation of Exercise Compared to Day 1	Increased Time to Full Return to School/Work	Increased Time to Full Return to Sport
Day 3	45.9%	36.5%
Day 5	70.5%	59.5%
Day 7	83.1%	73.2%
Day 14	94.7%	88.9%

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How Do We Safely Prescribe Exercise?

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Buffalo Concussion Treadmill Test


COMPETITIVE SPORTS

Use of Graded Exercise Testing in Concussion and Return-to-Activity Management

John J. Leddy, MD, FACSM FACP[1] and Barry Willer, PhD[2]

Abstract
Concussion is a physiologic brain injury that produces systemic and cognitive symptoms. The metabolic and physiologic changes of concussion result in altered autonomic function and control of cerebral blood flow. Evaluation and treatment approaches based upon the physiology of concussion may therefore add a new dimension to concussion care. In this article, we discuss the use of a standard treadmill test, the Buffalo Concussion Treadmill Test (BCTT), in acute concussion and in postconcussion syndrome (PCS). The BCTT has been shown to

patient is involved in some limited exercise and cognitive activity after concussion but is worse when the activity is either too great or too little.
Concussion has been thought traditionally to represent primarily a disturbance of cognition, and there is a considerable body of research describing and promoting cognitive testing as

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Exercise Group vs Rest Group

TABLE 3. Recovery Time Since Initial Visit, Total Recovery Time, and Incidence of Delayed Recovery

	EG (n = 24)	RG (n = 30)	P
Recovery time since initial visit (d)	8.29 ± 3.85	23.93 ± 41.73	0.048*
Total recovery time (d)	13.04 ± 4.89	28.43 ± 41.78	0.052*
Total symptoms (% not recovered by 14 d)	8% (2/24)	33% (10/30)	0.028†
Physical symptoms (% not recovered by 14 d)	8% (2/24)	33% (10/30)	0.028†
Cognitive symptoms (% not recovered by 14 d)	4.2% (1/24)	27% (8/30)	0.027†
Sleep symptoms (% not recovered by 14 d)	0% (0/24)	23% (7/30)	0.011†
Affective symptoms (% not recovered by 14 d)	8% (2/24)	7% (2/30)	0.816†
Delayed recovery (recovery > 30 d)	0% (0/24)	13% (4/30)	0.063†

*Welch 2-sample t tests with unequal variances.

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Amsterdam Consensus (2023)

- "Absolute Rest" not beneficial
- "Relative Rest" for 24-48 hours
  - E.g., walking or stationary bike
- Systematically advance based on symptom exacerbation.
- "HCPs with access to exercise testing can safely prescribe subsymptom threshold aerobic exercise treatment without 2-10 days rest after SRC, based on the individual's HR threshold (HRt)."


Consensus statement

Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport–Amsterdam, October 2022

Jon S Patricios,[1] Kathryn J Schneider,[2] Jiri Dvorak,[3] Osman Hassan Ahmed,[4,5] Cheri Blauwet,[6,7] Robert C Cantu,[8,9] Gavin A Davis,[10,11] Ruben J Echemendia,[12,13] Michael Makdissi,[14,15] Michael McNamee,[16,17] Steven Broglio,[18] Carolyn A Emery,[2] Nina Feddermann-Demont,[19,20] Gordon Ward Fuller,[21] Christopher C Giza,[22,23] Kevin M Guskiewicz,[24] Brian Hainline,[25] Grant L Iverson,[26,27] Jeffrey S Kutcher,[28] John J Leddy,[29] David Maddocks,[30] Geoff Manley,[31] Michael McCrea,[32] Laura K Purcell,[33] Margot Putukian,[34] Haruhiko Sato,[35] Markku P Tuominen,[36] Michael Turner,[37,38] Keith Owen Yeates,[39] Stanley A Herring,[40,41] Willem Meeuwisse[42]

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JSP and KJS are joint first authors.

Accepted 2 June 2023

ABSTRACT
For over two decades, the Concussion in Sport Group has held meetings and developed five international statements on concussion in sport. This 6th statement summarises the processes and outcomes of the 6th International Conference on Concussion in Sport held in Amsterdam on 27–30 October 2022 and should be read in conjunction with the (1) methodology paper that outlines the consensus process in detail and (2) 10 systematic reviews that informed the conference outcomes. Over 3½ years, author groups conducted systematic reviews of predetermined priority topics relevant to concussion in sport. The format of the conference, expert panel meetings and workshops methodology. The purpose of this Statement is to provide a summary of the evidence and practice recommendations based on science and expert panel consensus recommendations at the time of the conference. Additional outputs of the consensus process include freely available evidence-informed tools to assist in the detection and assessment of SRC, including the Concussion Recognition Tool-6 (CRT6), Sport Concussion Assessment Tool-6 (SCAT6), Child SCAT6, Sport Concussion Office Assessment Tool-6 (SCOAT6) and Child SCOAT6. Apart from this Statement, in the interest of knowledge translation, the tools are free to distribute in their original formats.

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Studies Pouring in Now…

- Worts et al. 2019
- Popovich et al. 2019
- Willer et al. 2019
- Prince et al. 2020
- Henke et al. 2020

- Clinical Bottom Line: The current literature suggests that early physical activity in the acute phase (2-7 days) following a concussion may decrease the time needed for a symptom resolution compared to strict rest.

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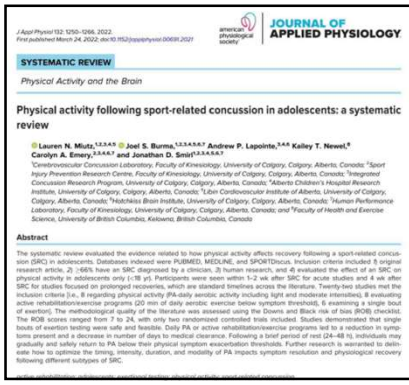

JOURNAL OF APPLIED PHYSIOLOGY

SYSTEMATIC REVIEW

Physical Activity and the Brain

Physical activity following sport-related concussion in adolescents: a systematic review

Lauren N. Miutz, Joel S. Burma, Andrew P. Lapointe, Kailey T. Newel, Carolyn A. Emery, and Jonathan D. Smirl

Abstract

The systematic review evaluated the evidence related to how physical activity affects recovery following a sport-related concussion (SRC) in adolescents. Databases indexed were PUBMED, MEDLINE, and SPORTDiscus. Inclusion criteria included 1) original research article, 2) ≥66% have an SRC diagnosed by a clinician, 3) human research, and 4) evaluated the effect of an SRC on physical activity in adolescents only (<18 yr). Participants were seen within 1–2 wk after SRC for acute studies and 4 wk after SRC for studies focused on prolonged recoveries, which are standard timelines across the literature. Twenty-two studies met the inclusion criteria (i.e., 8 regarding physical activity (PA–daily aerobic activity including light and moderate intensities), 8 evaluating active rehabilitation/exercise programs (20 min of daily aerobic exercise below symptom threshold), 6 examining a single bout of exertion). The methodological quality of the literature was assessed using the Downs and Black risk of bias (ROB) checklist. The ROB scores ranged from 7 to 24, with only two randomized controlled trials included. Studies demonstrated that single bouts of exertion testing were safe and feasible. Daily PA or active rehabilitation/exercise programs led to a reduction in symptoms present and a decrease in number of days to medical clearance. Following a brief period of rest (24–48 h), individuals may gradually and safely return to PA below their physical symptom exacerbation thresholds. Further research is warranted to delineate how to optimize the timing, intensity, duration, and modality of PA impacts symptom resolution and physiological recovery following different subtypes of SRC.

Miutz et al. 2022

22 studies met inclusion criteria.

Conclusion: Following a brief period of rest (24-48 hours), individuals can gradually and safely return to PA below their physical symptom exacerbation thresholds.

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Buffalo Concussion Treadmill Test

Safely assessing sub-symptom threshold exercise…

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BCTT Purpose

- To investigate exercise tolerance in patients with concussion.
- To identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (i.e., the **Heart Rate Threshold [HRt]**) in concussed patients and assist in treatment protocols.
- To aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Cervicogenic, Vestibulo-ocular, Psychological) and etiology of the concussion.
- To identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

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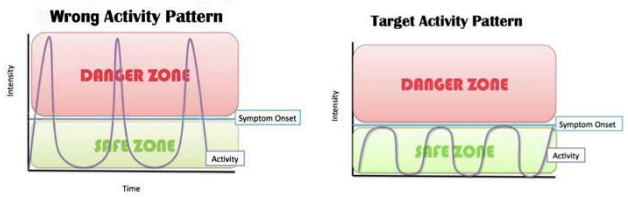
BCTT Purpose



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BCTT Eligibility

Absolute Contraindications

Acute MI (w/in 2 days)
High-risk unstable angina
Uncontrolled cardiac arrhythmias
Symptomatic severe aortic stenosis
Uncontrolled heart failure
Acute pulmonary embolism / infarction
Acute myocarditis / pericarditis
Acute aortic dissection

Relative Contraindications

- Left main coronary stenosis
- Moderate stenotic valvular heart disease
- Electrolyte abnormalities
- Severe arterial hypertension (>200 mgHg systolic or >110 mmHg diastolic)
- Tachyarrythmias / bradyarrhythmias
- Hypertrophic cardiomyopathy / other forms of outflow tract obstruction
- Mental / physical impairment
- High degree artrioventricular block

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BCTT Liability Waiver

- Always have patient sign and acknowledge.

Buffalo Concussion Treadmill / Bike Test

Patient Name:	Today's Date:

Safety Considerations: I am comfortable performing this exercise in the clothing and shoes I am wearing.	No ☐ Yes ☐
Absolute Contraindications	
• Recent Heart Attack	No ☐ Yes ☐
• High-Risk Unstable Angina	No ☐ Yes ☐
• Uncontrolled Cardiac Arrhythmias	No ☐ Yes ☐
• Severe Aortic Stenosis	No ☐ Yes ☐
• Uncontrolled Heart Failure	No ☐ Yes ☐
• Acute Pulmonary Embolism / Infarction	No ☐ Yes ☐
• Acute Myocarditis / Pericarditis	No ☐ Yes ☐
• Acute Aortic Dissection	No ☐ Yes ☐
Relative Contraindications	
• Left Main Coronary Stenosis	No ☐ Yes ☐
• Moderate Stenotic Valvular Heart Disease	No ☐ Yes ☐
• Electrolyte Abnormalities	No ☐ Yes ☐
• Blood Pressure Systolic > 200 mmHg	No ☐ Yes ☐
• Blood Pressure Diastolic > 110 mmHg	No ☐ Yes ☐
• Tachyarrythmias / Bradyarrhythmias	No ☐ Yes ☐
• Hypertrophic Cardiomyopathy	No ☐ Yes ☐
• Mental / Physical Impairment with Inability to Exercise	No ☐ Yes ☐
• High-Degree Atrioventricular Block	No ☐ Yes ☐
Terminating the Test • Maximum Exertion (RPE Score > 17.5) • Symptom Exacerbation > 2 Points • Experimenter Notes Rapid Progression of Symptoms • Patient Reports Inability to Continue Test	

Patient Signature: ______________________ **Date:** ______________________

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Exertional Testing

Buffalo Concussion Treadmill / Bike Test

Patient Name:	Today's Date:
Blood Pressure:	Heart Rate:
Calculate Maximum Heart Rate:	220 - _____ (Age) x _____ % = _____ BPM
Test #:	

Purpose	
	• Investigate exercise tolerance in patients with concussion. • Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols. • Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion. • Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A		N/A			
0	N/A	0					
1	2.5	0					
2	2.5	0					
3		1					
4		2					
5		3					
6		4					
7		5					
8		6					
9		7					
10		8					
11		9					
12		10					
13		11					
14		12					
15		13					
16		14					
17		15					
18		0.4					
19		0.4					
20		0.4					
Post		2.5					

Passed:	☐
Failed:	☐
Maximum HR at Failure:	BPM
Sub-Symptom Threshold:	BPM

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Dx / Plan

DIAGNOSES (ICD-10)

Concussion W/O LOC (Subsequent Visit)	☐ S06.0X0D
Concussion W/ LOC < 30 Min (Subsequent Visit)	☐ S06.0X1D
Concussion W/ LOC Unspecified Duration (Subsequent Visit)	☐ S06.0X9D
Persistent Concussive Symptoms (PCS) AKA Post Concussion Syndrome	☐ F07.81
Additional Diagnoses:	

PLAN / RECOMMENDATIONS

BCTT Testing	☐ Failed ☐ Passed
Sub-Symptom Exercise: When the patient fails the BCTT, this represents Physiologic Concussion. The patient is instructed to begin sub-symptom threshold exercise with target HR of 80% of the BCTT symptom threshold HR (90% for athletes).	☐ Sub-Symptom Threshold = _____ BPM Patient instructed to continue with sub-symptom threshold exercise for 20-30 minutes daily. Patient was instructed that if the exercise induces symptoms, they are to stop the exercise that day. Continue exercise the following day at HR 10% lower.
Schedule Vestibulo-Ocular PCS Exam	☐
Schedule Cervicogenic PCS Exam	☐
Neurocognitive Testing	☐
Neurologic Co-Management	☐
Psychological Complicating Factors Present	No ☐ Yes ☐
Time: Today, _____ minutes were spent reviewing the patient's current status, outcome measures, performing BCTT, discussing my recommendations, documenting my findings and completing the chart note. The patient indicated an understanding of our discussion and we will implement the above treatment plan.	☐ 99203 (New Patient: 30-44 Min) ☐ 99211 (Est Patient: Brief OV) ☐ 99212 (Est Patient: 10-19 Min) ☐ 99213 (Est Patient: 20-29 Min) ☐ 99214 (Est Patient: 30-39 Min) ☐ 99215 (Est Patient: 40-54 Min) ☐ 97750 (Physical Performance Test / BCTT) ☐ 97112 (Neuromuscular Re-education)

Doctor's Notes:

Provider Signature: ______________________ Date: ______________________

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BCTT Equipment Requirements

- Treadmill with capacity to reach 15 degrees of incline.
- HR monitor
- BCTT Assessment Form
- Likert Scale
- Borg Rating of Perceived Exertion (RPE)

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BCTT Safety Considerations

- Dress for exercise (clothing/shoes)
- Engage in casual conversation during exercise.
- Watch for any difficulty communicating, paleness, or serious discomfort.
- Assess for postural or structural changes (slouching, leaning head).

