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Mild TBI - The Not So Mild Effects

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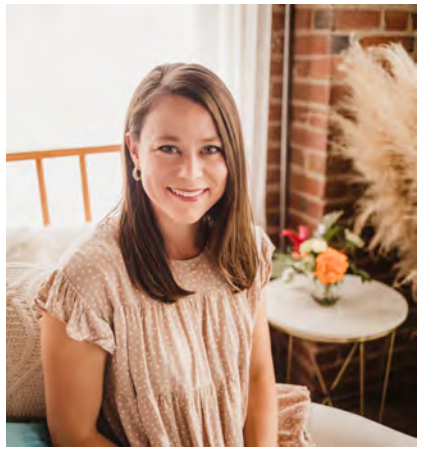

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Disclosures

Presenter Disclosure: No relevant financial relationships to disclose.

Content Disclosures:

Liz Fuemmeler works on product development for Interacoustics, a diagnostic product company for hearing and balance disorders. She also works at a private practice, Professional Hearing Center.

Julie Shoemake works at a private practice, Hearing & Balance Specialists of Kansas City.

This presentation does not focus exclusively on any specific product or service. We are not qualified to give legal advice.

Learning Objectives

After this presentation, participants will be able to:

- Describe a mild traumatic brain injury/concussion and the most common impacts of a concussion on hearing, cognition, vision, and vestibular tests to perform post-concussion.
- Identify appropriate hearing and vestibular tests to perform post-concussion.
- Describe common assessments and treatment methods used to improve cognition, including auditory processing disorders, in patients post-concussion.

Concussion Overview

Traumatic Brain Injury

Concussion

“A **concussion** is a type of traumatic brain injury—or TBI—caused by a bump, blow, or jolt to the head or by a hit to the body that causes the head and brain to move rapidly back and forth” CDC, 2019.

Prevalence of TBIs

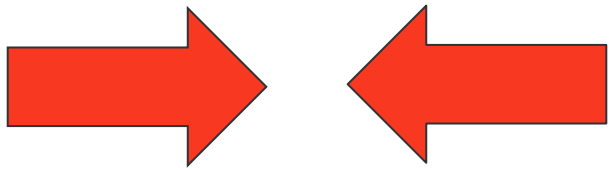
- 42 million people are