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Borg RPE

Measure of perceived physical activity. Can be explained as a measure of "how hard you feel like your body is working."

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

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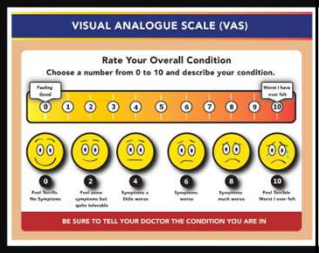
Likert Scale (VAS)

- I don't like to call it VAS. Patients may equate to pain.
- We are looking for existing symptom exacerbation(s) and/or new symptom(s) relating to the Concussion.



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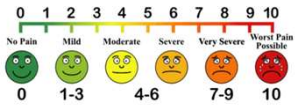
Use Symptom Severity Scale → Likert



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1. Inform patient what to expect.
2. Explain Likert and Borg RPE Scales.
3. Obtain resting HR after 2 min seating.
4. Two-minute warmup at 2.5 mph.
5. Speed 3.4 mph (< 5'10") or 3.6 mph.
6. Each 1 min. increase incline by 1 degree and reassess HR, Likert, and RPE.
7. Likert: 1 point for worsening of existing symptom and/or for new symptom.
8. If attain 15 degrees, increase speed by 0.4 mph each minute.
9. Once test completed, decrease speed to 2.0 mph and set incline to 0 for 2 min.
10. Patient rest in chair until symptoms return to baseline or patient can function.

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Step 1

Obtain Resting HR and BP after patient has sat for at least 2 min.

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Record Resting Vitals

Buffalo Concussion Treadmill / Bike Test

Patient Name: Sam Sample	Today's Date: 4/28/23
Blood Pressure: 147/91	Heart Rate: 96
Calculate Maximum Heart Rate: 128	220 - 60 (Age) x 80 % = 128 BPM
Test #: 1	

Purpose	• Investigate exercise tolerance in patients with concussion. • Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols. • Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.

- Record Resting BP and HR
- Make calculations
- Assess Likert Scale

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Step 2

- **Record standing HR after 1 min**
- **Reassess Likert (Sx) Scale**
- **Explain that the first 2 minutes will be warm-up at 2.5 mph**
- **Reassess HR, Likert and RPE at 1 min intervals**

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Record Warm-Up Phase

- **During the warm-up phase, talk to patient and record findings at one-minute intervals.**
- **Assess patient ability to tolerate increased speed and incline.**

Buffalo Concussion Treadmill / Bike Test

Name: Sam Sample	Today's Date: 7/27/23
Pressure: 147/91	Heart Rate: 96
ate Maximum Heart Rate: 128	220 - 60 (Age) x 80 % = 128 BPM
1	

e
- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protoc
- Aid in differentiating between possible diagnoses for concussive symptoms (Physi Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observat
N/A	N/A	96	N/A	4	HA, Lightheaded	
N/A	0	98	6	4		
2.5	0	105	9	4		
2.5	0	109	11	5	↑ HA	
	1					
	2					
	3					
	4					
	5					
	6					

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Step 3

- **At minute 3, if tolerated, increase speed and raise incline 1 level/min.**
  - **3.4 mph < 5' 10"**
  - **3.6 mph ≥ 5' 10"**

Buffalo Concussion Treadmill / Bike Test

Patient Name: Sam Sample	Today's Date: 7/27/23
Blood Pressure: 147/91	Heart Rate: 96
Calculate Maximum Heart Rate: 128	220 - 60 (Age) x 80 % = 128 BPM
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Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	96	N/A	4	HA, Lightheaded	
0	N/A	0	98	6	4		
1	2.5	0	105	9	4		
2	2.5	0	109	11	5	↑ HA	
3	3.9	1	115	12	5		
4		2	123	15	7	Hazy + Blurred Vision	
5		3					

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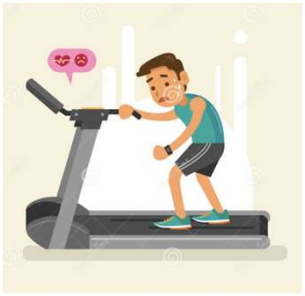
BCTT Termination Criteria

- **FAIL**
  - Symptom Exacerbation: Increase of 3 or more points on Likert from resting (1 point during first 7 days from injury).
  - Complaints: Rapid progression of complaints, near syncope, or communication difficulties.
  - Patient requests to stop for any reason. Record reason.
- **PASS**
  - Voluntary Exhaustion: RPE > 17.5
  - Patient reaches 90% age predicted HRT (220-age); 80% elderly or sedentary.



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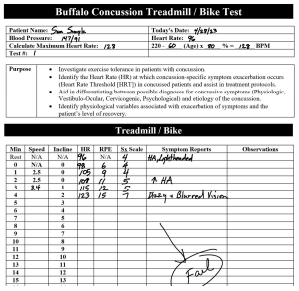
Failure Example

- 3 Point Increase on Likert
  - 1 Exacerbation
  - 2 New Symptoms
- Calculate Sub-Symptom Threshold HR
  - What would it be on this elderly patient?



Buffalo Concussion Treadmill / Bike Test

Patient Name: Sue Smyth — Today's Date: 4/23/23
Blood Pressure: 147/91 — Heart Rate: 84
Calculate Maximum Heart Rate: 183 — 220 - 60 (Age) x .80 % = 152 BPM
Test #: 1

Purpose
- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	84	N/A	0	HA Lightheaded	
0	N/A	0	98	6	0		
1	2.5	0	105	9	0		
2	2.5	0	109	11	2	↑ HA	
3	2.5	1	115	12	2		
4		2	123	15	3	Blurry + Blurred Vision	
5		3					
6		4					
7		5					
8		6					
9		7					
10		8					
11		9					
12		10					
13		11					
14		12					
15		13					

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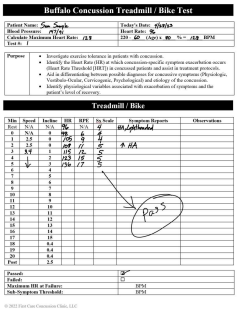
Pass



Buffalo Concussion Treadmill / Bike Test

Patient Name: Sue Smyth — Today's Date: 4/23/23
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Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	84	N/A	0	HA Lightheaded	
0	N/A	0	98	6	0		
1	2.5	0	105	9	0		
2	2.5	0	109	11	2	↑ HA	
3	2.5	1	115	12	2		
4		2	123	15	3		
5		3	138	17	5		
6		4					
7		5					
8		6					
9		7					
10		8					
11		9					
12		10					
13		11					
14		12					
15		13					
16		14					
17		15					
18		16					
19		8.4					
20		8.4					
Post		2.5					

Passed:	☑
Failed:	☐
Maximum HR at Failure:	BPM
Sub-Symptom Threshold:	BPM

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BCTT Interpretation

- Maximum HR at symptom exacerbation is called Heart Rate Threshold (HRt).
- Safe level of exercise is 90% HRt; 80% HRt for sedentary/elderly.
- Patients who have symptoms at rest but pass BCTT should be evaluated for dysfunction of:
  - Vestibulo-Ocular System
  - Cervical Somatosensory System
  - Psychologic Causes…

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Sample 20-Yr Old

Buffalo Concussion Treadmill / Bike Test

Patient Name: Sam Sample	Today's Date: 8/5/22
Blood Pressure: 126/84	Heart Rate: 72
Calculate Maximum Heart Rate:	220 - 20 (Age) x .80 % = 180 BPM
Test #: 1	

Purpose

- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	76	N/A	4	Fronted HA	
0	N/A	0	84	8	4		
1	2.5	0	86	9	4		
2	2.5	0	88	9	4		
3	3.2	1	96	10	4		
4	↑	2	98	11	4		
5		3	106	11	4		
6		4	112	13	5	Head pressure ↑	
7		5	118	13	5		
8	↓	6	120	14	7	Dizziness ↑ HA	
9		5					
10		8					
11		9					
12		10					
13		11					
14		12					
15		13					
16		14					

Fail

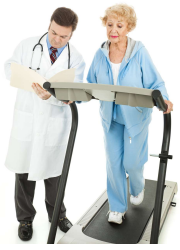
133

BCTT Discussion

The patient failed the BCTT with a HR of **120 and RPE of 14**. This represents Physiologic Concussion. The patient was instructed to begin sub-symptom threshold exercise with target HR of 90% of the BCTT HR symptom threshold (80% for sedentary/elderly).

Sub-symptom threshold exercise = **108 BPM.** Patient instructed to continue with sub-symptom threshold exercise for 20-30 minutes daily. Patient was instructed that if the exercise induces symptoms, they are to stop the exercise that day. Continue exercise the following day at HR 10% lower.

134



BCTT Examples

135

Sam Sample, Jr.

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: Sam Sample, Jr.	Today's Date: 1/23/13
Blood Pressure: 119/66	Heart Rate: 58
Calculate Maximum Heart Rate: 180	220 - 20 (Age) x 90 % = 180 BPM
Test #: 1	

Purpose

- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	58	N/A	3	Lightheaded, Mild HA (frontal	
0	N/A	0					
1	2.5	0					
2	2.5	0					
3		1					
4		2					
5		3					
6		4					
7		5					
8		6					
9		7					
10		8					

136

Sam Sample, Jr.

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: Sam Sample, Jr.	Today's Date: 1/23/13
Blood Pressure: 119/66	Heart Rate: 58
Calculate Maximum Heart Rate: 180	220 - 20 (Age) x 90 % = 180 BPM
Test #: 1	

Purpose

- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	58	N/A	3	Lightheaded, Mild HA (frontal	
0	N/A	0	66	6	3		
1	2.5	0	70	9	3		
2	2.5	0	72	9	3		
3		1					
4		2					
5		3					
6		4				.	
7		5					
8		6					
9		7					
10		8					
11		9					
12		10					

137

Sam Sample, Jr.

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: Sam Sample, Jr.	Today's Date: 1/23/13
Blood Pressure: 119/66	Heart Rate: 58
Calculate Maximum Heart Rate: 180	220 - 20 (Age) x 90 % = 180 BPM
Test #: 1	

Purpose

- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	58	N/A	3	Lightheaded, Mild HA (frontal	
0	N/A	0	66	6	3		
1	2.5	0	70	9	3		
2	2.5	0	72	9	3		
3	2.6	1	70	9	3		
4		2	82	9	3		
5		3	96	10	3		
6		4	98	10	3	.	
7		5	96	11	3		
8		6	110	12	4	Lightheadedness	
9		7	124	13	4		
10		8	128	15	7	Inc HA, Dizzy, Nausea	
11		9					
12		10					

138

slido

Why did Sam Sample Jr. fail?

ⓘ Start presenting to display the poll results on this slide.

139

Sam Sample, Jr.

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: Sam Sample, Jr	Today's Date: 4/28/23
Blood Pressure: 118/66	Heart Rate: 58
Calculate Maximum Heart Rate: 180	220 - 20 (Age) x 90 % = 180 BPM
Test #: 1	

Purpose	• Investigate exercise tolerance in patients with concussion. • Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols. • Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion. • Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	58	N/A	3	Lightheaded, Mild HA frontal	
0	N/A	0	66	6	3		
1	2.5	0	70	9	3		
2	2.5	0	72	9	3		
3	3.6	1	70	9	3		
4		2	82	9	3		
5		3	92	10	3		
6		4	88	10	3		
7		5	96	11	3		
8		6	110	12	4	↗ Lightheadedness	
9		7	124	13	4		
10		8	128	15	7	Occ HA, Dizzy, Nausea	
11		9					
12		10					
13		11					
14		12					
15		13				Fail	
16		14					
17		15					
18		0.4					
19		0.4					
20		0.4					
Post		2.5					

Passed:	☐
Failed:	☑
Maximum HR at Failure:	128 BPM
Sub-Symptom Threshold:	115 BPM

140

Sue Sample

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: Sue Sample	Today's Date: 4/28/23
Blood Pressure: 145/87	Heart Rate: 76
Calculate Maximum Heart Rate: 144	220 - 40 (Age) x 80 % = 144 BPM
Test #: 1	

Purpose	• Investigate exercise tolerance in patients with concussion. • Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols. • Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion. • Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	76	N/A	5	HA frontal, dizzy, lightheaded	
0	N/A	0	112	6	7	↗ dizzy, ↑ lightheaded	
1	2.5	0					
2	2.5	0					
3		1					
4		2					
5		3					
6		4					
7		5					
8		6					
9		7					
10		8					
11		9					

141

slido

What is the next step in performing the BCTT on Sue Sample?

ⓘ Start presenting to display the poll results on this slide.

142

Sue Sample

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: Sue Sample	Today's Date: 4/28/23
Blood Pressure: 145/87	Heart Rate: 76
Calculate Maximum Heart Rate: 144	220 - 40 (Age) x 80 % = 144 BPM
Test #: 1	

Purpose
- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	76	N/A	5	HA frontal, dizzy, lightheaded	
0	N/A	0	112	6	7	↑ dizzy, ↑ lightheaded	
1	2.5	0					
2	2.5	0					
3		1					
4		2					
5		3					
6		4					
7		5					
8		6					
9		7					
10		8					
11		9					

143

Fred Flintstone

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: Fred Flintstone	Today's Date: 4/28/23
Blood Pressure: 160/92	Heart Rate: 86
Calculate Maximum Heart Rate: 136	220 - 50 (Age) x 80 % = 136 BPM
Test #: 1	

Purpose
- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	86	N/A	4	Frontal HA	
0	N/A	0	92	6	4		
1	2.5	0					
2	2.5	0					
3		1					
4		2					
5		3					
6		4					
7		5					
8		6					
9		7					
10		8					

144

Fred Flintstone

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: Fred Flintstone	Today's Date: 4/28/23
Blood Pressure: 160/92	Heart Rate: 86
Calculate Maximum Heart Rate: 136	220 - 50 (Age) x 80 % = 136 BPM
Test #: 1	

Purpose
- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	86	N/A	4	Frontal HA	
0	N/A	0	92	6	4		
1	2.5	0	103	9	4		
2	2.5	0	105	10	4		
3	3.0	1	110	12	4		
4	↓	2	118	13	5	↑ HA	
5		3	128	15	5		
6		4	136	18	6	Dizzy	
7		5					
8		6					
9		7					
10		8					
11		9					

145

slido

Did Fred Flintstone pass or fail the BCTT test.

ⓘ Start presenting to display the poll results on this slide.

146

Fred Flintstone

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: Fred Flintstone	Today's Date: 4/28/23
Blood Pressure: 160/92	Heart Rate: 86
Calculate Maximum Heart Rate: 136	220 - 50 (Age) x 80 % = 136 BPM
Test #: 1	

Purpose
- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

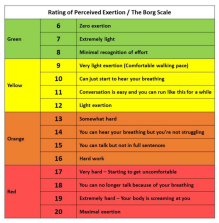
Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	86	N/A	4	Frontal HA	
0	N/A	0	92	6	4		
1	2.5	0	103	9	4		
2	2.5	0	105	10	4		
3	3.0	1	110	12	4		
4	↓	2	118	13	5	↑ HA	
5		3	128	15	5		
6		4	136	18	6	Dizzy	
7	2.5	5	132	17	6		
8	2.5	6	127	15	6		
9		7					
10		8					
11		9					
12		10				↑ dizziness + nausea getting	
13		11				off treadmill.	
14		12					
15		13					
16		14					
17		15			(8)	Fail	
18		0.4					
19		0.4					
20		0.4					
Post		2.5					

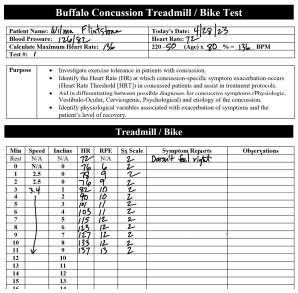
Passed:	☐
Failed:	☑
Maximum HR at Failure:	136 BPM
Sub-Symptom Threshold:	109 BPM

147

Wilma Flintstone



Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard - Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard - Your body is screaming at you
	20	Maximal exertion



Buffalo Concussion Treadmill / Bike Test

Patient Name: Wilma Flintstone	Today's Date: 4/23/25
Blood Pressure: 134/82	Heart Rate: 72
Calculate Maximum Heart Rate: 156	220 - 50 (Age) x .80 % = 136 BPM
Test #: 1	

Purpose

- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	72	N/A	2	Dizzy if I look right	
0	N/A	0	76	6	2		
1	2.5	0	78	9	2		
2	2.5	0	76	9	2		
3	2.4	1	82	10	2		
4		2	90	10	2		
5		3	96	11	2		
6		4	105	11	2		
7		5	118	12	2		
8		6	125	12	2		
9		7	132	12	2		
10		8	133	12	2		
11		9	137	13	2		
12		10					
13		11					
14		12					
15		13					
16		14					

148

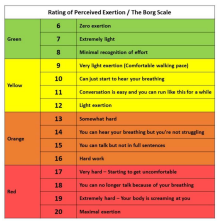
slido

Did Wilma Flintstone pass or fail the BCTT test.

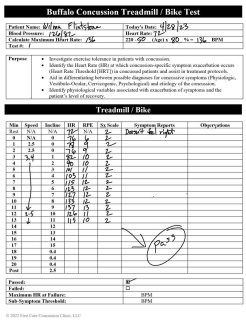
ⓘ Start presenting to display the poll results on this slide.

149

Wilma Flintstone



Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard - Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard - Your body is screaming at you
	20	Maximal exertion



Buffalo Concussion Treadmill / Bike Test

Patient Name: Wilma Flintstone	Today's Date: 4/23/25
Blood Pressure: 134/82	Heart Rate: 72
Calculate Maximum Heart Rate: 156	220 - 50 (Age) x .80 % = 136 BPM
Test #: 1	

Purpose

- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	72	N/A	2	Dizzy if I look right	
0	N/A	0	76	6	2		
1	2.5	0	78	9	2		
2	2.5	0	76	9	2		
3	2.4	1	82	10	2		
4		2	90	10	2		
5		3	96	11	2		
6		4	105	11	2		
7		5	118	12	2		
8		6	125	12	2		
9		7	132	12	2		
10		8	133	12	2		
11		9	137	13	2		
12		10					
13		11					
14		12					
15		13					
16		14					
17		15					
18		16					
19		17					
20		18					
Post		19					

Passed:	87
Failed:	☐
Maximum HR at Failure:	BPM
Sub-Symptom Threshold:	BPM

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Joe Athlete

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: Joe Athlete	Today's Date: 4/28/23
Blood Pressure: 112/66	Heart Rate: 52
Calculate Maximum Heart Rate: 180	220 - 20 (Age) x 90 % = 180 BPM
Test #: 1	

Purpose	• Investigate exercise tolerance in patients with concussion. • Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols. • Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion. • Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	52	N/A	1	Head pressure	
0	N/A	0	54	6	1		
1	2.5	0	55	9	1		
2	2.5	0	55	9	1		
3	3.6	1	60	9	1		
4	↓	2	62	9	1		
5	↓	3	65	9	1		
6	↓	4	64	9	1		
7	3.8	5	65	9	1		
8	↓	6	72	9	1		
9	↓	7	81	10	1		
10	↓	8	84	10	1		
11	4.0	9	82	10	1		
12	↓	10	92	10	1		
13	↓	11	98	11	1		
14	↓	12	104	11	1		
15	↓	13	110	11	1		
16	↓	14	118	11	1		
17	↓	15	109	11	1		
18	4.4	0.4	116	11	1		
19	4.8	0.4	121	12	1		
20	5.2	0.4	129	12	1		
Post		2.5					

Passed:	☐
Failed:	☐
Maximum HR at Failure:	BPM
Sub-Symptom Threshold:	BPM

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Did Joe Athlete pass or fail the BCTT?

ⓘ Start presenting to display the poll results on this slide.

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Joe Athlete

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard – Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard – Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: Joe Athlete	Today's Date: 4/28/23
Blood Pressure: 112/66	Heart Rate: 52
Calculate Maximum Heart Rate: 180	220 - 20 (Age) x 90 % = 180 BPM
Test #: 1	

Purpose	• Investigate exercise tolerance in patients with concussion. • Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols. • Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion. • Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	52	N/A	1	Head pressure	
0	N/A	0	54	6	1		
1	2.5	0	55	9	1		
2	2.5	0	55	9	1		
3	3.6	1	60	9	1	↓	
4	↓	2	62	9	1	5.6 132 12 2	↑ Load (P)
5	↓	3	65	9	1	6.0 144 12 2	
6	↓	4	64	9	1	6.4 167 13 2	
7	3.8	5	65	9	1	6.8 181 15 2	
8	↓	6	72	9	1		
9	↓	7	81	10	1	2.5 151 13 2	
10	↓	8	84	10	1	2.5 124 12 2	
11	4.0	9	82	10	1		
12	↓	10	92	10	1		↓
13	↓	11	98	11	1		
14	↓	12	104	11	1		
15	↓	13	110	11	1		
16	↓	14	118	11	1		pass
17	↓	15	109	11	1		
18	4.4	0.4	116	11	1		
19	4.8	0.4	121	12	1		
20	5.2	0.4	129	12	1		
Post		2.5					

Passed:	☑
Failed:	☐
Maximum HR at Failure:	BPM
Sub-Symptom Threshold:	BPM

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Lazy Leo

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard - Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard - Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Patient Name: [illegible]	Today's Date: 4/23/25
Blood Pressure: 142/96	Heart Rate: 86
Calculate Maximum Heart Rate:	220 - 40 (Age) x .90 % = 144 BPM
Test #: 1	

Purpose

- Investigate exercise tolerance in patients with concussion.
- Identify the Heart Rate (HR) at which concussion-specific symptom exacerbation occurs (Heart Rate Threshold [HRT]) in concussed patients and assist in treatment protocols.
- Aid in differentiating between possible diagnoses for concussive symptoms (Physiologic, Vestibulo-Ocular, Cervicogenic, Psychological) and etiology of the concussion.
- Identify physiological variables associated with exacerbation of symptoms and the patient's level of recovery.

Treadmill / Bike

Min	Speed	Incline	HR	RPE	Sx Scale	Symptom Reports	Observations
Rest	N/A	N/A	86	N/A	1	HA, tightness	
0	N/A	0	92	6	1		
1	2.5	0	96	9	2		
2	2.5	0	104	10	2		
3	3.6	1	117	13	4		
4	"	2	126	15	4		
5	"	3	131	17	4		
6	"	4	153	18.5	5	Dizzy	
7	V	5					
8		6					
9		7					
10		8					
11		9					
12		10					

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slido

Did Lazy Leo pass or fail the BCTT?

Start presenting to display the poll results on this slide.

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Lazy Leo

Rating of Perceived Exertion / The Borg Scale

Green	6	Zero exertion
	7	Extremely light
	8	Minimal recognition of effort
Yellow	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
	11	Conversation is easy and you can run like this for a while
	12	Light exertion
Orange	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
	15	You can talk but not in full sentences
	16	Hard work
Red	17	Very hard - Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard - Your body is screaming at you
	20	Maximal exertion

Buffalo Concussion Treadmill / Bike Test

Treadmill / Bike

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The Buffalo Concussion Bike Test for Concussion Assessment in Adolescents

Mohammad N. Haider, MD,*[†‡] Samantha L. Johnson, MSc,[†] Rebekah Mannix, MD,[§] Alexander J. Macfarlane, BSc,[†] Dylan Constantino, BSc,[†] Blair D. Johnson, PhD,[†] Barry Willer, PhD,[¶] and John Leddy, MD[†]

Background: The Buffalo Concussion Treadmill Test (BCTT) is a graded exertion test for assessing exercise tolerance after concussion, but its utility is limited for certain populations.

Hypothesis: We developed the Buffalo Concussion Bike Test (BCBT) and tested its comparability with the BCTT. We hypothesize that heart rate (HR) at symptom exacerbation on the BCBT will be equivalent to the BCTT.

Study Design: Case-control study.

Level of Evidence: Level 3.

Methods: Adolescents with acute concussion (AC) (n = 20; mean age, 15.9 ± 1.1 years; 60% male) presenting to a concussion clinic within 10 days of injury and age- and sex-matched healthy controls (n = 20; mean age, 15.9 ± 1.1 years; 60% male) performed the BCTT at first visit and returned within 5 days to perform the BCBT. Test duration, HR, symptom severity (measured using a visual analog scale), and exertion (measured using the Borg Rating of Perceived Exertion) were collected during each test.

Results: Adolescents with AC who were exercise intolerant on the BCTT were also intolerant on the BCBT, with symptom exacerbation occurring at a mean 8.1 ± 2.8 minutes on the BCTT versus 14.6 ± 6.0 minutes on the BCBT ($P < 0.01$). Two 1-sided *t* tests showed that the HR at symptom exacerbation in AC patients (137 ± 28 bpm on BCTT vs 135 ± 25 bpm on BCBT; 95% CI, ±0.01-0.03) and at voluntary exhaustion for controls (175 ± 13 bpm on BCTT vs 175 ± 13 bpm on BCBT; 95% CI, 0.03-0.05) on each test were statistically equivalent.

Conclusion: The HR at symptom exacerbation on BCBT is equivalent to the BCTT for the assessment of exercise tolerance after concussion in adolescents.

Clinical Relevance: The BCBT can be used in patients with limited mobility or for research interventions that require limited participant motion.

Keywords: sport-related concussion; Buffalo Concussion Treadmill Test; BCTT; Buffalo Concussion Bike Test; BCBT; exercise test

Buffalo Concussion Bicycle Test

- If orthopedic injuries or disequilibrium prevent treadmill testing, option is to utilize the Buffalo Concussion Bicycle Test (BCBT).
- Information recorded every 2 minutes.
- Longer and more difficult than BCTT.

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BCBT Recommendations

- Warm up for 2 minutes without any tension.
- Gradually increase to 60 RPM
- Test Starts
  - Stay at 60 RPM throughout
  - Observe HR and let that be guide for when to increase tension.
  - Typically record at 2 minute intervals.
  - Same Pass/Fail criteria.

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Plan

- If fail, schedule another test in one week (2 weeks if sedentary / elderly).
  - Must perform steady-state sub-symptom threshold exercises.
- If pass, return to all non-contact physical activities.

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Considerations

- Not all patients will be able to perform the BCTT or BCBT
  - Orthopedic Injury(s)
  - Age
  - Dysequilibrium
  - Body Habitat
  - Pre-Existing Physical Condition
  - PCS Orthostatic Tacycardia Syndrome
    - Recommend starting exercise in recumbent position and graduate exercise.
  - Always be ready to "Think on Your Feet"

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Non-BCTT/BCBT Route

- Protocol (Leddy 2021)
  - 220 – Age = HRmax
  - HRmax x 50% = Initial Sub-Symptom Threshold
- Exercise 1 week without exacerbation.
- Increase 5% of HRmax intervals
- Goal is 80% of HRmax

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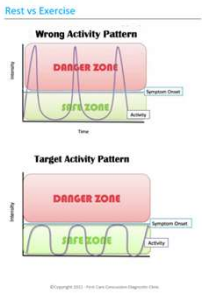
Rest vs Exercise Handout

Calculate Sub-Symptom Threshold

Give Rest vs Exercise Handout



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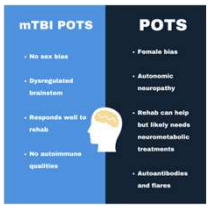
Post-Concussion Orthostatic Tachycardia



Original Research Article

Post-Concussive Orthostatic Tachycardia is Distinct from Postural Orthostatic Tachycardia Syndrome (POTS) in Children and Adolescents

Rachel Pearson, MD[1,2,3], Christopher A. Sheridan, CSCS[1,4], Kaylee Kang[1], Anne Brown[1], Michael Baharn[1,2], Robert Asarnow, PhD[5], Christopher C. Giza, MD[1,2], and Meeryo C. Choe, MD[1,2]

Abstract

Background: Orthostatic tachycardia (OT) affects some patients after concussion/mild traumatic brain injury (mTBI). In this study, we sought to identify the factors associated with increased risk for OT in patients with mTBI. **Methods:** We conducted a retrospective review of 268 patients (8-25 years) with mTBIconcussion to determine the prevalence of OT, defined as orthostatic heart rate change ≥40 bpm for those ≥19 years of age and ≥30 bpm on acine standing test for those <19 years of age. **Results:** Among the study population, 75 (n = 19) exhibited post-concussive OT. The only significant difference between OT and non-OT groups was that history of prior concussion was more prevalent in the OT group. **Conclusion:** A substantial subset (7%) of concussion clinic patients exhibit OT. While POTS literature describes female and adolescent predominance, post-concussive OT had similar prevalence across age and gender groups in this study, suggesting that it may be distinct from POTS.

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Remember...

Post-Concussion Orthostatic Hypotension

- Drop in systolic BP => 20 mm Hg or drop in diastolic BP = > 10 mm Hg between supine and standing positions.

Post-Concussion Orthostatic Tachycardia

- Sustained increase in HR of => 30 bpm in patients over 19 years of age.
- Sustained increase in HR of => 40 bpm in patients 19 years of age and under.
- Absence of orthostatic hypotension upon transition from supine to standing.

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With Orthostatic Intolerance…

- Physical deconditioning may contribute to post-concussive OT.
- As the deconditioned state is corrected, the underlying mechanism for OT resolved.
- Graded exercise protocols may need to be adjusted in patients exhibiting post-concussive OT.
  - Pearson 2022

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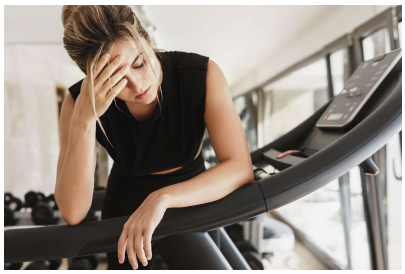
BCTT Demonstration



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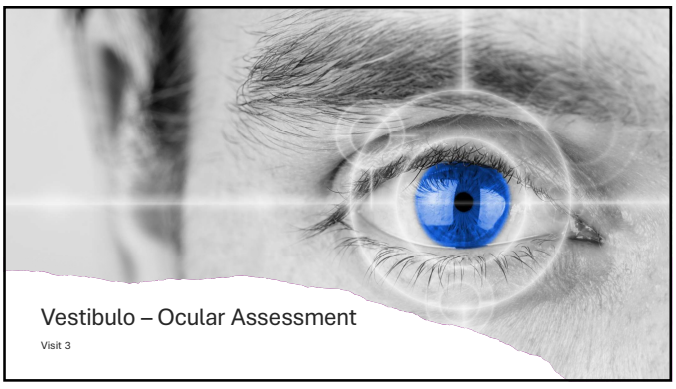

Vestibulo – Ocular Assessment

Visit 3

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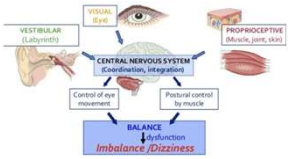
Development of Vestibulo-Ocular PCS

- "The integration of the vestibular, oculomotor and somatosensory systems is necessary to allow human beings to optimally navigate and function within a complex visuospatial environment. This complex system is comprised of highly specialized neural networks that interact at multiple levels of the craniospinal axis to regulate gait, maintain balance and postural control, as well as co-ordinate eye-movements."
- Ellis (2015)



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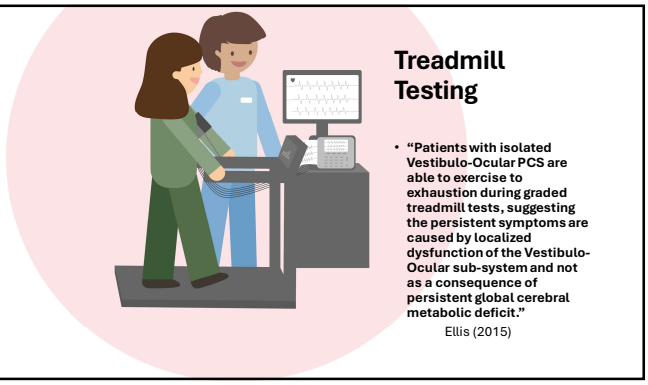

Treadmill Testing

- **"Patients with isolated Vestibulo-Ocular PCS are able to exercise to exhaustion during graded treadmill tests, suggesting the persistent symptoms are caused by localized dysfunction of the Vestibulo-Ocular sub-system and not as a consequence of persistent global cerebral metabolic deficit."**

Ellis (2015)

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Organization of Vestibular System

- **Vestibulo-Ocular System**
  - Maintains visual stability during head movements.
  - Impairments commonly manifest as:
    - Dizziness
    - Visual Instability
- **Vestibulo-Spinal System**
  - Responsible for postural control.
  - Impairment commonly manifest as:
    - Disrupted Balance
    - Disequilibrium

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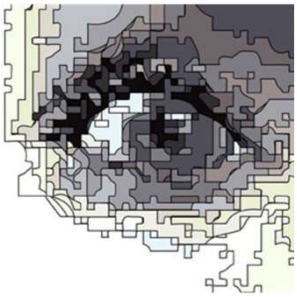
Development of VOMS

- Prior to 2014, assessment of the vestibular system occurred only through BESS or SOT (balance testing).
- These are only static measurements and only assess the Vestibulo-Spinal System.
- Did not address the Vestibulo-Ocular System.



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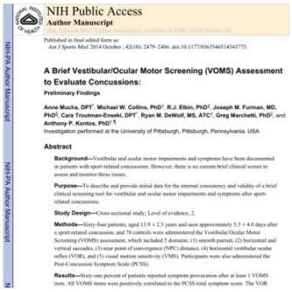
Vestibular-Ocular Motor Screen (VOMS)

- Developed to assess vestibular and ocular impairments via patient reported symptom provocation.
- Symptoms are reassessed after each test.
- Looking for provocation of symptoms (2-point increase in any symptom from baseline)
  - Mucha (2014)
  - Elbin (2018)



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Am J Sports Med. 2014 October ; 42(10): 2479–2486. doi:10.1177/0363546514543775.

A Brief Vestibular/Ocular Motor Screening (VOMS) Assessment to Evaluate Concussions: Preliminary Findings

Anne Mucha, DPT[1], Michael W. Collins, PhD[2], R.J. Elbin, PhD[2], Joseph M. Furman, MD, PhD[2], Cara Troutman-Enseki, DPT[1], Ryan M. DeWolf, MS, ATC[1], Greg Marchetti, PhD[2], and Anthony P. Kontos, PhD[2,3]
Investigation performed at the University of Pittsburgh, Pittsburgh, Pennsylvania, USA

Abstract

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

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Domains

- VOMS consists of 5 domains:
  - Smooth Pursuits (0-10)
  - Horizontal and Vertical Saccades (0-10)
  - Convergence (0-10)
  - Horizontal and Vertical VOR (0-10)
  - Visual Motion Sensitivity (0-10)

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Vestibular-Oculomotor Motor Screen (VOMS)

Purpose: The VOMS testing was developed to assess vestibular and ocular motor impairments via patient reported symptom provocation after each assessment. The VOMS consists of 5 domains: Smooth Pursuits (0-10), Horizontal and Vertical Saccades (0-10), Convergence (0-10), Horizontal and Vertical Vestibular Reflex (VOR)(0-10), and Visual Motion Sensitivity (0-10). Baseline symptoms are taken in reference to Headaches, Dizziness, Nausea, and Fogginess. The symptoms are reassessed after each test. The testing is looking for provocation of symptoms (2-point increase in any symptom from baseline (Mucha et al. 2015; Elbin et al. 2018). The VOMS test is designed to help establish vestibular / oculomotor dysfunction and help guide rehabilitation and potentially academic accommodations. If positive, initial rehabilitation corresponds to VOMS findings.

VOM Test	Headache	Dizziness	Nausea	Fogginess	Comments
Baseline Symptoms					
Smooth Pursuits					
Saccades – Horizontal					
Saccades – Vertical					
Near Point Convergence					cm
VOR – Horizontal					
VOR – Vertical					
Visual Motion Sensitivity					

VOMS

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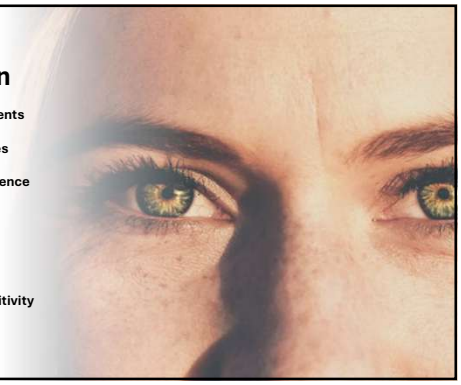
Differentiation

- 4 Oculomotor Components
  - Smooth Pursuits
  - Horizontal Saccades
  - Vertical Saccades
  - Near Point Convergence (NPC)
- 3 Vestibulo-Ocular Components
  - Horizontal VOR
  - Vertical VOR
  - Visual Motion Sensitivity (VMS)



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Smooth Pursuits

- Testing ability to follow a slowly moving target.
- Target 24" from patient.
- Move target horizontally 18" to right and then 18" to left from the midline. Repeat 2x in smooth continuous motion (2 seconds to complete 1 cycle).
- Switch motion to vertical plane (18" superior and 18" inferior).
- Reassess symptoms.

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Smooth Pursuits

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Saccades: Horizontal

- Testing ability of the eyes to move quickly between targets.
- Targets held 3 feet from patient horizontally 18" from midline.
- Patient's gaze 30 degrees to right and 30 degrees to the left moving their eyes as quickly as possible between the targets for 10 repetitions.
- Reassess symptoms.

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Horizontal Saccades

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Saccades: Vertical

- Testing ability of the eyes to move quickly between targets.
- Targets held 3 feet from patient vertically 18" from midline.
- Patient's gaze 30 degrees up and 30 degrees down moving their eyes as quickly as possible between the targets for 10 repetitions.
- Reassess symptoms.

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Vertical Saccades

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Near Point Convergence

- **Measure the ability to view a near target without double vision.**
- **Wear corrective lenses (if needed)**
- **Use Convergence Ruler.**
- **Looking for double vision, not blurriness.**
- **Record distance (cm) when double vision occurs (normal < 6 cm).**
- **Reassess symptoms.**

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Near Point Convergence

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Convergence Insufficiency Video

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Vestibulo-Ocular Reflex (VOR): Horizontal

- Assess ability to stabilize vision as the head moves.
- Target distance = 3’
- Patient rotates head horizontally 20 degrees to each side for 10 repetitions (metronome can be used and set to 180 bpm).
- Reassess symptoms.

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Horizontal VOR

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Vestibulo-Ocular Reflex (VOR): Vertical

- Assess ability to stabilize vision as the head moves.
- Target distance = 3’
- Patient moves head vertically 20 degrees up and 20 degrees down for 10 repetitions (metronome can be used and set to 180 bpm).
- Reassess symptoms.

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Vertical VOR

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Visual Motion Sensitivity (VMS)

- Assess VMS and ability to inhibit vestibular-induced eye movements using vision.
- Patient holds arms outstretched and focuses on thumbs. Rotates trunk and arms as a unit (80 degrees to the right and 80 degrees to the left).
- Metronome can be use (50 bpm).
- 5 repetitions performed.
- Reassess symptoms.

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Visual Motion Sensitivity

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Visual Motion Sensitivity (VMS)

- Often can detect on history and/or VOMS testing.
- Patients with VMS often rely too much on their visual system, which means their brains can be “tricked”.
- AKA Visual Vestibular Mismatch (VVM)

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Keep in Mind…

- **Many patients will not complete VOMS testing.**
- **Be sensitive of when testing should be discontinued; particularly during early assessment.**

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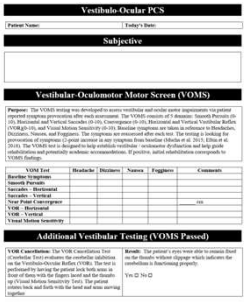
VOR Cancellation

- VOR Cancellation AKA (Cerebellar Test) evaluates the cerebellar inhibition on the Vestibulo-Ocular Reflex (VOR).
- Performed during the VMS test. Assess whether the patient's eyes are able to maintain fixation on their thumbs without slippage (indicates cerebellum is functioning properly).
- Abnormal = Eye(s) move in opposite direction to rotation with catch-up saccades to refix gaze on outstretched thumbs.



Vestibulo-Ocular PCS

Patient Name:	Today's Date:

Subjective

Vestibular-Oculomotor Motor Screen (VOMS)

Purpose: The VOMS testing was developed to assess vestibular and ocular motor impairments via patient reported symptoms provocation after each assessment. The VOMS consists of 5 domains: Smooth Pursuits (0-10), Horizontal and Vertical Saccades (0-10), Convergence (0-10), Horizontal and Vertical Vestibular Reflex (VORx)(0-10), and Visual Motion Sensitivity (0-10). Baseline symptoms are taken in reference to Headaches, Dizziness, Nausea, and Fogginess. The symptoms are reassessed after each test. The testing is looking for provocation of symptoms (2-point increase in any symptom from baseline (Mucha et al. 2013, Elbin et al. 2018). The VOMS test is designed to help establish vestibular / oculomotor dysfunction and help guide rehabilitation and potentially academic accommodations. If positive, initial rehabilitation corresponds to VOMS findings.

VOMS Test	Headache	Dizziness	Nausea	Fogginess	Comments
Baseline Symptoms					
Smooth Pursuits					
Saccades – Horizontal					
Saccades – Vertical					
Near Point Convergence					____ cm
VOR – Horizontal					
VOR – Vertical					
Visual Motion Sensitivity					

Additional Vestibular Testing (VOMS Passed)

VOR Cancellation: The VOR Cancellation Test (Cerebellar Test) evaluates the cerebellar inhibition on the Vestibulo-Ocular Reflex (VOR). The test is performed by having the patient lock both eyes in front of them with the fingers laced and the thumbs up (Visual Motion Sensitivity Test). The patient rotates back and forth with the head and torso moving together.

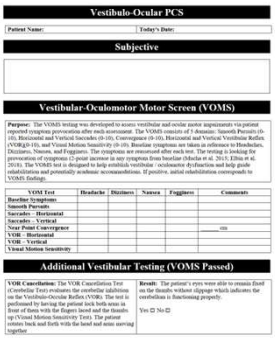
Result: The patient's eyes were able to remain fixed on the thumbs without slippage which indicates the cerebellum is functioning properly.

Yes ☐ No ☐

194

VOMS Training

- Volunteer
  - Recent Concussion or History of PCS?
- Partner
  - Perform VOMS



Vestibulo-Ocular PCS

Patient Name:	Today's Date:

Subjective

Vestibular-Oculomotor Motor Screen (VOMS)

Purpose: The VOMS testing was developed to assess vestibular and ocular motor impairments via patient reported symptoms provocation after each assessment. The VOMS consists of 5 domains: Smooth Pursuits (0-10), Horizontal and Vertical Saccades (0-10), Convergence (0-10), Horizontal and Vertical Vestibular Reflex (VORx)(0-10), and Visual Motion Sensitivity (0-10). Baseline symptoms are taken in reference to Headaches, Dizziness, Nausea, and Fogginess. The symptoms are reassessed after each test. The testing is looking for provocation of symptoms (2-point increase in any symptom from baseline (Mucha et al. 2013, Elbin et al. 2018). The VOMS test is designed to help establish vestibular / oculomotor dysfunction and help guide rehabilitation and potentially academic accommodations. If positive, initial rehabilitation corresponds to VOMS findings.

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Saccades – Horizontal					
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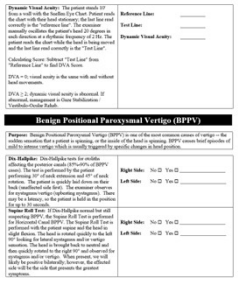
Result: The patient's eyes were able to remain fixed on the thumbs without slippage which indicates the cerebellum is functioning properly.

Yes ☐ No ☐

195

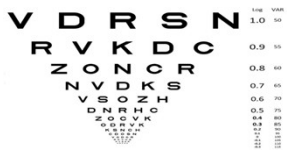
DVA & BPPV



Benign Positional Paroxysmal Vertigo (BPPV)

196

Dynamic Visual Acuity

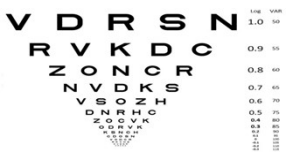


- **10' from the Eye Chart.**
- **Read chart with head stationary.**
- **Last line read correctly is the "Reference Line"**
- **Examiner manually oscillates patient's head 20 degrees in each direction (freq. 2 Hz).**
- **Last line read is "Test Line".**
- **Test Line – Reference Line = DVA**
- **DVA => 2 (Abnormal)**

197

Rotatory Chair Test

- Following DVA testing, the patient's head is held steady while the patient twists in a swivel chair as the eye chart is read.
- If impairment with Rotatory Chair Test but not with Dynamic Visual Acuity Test, patient's condition is likely Cervicogenic.



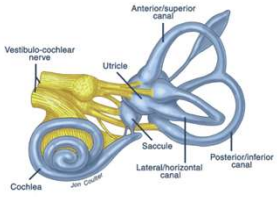
198

199

199

Benign Positional Paroxysmal Vertigo (BPPV)

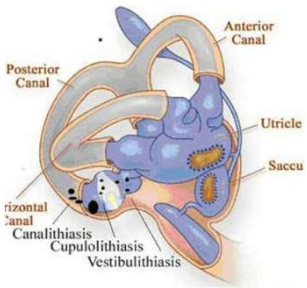
- BPPV is one of the most common causes of vertigo - the sudden sensation of the patient's surroundings spinning.
- BPPV causes brief episodes of mild to intense vertigo which is usually triggered by specific changes in head position.



200

BPPV

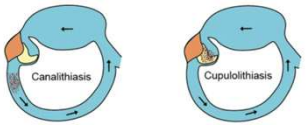
- Posterior Canals most common (85%-90%).
- Horizontal Canals (10%-15%)
- Anterior Canal very rare (3%).



201

BPPV

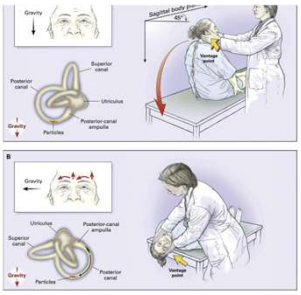
- Canalithiasis (Loose Debris)
  - Most common
  - Latency of nystagmus (5-10 seconds)
  - Nystagmus fatigues (30-60 seconds)
- Cupulolithiasis (Adhered to Cupula)
  - Rare
  - No latency of nystagmus
  - No fatigue in nystagmus during testing
  - Usually refer out



202

Dix-Hallpike

- Assesses for otoliths affecting the posterior canals (85%-90%)
- Patient performs 30 degrees of extension and 45 degrees of rotation.
- Patient quickly laid down on their back (unaffected side first).
- Observe for upbeating nystagmus and/or vertigo (may be latency so hold in position for up to 30 sec).
- If nystagmus fatigues, may be a candidate for Epley Maneuver.



203

Epley Maneuver

204

Procedure Note

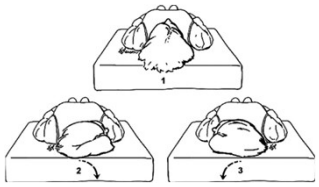
Procedure Note:

Epley Maneuver:	The patient exhibited a positive Dix-Hallpike Test on the []. This test evaluates the posterior canals only. However, the posterior canal is responsible for approximately 85% of BPPV conditions.
Consent:	Prior to the procedure a verbal consent was obtained with an explanation of the procedure. No guarantees were given or implied. Risks of the procedure include worsening of the vertigo, nausea, vomiting, etc.
Procedure:	• When Dix-Hallpike Test was performed and found to be positive, the Epley's Maneuver was started. • The patient remained supine with the head extended 30° and rotated to 45° ipsilaterally for 30-60 seconds -- until the vertigo/nystagmas fatigued. • The patient was then instructed to turn the head 90° to the contralateral side (head remained extended 30° and now 45° to the contralateral side) for 30-60 seconds. • The patient was then instructed to turn on the contralateral side with their head facing the ground for 30-60 seconds. • The patient was then sat up with their head tilted forward for 1 minute.
Disposition:	The patient tolerated the procedure well. There was a 15-minute interval at which point Dix-Hallpike was retested. The Epley Maneuver can be performed up to three times.
Discharge:	Standard post-procedure care was explained and return precautions were explained. The patient was given home-based instructions for the Half Somersault Maneuver if the symptoms reoccur.

205

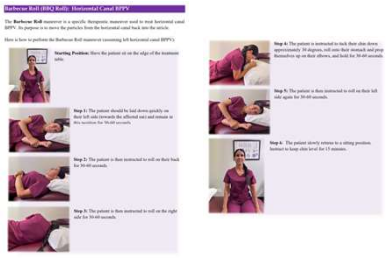
Supine Roll Test

- If Dix-Hallpike is normal but still suspect BPPV, the Supine Roll Test is performed for Horizontal Canal BPPV.
- Patient supine. Rotate head quickly right 90 degrees and observe for lateral beating nystagmus and/or vertigo. Repeat on left side.
- May be positive bilaterally; if so, the affected side will be most symptomatic (down side).



206

Barbeque Roll



207

Procedure Note

Procedure Note:

BBQ Roll: The patient exhibited a positive Supine Roll Test on the []. This test evaluates the horizontal canals only.

Consent: Prior to the procedure a verbal consent was obtained with an explanation of the procedure. No guarantees were given or implied. Risks of the procedure include worsening of the vertigo, nausea, vomiting, etc.

Procedure:
- The patient was instructed to lie on the ipsilateral side (affected side) for 30-60 seconds.
- The patient was then instructed to roll on their back for 30-60 seconds.
- The patient was then instructed to turn on the contralateral side for 30-60 seconds.
- The patient was then instructed to tuck the chin down slightly and roll on the stomach while propping up on the elbows for 30-60 seconds.
- The patient was then instructed to roll on the ipsilateral side and wait for 30-60 seconds.
- The patient was then slowly returned to the sitting position while keeping the chin level for 15 minutes.

Disposition: The patient tolerated the procedure well. After waiting 15 minutes, the Supine Roll Test was performed again. The BBQ Roll can be performed up to three times on the same visit. If unsuccessful, the Gufoni Maneuver can be performed.

Discharge: Standard post-procedure care was explained and return precautions were explained.

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Benign Positional Paroxysmal Vertigo (BPPV)

Purpose: Benign Positional Paroxysmal Vertigo (BPPV) is one of the most common causes of vertigo -- the sudden sensation that a patient is spinning, or the inside of the head is spinning. BPPV causes brief episodes of mild to intense vertigo which is usually triggered by specific changes in head position.

Dix-Hallpike: Dix-Hallpike tests for otolithu affecting the posterior canals (85%-90% of BPPV cases). The test is performed by the patient performing 30° of neck extension and 45° of neck rotation. The patient is quickly laid down on their back (unaffected side first). The examiner observes for nystagmus/vertigo (upbeating nystagmus). There may be a latency, so the patient is held in the position for up to 30 seconds.	**Right Side:** No ☐ Yes ☐ _____ **Left Side:** No ☐ Yes ☐ _____
Supine Roll Test: If Dix-Hallpike normal but still suspecting BPPV, the Supine Roll Test is performed for Horizontal Canal BPPV. The Supine Roll Test is performed with the patient supine and the head in slight flexion. The head is rotated quickly to the left 90° looking for lateral nystagmus and/or vertigo sensation. The head is brought back to neutral and then quickly rotated to the right 90° and observed for nystagmus and/or vertigo. When present, we will likely be positive bilaterally; however, the effected side will be the side that presents the greatest symptoms.	**Right Side:** No ☐ Yes ☐ _____ **Left Side:** No ☐ Yes ☐ _____

BPPV

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Vestibulo-Ocular Dx / Plan

- Appropriate Diagnosis
- Plan
  - Pass/Fail
  - Rehabilitation Prescription
  - Recommendations
  - Co-management
  - Billing

DIAGNOSES (ICD-10)

Concussion W/O LOC (Subsequent Visit)	☐ S06.0X0D
Concussion W/ LOC < 30 Min (Subsequent Visit)	☐ S06.0X1D
Concussion W/ LOC Unspecified Duration (Subsequent Visit)	☐ S06.0X9D
Persistent Concussive Symptoms (PCS) AKA Post-Concussion Syndrome	☐ F07.81
Additional Diagnoses:	
Convergence Insufficiency	☐ H51.11
Dizziness	☐ R42
BPPV	☐ H81.10

PLAN / RECOMMENDATIONS

Vestibulo-Ocular PCS Testing	☐ Failed ☐ Passed
Vestibulo-Ocular Rehab Prescribed: When prescribed, each exercise is reviewed with the patient in detail. The patient is also given a detailed instruction handout. It is important the patient performs the exercises 3-4x/day. The patient indicated any understanding.	☐ Vestibulo-Ocular Rehab Level 1 ☐ Vestibulo-Ocular Rehab Level 2 ☐ Vestibulo-Ocular Rehab Level 3 ☐ Accommodation Insufficiency ☐ Convergence Insufficiency ☐ Brock String Rehab Exercises ☐ Visual Motion Sensitivity Exercises
Schedule:	☐ Physiologic Testing (BCTT / BCBT) ☐ Vestibulo-Ocular Eval ☐ Cervicogenic Eval ☐ BESS Testing
Neurocognitive Testing Reviewed	☐
Neurologic Co-Management Reviewed	☐
Psychological	☐
Complicating Factors Present	No ☐ Yes ☐
Time: Today, I spent _____ minutes reviewing the patient's current status, outcome measures, performing a Vestibulo-Ocular evaluation, discussing my recommendations, documenting my findings,	☐ 99203 (New Patient: 30-44 Min) ☐ 99204 (New Patient: 45-59 Min) ☐ 99211 (Est Patient; Brief OV) ☐ 99212 (Est Patient; 10-19 Min) ☐ 99213 (Est Patient; 20-29 Min)

210

Vestibulo-Ocular Rehab: Instructions

- Based on results of the Vestibulo-Ocular testing.
- Exercises are designed to provoke symptoms.
- Accomplished by gradually desensitizing, or habituating, the brain so that it can tolerate these unpleasant situations more and more.
- Work through symptoms up to 5/10.

First Care Concussion Diagnostic Clinic

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Concepts in Vestibulo-Ocular Rehabilitation

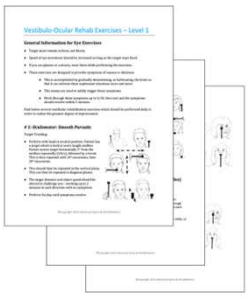
- **Adaptation**
  - Adaptation refers to the process by which the brain modifies its response to a repeated or sustained stimulus. The purpose of adaptation is to improve the function and efficiency of the sensory systems. In the context of post-concussion exercises, adaptation is about training the brain to improve its ability to process sensory information accurately, even when that information initially provokes symptoms.
- **Habituation**
  - Habituation, on the other hand, refers to the process by which the brain reduces its response to a repeated or sustained stimulus. This is a form of learning in which an organism decreases or ceases its responses to a stimulus after repeated or prolonged presentations. The purpose of habituation is to decrease the sensitivity of the nervous system to stimuli that are harmless or unimportant.

212

Vestibulo-Ocular Rehab Exercises Level 1-5

213

Vestibulo-Ocular Rehab Level 1



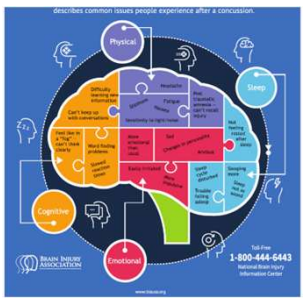
214

Vestibulo-Ocular Rehab Level 1 Video

215

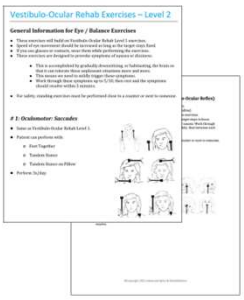
Summary: VO Rehab Level 1

- Many times, the exercises may need to be customized, such as in the following examples:
  - Significantly concussed patients with high symptom severity score and difficulty with smooth pursuit during VOMS may only be able to tolerate #1 Smooth Pursuit Rehabilitation for several days.
  - Patients who failed VOMS while performing saccade testing may only be able to perform #1 Smooth Pursuit and #2 Horizontal and Vertical Saccade rehabilitation.
  - Patients who had no difficulty with smooth pursuit or saccades but provoked with VOR may need to concentrate on #3 and #4 Gaze Stabilization (VOR) exercises. In this situation, you may have the patient perform #2 Saccades only once per day but VOR 3x/day. Even if asymptomatic with saccades, these exercises will still help strengthen the ocular musculature.



216

Vestibulo-Ocular Rehab Level 2



217

VO Level 2: Saccades

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VO Level 2: Gaze Stabilization (VOR)

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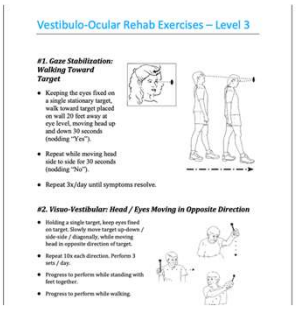
Vestibulo-Ocular Rehab Level 3


Vestibulo-Ocular Rehab Exercises – Level 3

#1. Gaze Stabilization: Walking Toward Target

- Keeping the eyes fixed on a single stationary target, walk toward target placed on wall 20 feet away at eye level, moving head up and down 30 seconds (nodding "Yes").
- Repeat while moving head side to side for 30 seconds (nodding "No").
- Repeat 3x/day until symptoms resolve.

#2. Visuo-Vestibular: Head / Eyes Moving in Opposite Direction

- Holding a single target, keep eyes fixed on target. Slowly move target up-down / side-side / diagonally, while moving head in opposite direction of target.
- Repeat 10x each direction. Perform 3 sets / day.
- Progress to perform while standing with feet together.
- Progress to perform while walking.

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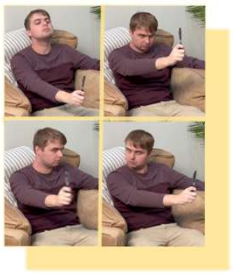
VO Rehab Level 3

Dynamic Walking (VOR)

Visuo-Vestibular (VOR x 2)



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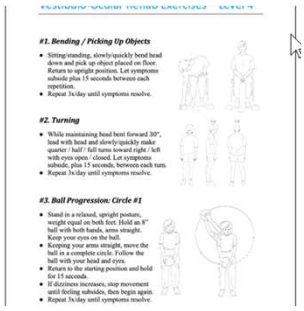
Vestibulo-Ocular Rehab Level 4


#1. Bending / Picking Up Objects

- Sitting/standing, slowly/quickly bend head down and pick up object placed on floor. Return to upright position. Let symptoms subside plus 15 seconds between each repetition.
- Repeat 3x/day until symptoms resolve.

#2. Turning

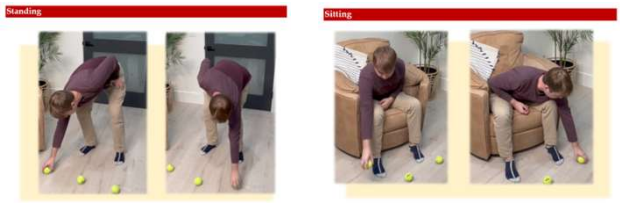
- While maintaining head bent forward 30°, head with head and slowly/quickly make quarter / half / full turns toward right / left with eyes open / closed. Let symptoms subside, plus 15 seconds, between each turn.
- Repeat 3x/day until symptoms resolve.

#3. Ball Progression: Circle #1

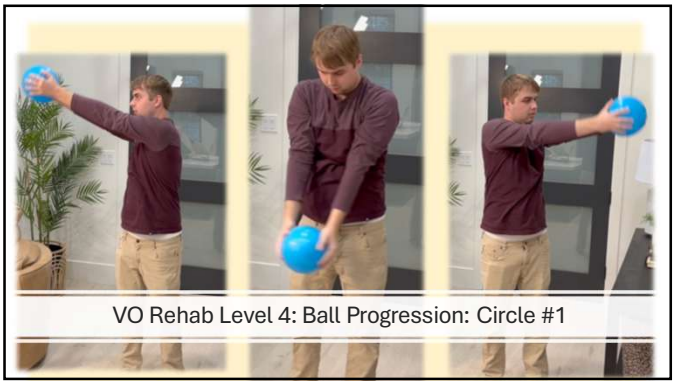
- Stand in a relaxed, upright posture, weight equal on both feet. Hold an 8" ball with both hands, arms straight. Keep your eyes on the ball.
- Keeping your arms straight, move the ball in a complete circle. Follow the ball with your head and eyes.
- Return to the starting position and hold for 15 seconds
- If dizziness increases, stop movement until feeling subsides, then begin again.
- Repeat 3x/day until symptoms resolve.

222

VO Rehab Level 4



223



VO Rehab Level 4: Ball Progression: Circle #1

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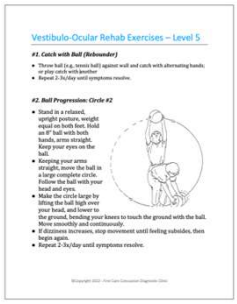
Vestibulo-Ocular Rehab Level 5



225

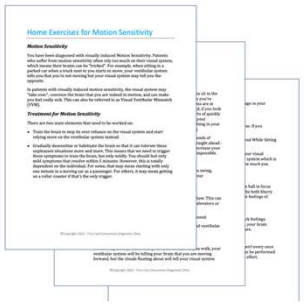
Catch the Ball

VO Rehab Level 5

Ball Progression: Circle #2

226

Visual Motion Sensitivity (VMS)



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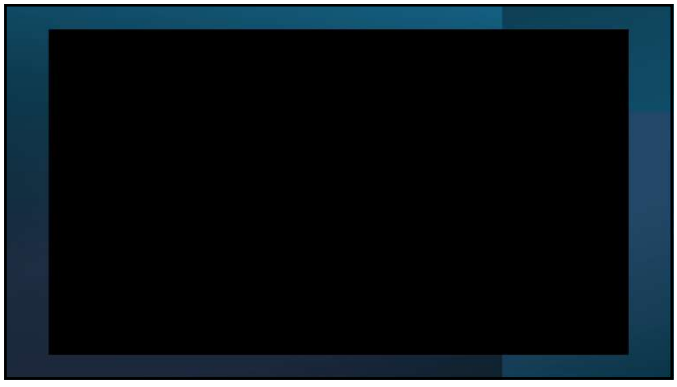

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VMS Habituation Exercises

- Look Out Side Window of Moving Car (Passenger)
- Twisting Looking at Thumbs (VMS Test)
- Swing Set
- Play Mario-Kart (or other video game)
- Watch Clouds While Walking
- Log Roll Down Hill
- Read While Passenger in Car
- Read While Sitting in Rocking Chair
- Play Focused Catch
- Chair Spins
- Etc…

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Brock String

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Vestibulo-Ocular Rehab Breakout

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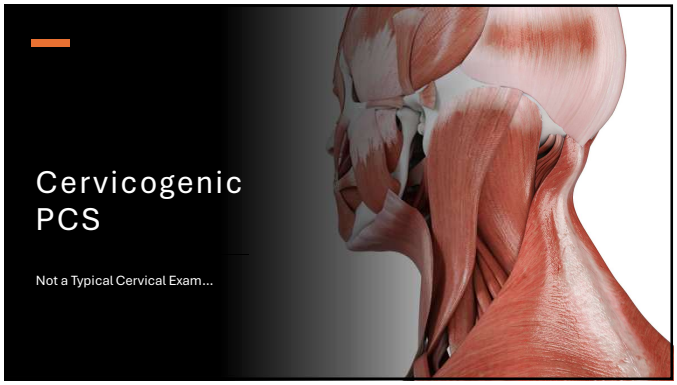
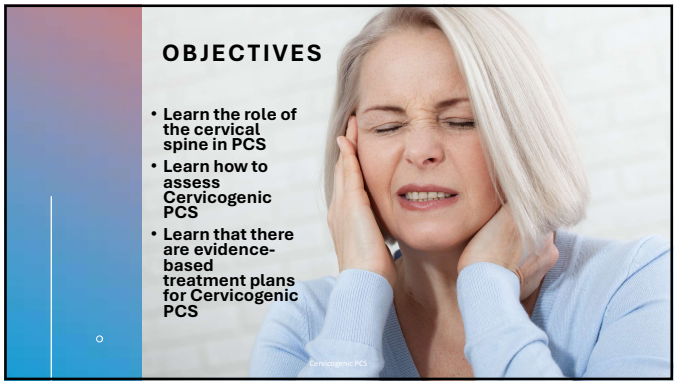

Cervicogenic
PCS
Not a Typical Cervical Exam...

232


OBJECTIVES
• Learn the role of the cervical spine in PCS
• Learn how to assess Cervicogenic PCS
• Learn that there are evidence-based treatment plans for Cervicogenic PCS

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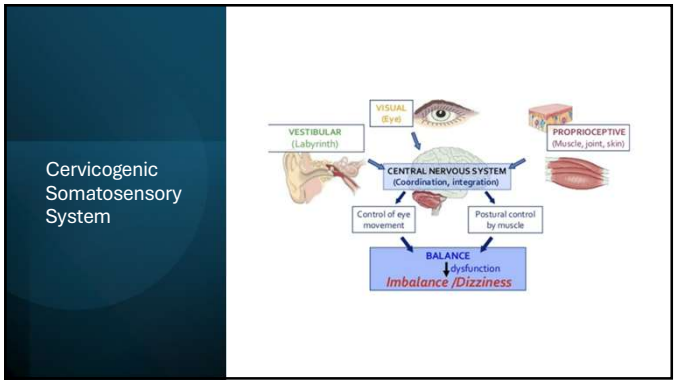
Cervicogenic
Somatosensory
System
VISUAL
(Eye)
VESTIBULAR
(Labyrinth)
PROPRIOCEPTIVE
(Muscle, joint, skin)
CENTRAL NERVOUS SYSTEM
(Coordination, integration)
Control of eye movement
Postural control by muscle
BALANCE
dysfunction
Imbalance /Dizziness

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Differential Diagnoses

Acute Concussion Differential Checklist (Kutcher Clinic)

	Concussion	Migraine	Cervicogenic	Cranial Nerve
Headache	X	X	X	X
Head Pressure	X	X	X	X
Neck Pain	X	X	X	X
Nausea/Vomit	X	X	X	X
Dizziness	X	X	X	X
Blurred Vision	X	X	X	X
Balance Problems	X	X	X	X
Light Sensitivity	X	X		X
Noise Sensitivity	X	X		X
Feeling Slowed Down	X	X	X	X
Feeling "In a Fog"	X	X	X	X
"Don't Feel Right"	X	X	X	X
Diff. Concentrating	X	X		
Diff. Remembering	X	X		
Fatigue/Low Energy	X	X		
Confusion	X	X		
Drowsiness	X	X		
More Emotional	X	X	X	
Irritability	X	X	X	
Sadness	X	X	X	
Nervous/Anxious	X	X		
Trouble Falling Asleep	X	X	X	

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Differentiation

- "Cervical injuries and Concussion can share similar mechanisms and nearly identical symptoms or causes. Therefore, symptoms or causes alone may be insufficient to differentiate between patients with a concussion and patients with cervical injuries."

  Cheever et al. 2016

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Clinical Assessment

- "Clinical assessments, such as the cervical joint reposition error test, smooth-pursuit neck-torsion test, head-neck differentiation test, cervical flexion-rotation test, and physical examination of the cervical spine, can be performed after a head and neck pathomechanical event to identify the presence of cervical injury.
- **Differentiating between a concussion and cervical injury is clinically vital for timely and appropriate evidence-based treatment (emphasis added).**"
- Cheever et al. 2016

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Cervicogenic?

- In the context of Post Concussive Symptoms, cervicogenic components should be addressed.
- The goal is to recreate headaches, dizziness, and/or dysfunctional patterns that may be causing symptoms.
- The key to differential diagnosis of cervicogenic concussion symptoms is testing if cervical afferents cause symptoms or disruptions in balance and oculomotor control.
- This is in addition to a standard orthopedic examination of the cervical spine.

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Introduction

- "Cervicogenic PCS is characterized by persistent concussion symptoms and impairments caused by dysfunction of the cervical spine somatosensory system."

- "Clinical studies in patients with whiplash-type injuries and concussion, as well as experimental studies with animals and humans have established the important role of the cervical spine in mediating balance, head orientation and eye movement. The high density and complexity of muscle and joint mechanoreceptors throughout the cervical spine are a rich source of proprioceptive information that is conveyed to multiple levels of the CNS, including the cerebellum, brainstem and spinal cord."

Ellis et al. 2015

239

Differentiation of Reflexes

Cervico-Ocular Reflex (COR)

- The COR stabilizes the eye in response to trunk-to-head movements.
- The COR operates in conjunction with the VOR.
- The COR is elicited by proprioception of the facet joints of the cervical spine and deep muscles of the neck.
- Affected by cervical injury/pain.

Vestibulo-Ocular Reflex (VOR)

- Previously discussed.
- The VOR stabilizes the eye in response to vestibular input (i.e., movements of the head in space).
- Not typically affected by cervical injury/pain.

deVries et al. 2016

240

Differentiation of Reflexes

Cervico-Collic Reflex (CCR)

- The CCR is elicited by rotation of the body with the head fixed in place, leading to activation of the deep cervical muscles to help stabilize the head relative to the trunk.

Vestibulo-Collic Reflex (VCR)

- The VCR is mediated by the vestibular system leading to the activation of the deep neck muscles, which allows the head stabilization in space during rapid head movements.

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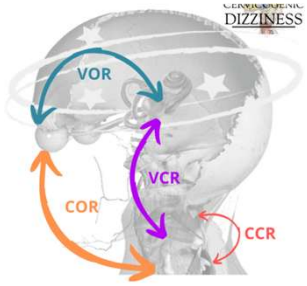
Reflexes

- Important reflexes associated with the cervical spine:
  - Cervical-Collic Reflex
  - Vestibulo-Collic Reflex
  - Cervico-Ocular Reflex



242

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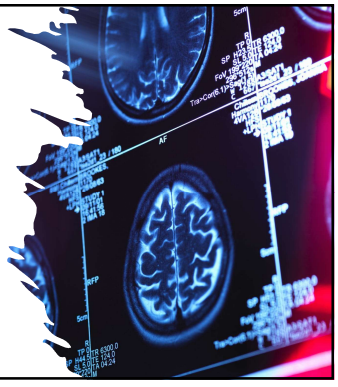
Can Mimic Vestibulo-Ocular PCS…

Dysfunction of these reflexes can lead to symptoms similar to those of Vestibulo-Ocular PCS, including dizziness, gait instability, light-headedness, mental fogginess and visual disturbances.

Both the CCR and the VCR work in a coordinated fashion to recruit the deep cervical muscles to help stabilize the head during head and body movements.



243

Treadmill Testing

- Patients with Cervicogenic PCS are capable of exercising to exhaustion during graded treadmill tests, suggesting that their persistent symptoms are caused by localized dysfunction of the cervical spine somatosensory system and not as a consequence of a global cerebral metabolic deficit (Physiologic PCS).

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Learning Activity

- 20 year old male involved in low velocity colinear rear end impact on 07/11/22.
- CC on 07/15/22 includes neck pain, dizziness, difficulty concentrating, and headaches.
- Diagnoses:
  - Post Concussion Syndrome
  - Post Traumatic Headaches
  - Cervical sprain/strain

rear end collision

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Cervicogenic PCS Worksheet

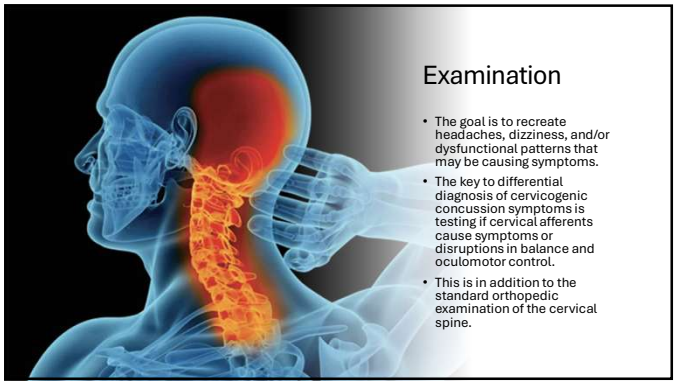
Cervicogenic PCS

Patient Name:	**Today's Date:**

Purpose: In the context of Post Concussive Symptoms, cervicogenic components need to be addressed in this case. The goal is to recreate headaches, dizziness, and/or dysfunctional patterns that may be causing symptoms. The key to differential diagnosis of cervicogenic concussion symptoms is testing if cervical afferents cause symptoms or disruptions in balance and oculomotor control. This is not a standard orthopedic examination of the cervical spine.

Sense of Unsteadiness	No ☐ Yes ☐
Sense of Dizziness	No ☐ Yes ☐
Sense of "Feeling Off"	No ☐ Yes ☐
Vision Related Symptoms	
Visual Fatigue	No ☐ Yes ☐
Sensitivity to Light	No ☐ Yes ☐
Blurred Vision	No ☐ Yes ☐
Difficulty Reading	No ☐ Yes ☐
Words Move on Page	No ☐ Yes ☐

246



Examination

- The goal is to recreate headaches, dizziness, and/or dysfunctional patterns that may be causing symptoms.
- The key to differential diagnosis of cervicogenic concussion symptoms is testing if cervical afferents cause symptoms or disruptions in balance and oculomotor control.
- This is in addition to the standard orthopedic examination of the cervical spine.

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Trigger Points (Travell & Simmons, 1999)

- **Latent Trigger Points**
  - "A myofascial TP that is clinically quiescent with respect to spontaneous pain; it is painful only when palpated. A latent TP may have all the other clinical characteristics of an active TP and always has a taut band that increases muscle tension and restricts ROM."
- **Active Trigger Points**
  - "A myofascial TP that causes a clinical pain complaint. It is always tender, prevents full lengthening of the muscle, weakens the muscle, refers a patient-recognized pain on direct compression, mediates a local twitch response of muscle fibers when adequately stimulated, and, when compressed within the patient's pain tolerance, produces referred motor phenomena and often autonomic phenomena, generally in its pain reference zone, and causes tenderness in the pain reference zone."

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Cervical TP Referral Patterns for Headaches

- Splenius Capitus
- Splenius Cervicis
- Suboccipitals
- SCM
- Superior Trapezius
- Semispinalis Capitis
- Occipitalis
- Longus Coli

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Muscle Finding Descriptors

- Spasm
- Guarding
- Hypertonicity
- Induration
- Trigger Point

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Trigger Points (Travell & Simmons, 1999)

- **Latent Trigger Points**
  - "A myofascial TP that is clinically quiescent with respect to spontaneous pain; it is painful only when palpated. A latent TP may have all the other clinical characteristics of an active TP and always has a taut band that increases muscle tension and restricts ROM."
- **Active Trigger Points**
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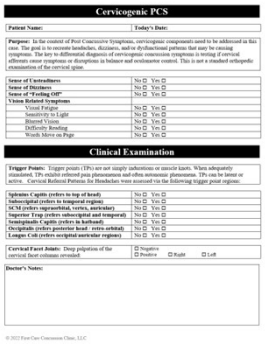
CERVICOGENIC PCS EXAM FORM



Cervicogenic PCS

Patient Name: | **Today's Date:**

Purpose: In the context of Post Concussive Symptoms, cervicogenic components need to be addressed as fast once. The goal is to excerate headaches, dizziness, and/or dysfunctional patterns that may be causing symptoms. The key to differential diagnosis of cervicogenic concussion symptoms is testing if cervical efferents cause symptoms or disruptions in balance and oculomotor control. This is not a standard orthopedic examination of the cervical spine.

Sense of Unsteadiness	No ☐ Yes ☐
Sense of Dizziness	No ☐ Yes ☐
Sense of "Feeling Off"	No ☐ Yes ☐
Vision Related Symptoms	
Vision Fatigue	No ☐ Yes ☐
Sensitivity to Light	No ☐ Yes ☐
Blurred Vision	No ☐ Yes ☐
Difficulty Reading	No ☐ Yes ☐
Worth Move on Page	No ☐ Yes ☐

Clinical Examination

Trigger Points: Trigger points (TPs) are not simply tuberosities or muscle knots. When adequately stimulated, TPs exhibit referred pain phenomenon and often autonomic phenomena. TPs can be latent or active. Cervical Referred Patterns for Headaches were assessed via the following trigger point regions:

Splenius Capitis (refers to top of head)	No ☐ Yes ☐
Suboccipital (refers to temporal region)	No ☐ Yes ☐
SCM (refers supraorbital, vertex, auricular)	No ☐ Yes ☐
Superior Trap (refers suboccipital and temporal)	No ☐ Yes ☐
Semispinalis Capitis (refers to hairband)	No ☐ Yes ☐
Occipitalis (refers posterior head - retro orbital)	No ☐ Yes ☐
Longus Colli (refers occipital-auricular regions)	No ☐ Yes ☐

Cervical Facet Joints: Deep palpation of the cervical facet columns revealed: ☐ Negative ☐ Positive ☐ Right ☐ Left

Doctor's Notes:

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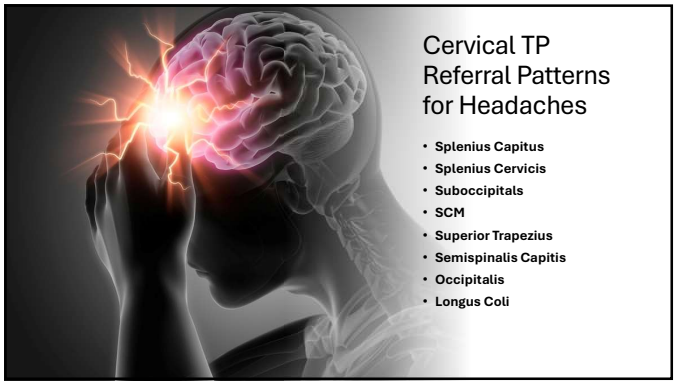

Cervical TP Referral Patterns for Headaches

- **Splenius Capitus**
- **Splenius Cervicis**
- **Suboccipitals**
- **SCM**
- **Superior Trapezius**
- **Semispinalis Capitis**
- **Occipitalis**
- **Longus Coli**

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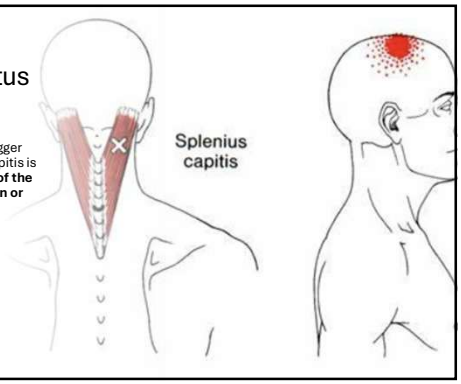
Splenius Capitus

- The main symptom of trigger points in the splenius capitis is referred **pain at the top of the head, close to the crown or vertex**.



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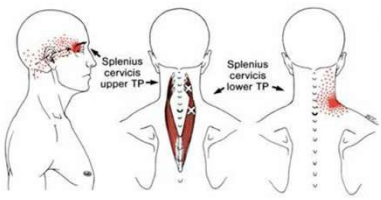
Splenius Cervicis

- The primary symptom of TrP's in the splenius cervicis is pain in the angle of the neck, head and especially the eye.

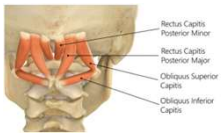


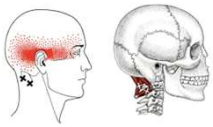
255

SUBOCCIPITALS

- Suboccipitals have active role in head positioning on the neck.
- Obliquus Capitis Inferior (OCI) is a dominant proprioceptor in the upper cervical spine due to high muscle spindle density.
- 3 patients with chief complaint of dizziness.
- Results:
  - Dry needling of the OCI produced sensation of dizziness.
  - 2 pts had complete resolution of dizziness.
  - All had significant reduction or complete resolution of dizziness at 6 month follow up.

Escaloni et al. 2018





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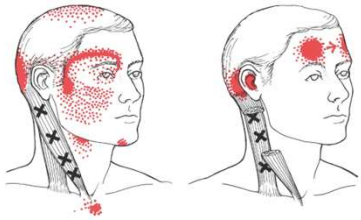
Sternocliedomastoid (SCM)

- **Trigger points** in **SCM** muscle refer to the posterior auricular/ auricular, as well as the supraorbital region.



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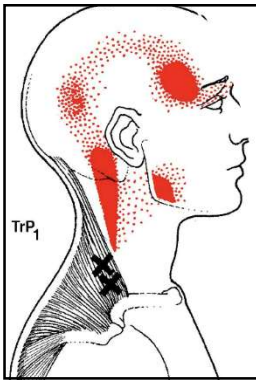

Superior Trapezius

- The Trapezius Trigger Points and Referred Pain. It refers **pain to the side of the neck and up into the temple region of the head**. The upper trapezius trigger point lies in the more horizontal fibers of the upper trapezius on the back of the shoulder, about halfway between the tip of the shoulder and the spine.

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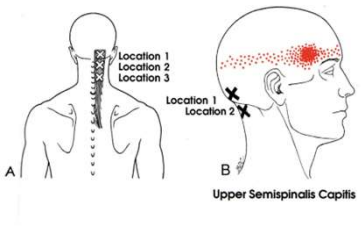
SEMISPINALIS CAPITIS

Refers to temporal region in a hatband distribution.



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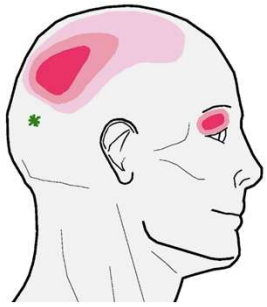
OCCIPITALIS

Refers to posterior head and retro-orbital region.



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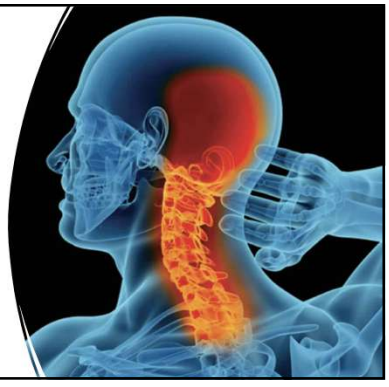
Clinical Tests

- "Key to differential diagnosis of cervicogenic syndromes is testing if cervical afferents cause symptoms or disruptive in balance and ocular motor control."
- Each test in this section attempts to remove visual and vestibular influences and isolate cervical position or movement-sensory information.
- Reproduction of symptoms or loss of motor-control accuracy during testing can then be attributed to cervical spine involvement.
  - Cheever et al. 2016



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Specific Tests

- Cervical Extension
- Head-Neck Differentiation Test
- Cervical Flexion-Rotation Test
- Cervical Joint Position Error Test (JPET)
- Smooth Pursuit Neck Torsion Test (SPNTT)
- Near Point Convergence (NPC) with Neck Torsion
- Tandem Gait Stance
- Walking with Head Turns

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Three Pillars of Sensorimotor Impairment

- Proprioception
- Oculomotor Control
- Postural Stability

Notation: There are tremendous neurological connections between cervical muscle spindles and eyes (Cervico-Ocular Reflex = COR) and vestibular apparatus and eyes (Vestibulo-Ocular Reflex = VOR). These are the fastest reflexes in the body telling the eyes to move at exactly the same rate as the neck when turning the head. If one of these mechanisms is off -- the patient will "feel off".

The Vestibulo-Ocular Reflex (VOR):
- Stabilizes images on the retina during head movement to ensure visual acuity.
- Sends information to the CNS which then creates a motor output to control movement of the eyes.
- The VOR is assessed in the VOMS Screen (Horizontal and Vertical VORs).

The Cervico-Ocular Reflex (COR):
- The COR is an afferent input from muscles in the neck.
- This is often assessed with the Smooth Pursuit Neck Torsion test (SPNT).

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Joint Position Error Test (JPET)

- **Tests the ability to relocate the head to a starting neutral position after maximal rotation in the transverse or sagittal plane with the eyes closed.**
- **Increased joint-reposition error indicates decreased sensorimotor control in the afferent pathway between the muscle spindles within the musculature of the cervical region and the CNS.**
- **JPET has shown high sensitivity (82%) and specificity (92%) for identifying patients with cervical injury.**
  - **Cheever et al. 2016**

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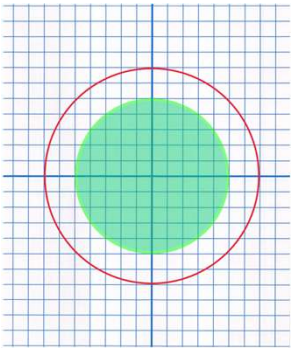

Joint Position Error Test (JPET)

Procedure: The JPET tests the ability to relocate the head to a starting (neutral) position with eyes closed. Patient wears a laser hat/helmet and is seated 1 meter (3.3') away from target. Laser is pointed at the target. The patient closes their eyes and turns the head all the way to the left and comes back to neutral. Once they feel they are in position a measurement is taken. Take a mean of 6 trials. Repeat with right rotation, extension and flexion. (Cheever et al. 2016; Reiley et al. 2017)

Grading:

- No Impairment = < 5 cm error
- Impaired = > 6.5 cm error
- Borderline = 5 cm - 6.5 cm error

Test is valid and reliable. Able to accurately discriminate between those with neck pain and whiplash vs. those without (Stanton et al. 2016; de Vries et al. 2015).

Error increases naturally with age.

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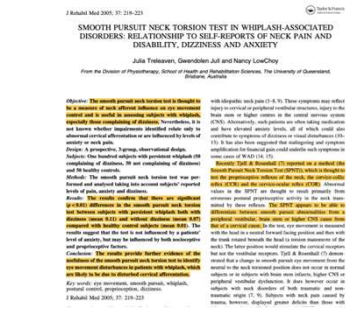

J Rehabil Med 2005; 37: 219–223

SMOOTH PURSUIT NECK TORSION TEST IN WHIPLASH-ASSOCIATED DISORDERS: RELATIONSHIP TO SELF-REPORTS OF NECK PAIN AND DISABILITY, DIZZINESS AND ANXIETY

Julia Treleaven, Gwendolen Jull and Nancy Low Choy

From the Division of Physiotherapy, School of Health and Rehabilitation Sciences, The University of Queensland, Brisbane, Australia

Smooth Pursuit Neck Torsion Test (SPNTT)

- Treleaven et al (2003) recommended adding SPNTT to the JPET for diagnosing cervical injury.
- Treleaven et al (2005) noted further validity of the SPNTT in identifying eye movement disturbances in patients with whiplash, which correlate with disturbed cervical afferentation.
- Designed to differentiate between smooth pursuit abnormalities from a peripheral vestibular, brainstem, or higher CNS cause versus a cervicogenic etiology or cervicogenic contribution.
- Moderate to Good inter-visit reliability (Rosker et al. 2021).

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Smooth Pursuit Neck Torsion Test (SPNTT)

Neck Problems = Saccades (may also cause HA, dizziness, and increased neck pain).

Test can be performed sitting or standing and eliminates input from vestibular system (head still).

Test is performed by actively rotating the neck 45° to one side and performing smooth pursuit eye tracking.

The muscle spindles are stretched on one side of the neck which results in increased spindle output.

- If position is abnormal there will be increased saccades and decreased smooth pursuits.
- Neck torsion reduced smooth pursuit among patients with vertigo due to whiplash associated disorders but did not reduce it among healthy controls or patients with central or peripheral vertigo (Sensitivity 90% and Specificity 91%)(Tjell & Rosenhall. 1998).

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Near Point Convergence (NPC) with Neck Torsion

- **Notation**: Patients with neck pain experience sensorimotor and oculomotor deficits and dizziness thought to be due to abnormal cervical afferent input.
- In a study with Giffard et al (2017), NPC was assessed in 42 subjects (21 with idiopathic neck pain [INP] and 21 controls with no neck pain). All subjects were tested in neutral, 45° torsion to right, and 45° torsion to left.
- **Results:** The results revealed no significant differences between groups in neutral position (control = 8.4 cm; INP = 8.7 cm). In torsion, INP group had much higher NPC differences. This demonstrates the influence of the neck on visual function.
- **Question:** How many cervicogenic patients are undergoing vision therapy as a stand alone? Need comprehensive approach.

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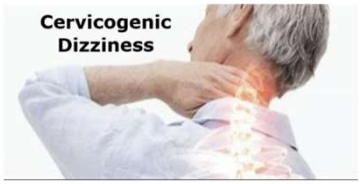
Cervicogenic Dizziness

Head-Neck Differentiation Test AKA Rotatory Chair Test

- Cervicogenic vertigo is generally not true vertigo (the room does not spin and there is no nystagmus).
- These patient's generally "just feel off". They have greater difficulty with extension but generally don't have problems lying supine.
- Cervicogenic vertigo patients were more likely to report that their symptoms increased with looking up and reporting that quick movements of their head increased their symptoms vs. other forms of dizziness (Reid et al. 2017).



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Rotatory Chair Test AKA Head-Neck Differential Test

- Patient sits in a roller chair and looks at a point on the wall.
- Patient's head is held still while they swivel their body back and forth.
- This test isolates the cervical afferents while eliminating vestibular involvement.
- If dizzy symptoms increase the test is positive.

Figure 3.

Head-neck differentiation test. A, The patient sits in a chair and looks at a point on the wall. B, The patient holds the head still as C, the clinician rotates the body from under the seat.

270

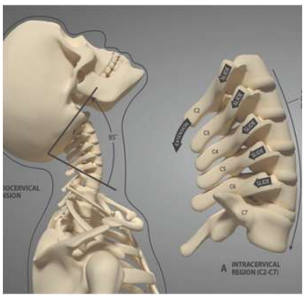
Cervical Flexion Rotation

- **Procedure**: The patient is supine, and the cervical spine is fully flexed and then rotated side to side slowly (to avoid eliciting vestibular stimulation). This test stimulates the ipsilateral SCM (Cheever et al. 2016).
- Test is positive with reproduction or increased symptoms.

271

Cervical Extension

- See DHI.
- Cervical Extension associated with loading of the facet joints (activating mechanoreceptors).
- Greater difficulty with extension but generally don't have problems lying supine.
- Cervicogenic vertigo patients were more likely to report that their symptoms increased with looking up and reporting that quick movements of their head increased their symptoms vs. other forms of dizziness (Reid et al. 2017).



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Postural Stability

Tandem Stand

- In static tandem with eyes closed 74% of patients with cervicogenic dizziness were unable to maintain the stance for 30 seconds (Field et al. 2008).

Gait in Neck Pain / Whiplash

- Decreased step width, length and speed (Uthaikhup et al. 2013).

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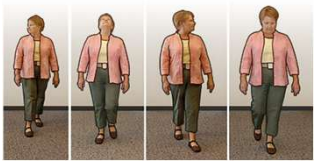
Postural Stability

- **Head Turns**
- Procedure: Patient walks 2-3 steps and then turns head right for 2-3 steps, then back to straight for 2-3 steps, then right again for 2-3 steps.
- Repeat for looking left, looking up and looking down.



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Cervicogenic PCS Exam Form

- **Cervicogenic Dizziness**
- **Sensorimotor Impairment**

Cervicogenic Dizziness

Notation: Cervicogenic dizziness is generally not true vertigo (the room does not spin and there is no nystagmus). These patient's generally "just feel off". They have greater difficulty with extension but generally don't have problems lying supine. Cervicogenic vertigo patients were more likely to report that their symptoms increased with looking up and reporting fast quick movements of their head increased their symptoms vs. other forms of dizziness (Reid et al. 2017).

Cervical Extension: Elicit Dizziness?	No ☐ Yes ☐
Rotatory Chair Test	Negative ☐ Positive ☐
Cervical Flexion - Rotation	Negative ☐ Positive ☐

Sensorimotor Impairment

Notation: There are three pillars of Sensorimotor Impairment:

- Proprioception
- Oculomotor Control
- Postural Stability

There are tremendous neurological connections between cervical muscle spindles and eyes (Cervico-Ocular Reflex = COR) and vestibular apparatus and eyes (Vestibulo-Ocular Reflex = VOR). These are the fastest reflexes in the body telling the eyes to move at exactly the same rate as the neck when turning the head. If one of these mechanisms is off – the patient will "feel off".

Proprioception: Cervical Joint Position Error Test (JPET)

Plane	1st	2nd	3rd
Right Rotation			
Left Rotation			
Flexion			
Extension			

Oculomotor		
Smooth Pursuit Neck Torsion Test (SPNTT)	Neutral: ☐ Normal	☐ Saccades
	Right Rotation: ☐ Normal	☐ Saccades

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Cervicogenic PCS Diagnosis / Treatment Options

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CERVICOGENIC PCS DIAGNOSIS / PLAN

- Pass / Fail
- Prescribe appropriate rehab
- Assess previously prescribed rehab
- Has BCTT been passed?
- Neurologic co-management?

DIAGNOSES (ICD-10)

Concussion W/O LOC (Subsequent Visit)	☐ S06.0X0D
Concussion W/ LOC < 30 Min (Subsequent Visit)	☐ S06.0X1D
Concussion W/ LOC > 30 Min Unspecified Duration (Subsequent Visit)	☐ S06.0X9D
Persistent Concussive Symptoms (PCS)	☐ R41.81
AKA Post Concussion Syndrome	
Convergence Insufficiency	☐ H51.11
Dizziness	☐ R42
BPPV	☐ H81.10

PLAN / RECOMMENDATIONS

Cervicogenic PCS Testing	☐ Failed ☐ Passed
Cervicogenic Rehab Prescribed: When prescribed, each exercise is reviewed with the patient in detail. The patient is also given a detailed instruction handout. It is important the patient performs the exercises 3-4x/day. The patient indicated any understanding	☐ Cervical Proprioception Rehab ☐ Vestibular Ocular Rehab Level 2 with Cervical Proprioception ☐ Vestibular Ocular Rehab Level 3 ☐ Convergence Insufficiency w/ Head Torsion ☐ Brock String Rehab w/ Head Torsion
Physiologic	
Schedule for BCTT / BCBT	☐ ☐
Schedule Cervicogenic PCS Testing	☐ ☐
Neurocognitive Testing	☐ ☐
Neurologic Co-Management	☐ ☐
Psychological	
Complicating Factors Present	No ☐ Yes ☐
Time: Today, I spent ____ minutes reviewing the patient's current status, outcome measures, performing a Cervicogenic PCS evaluation, discussing my recommendations, documenting my findings and completed the chart note. The patient indicated an understanding of our discussion and we will implement the above treatment plan.	☐ 99203 (New Patient, 30-44 Min) ☐ 99204 (New Patient, 45-59 Min) ☐ 99205 (New Patient, 60-74 Min) ☐ 99211 (Est Patient, 20-29 Min) ☐ 99214 (Est Patient, 30-39 Min) ☐ 99215 (Est Patient, 40-54 Min) ☐ 97112 (Neuromuscular Re-education)

Doctor's Notes:

Provider Signature: _____ Date: _____

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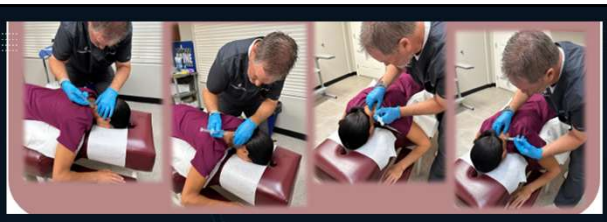

Trigger Point Therapy

- Acupressure
- Trigger Point Massage
- Active Release Technique (ART)
- Dry Needling
- Ozone / Prolozone Injections
- Trigger Point Injections

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Cervicogenic Dizziness

- Manual Therapy
  - Conclusion: Manual therapy is potentially effective for managing cervicogenic dizziness.
    - Yaseen et al. 2017
    - Reid et al. 2015
    - Wrisley et al. 2000
- Dry Needling
  - Escaloni et al. 2018
- Acupuncture
  - Aydin et al. 2018
  - Xie et al. 2018

The Journal of Physical Therapy Science

Review Article

The effectiveness of manual therapy in treating cervicogenic dizziness: a systematic review

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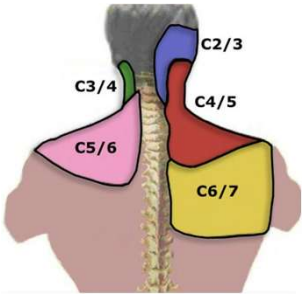
Cervical Facet Joints

- SMT
- Rehabilitation
- Pain Management
  - Facet Injections
  - MBB
  - RFA



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Post-Traumatic Headache

- Post-traumatic headache (PTH) is a frequent sequela of traumatic brain injury (TBI). It may also occur as a feature of the postconcussion syndrome symptom complex.
- After TBI, some patients have short-term acute PTH (<3 months) while PTH is persistent (>3 months duration) in others.

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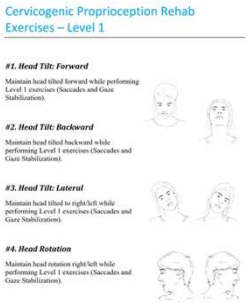
Cervicogenic Proprioception Rehab Level 1


Cervicogenic Proprioception Rehab Exercises – Level 1

#1. Head Tilt: Forward

Maintain head tilted forward while performing Level 1 exercises (Saccades and Gaze Stabilization).

#2. Head Tilt: Backward

Maintain head tilted backward while performing Level 1 exercises (Saccades and Gaze Stabilization).

#3. Head Tilt: Lateral

Maintain head tilted to right/left while performing Level 1 exercises (Saccades and Gaze Stabilization).

#4. Head Rotation

Maintain head rotation right/left while performing Level 1 exercises (Saccades and Gaze Stabilization).

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Cervicogenic Proprioception Rehab Level 2

Cervicogenic Proprioception Rehab Exercises – Level 2

Cervical Proprioception

Evaluation for a cervicogenic component to your mTBI / PCS was provocative. The following are prescribed rehabilitative exercises for cervical proprioception.

#1. Walking with Head Turns

- Walk 2 steps looking forward
- Walk 2 steps with head turned to right
- Walk 2 steps looking forward
- Walk 2 steps with head turned to right
- Turn around and perform the same procedure with left head turn, head looking up and then head looking down.
- Repeat 5-10 times.
- Repeat 2-3x/day until symptoms resolve.

#2. Large BESS-H: Progressive Exercise / Head Movement

- Procedure: Head movements are performed in a large H-pattern:
  - Neutral
  - Tandem Stance
  - Walking Forward
  - Walking Backward
- Head motion can progress: Slow --> Medium --> Fast (only increase speed when comfortable with all stages at slower speeds).

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Summary

- Cervicogenic PCS is the most overlooked sub-system component of mTBI transition to PCS.
- Cannot experience mTBI without cervical injury (Exception: Blast Injury).
- Assessment and treatment of Cervicogenic PCS can be a crucial component to resolution.

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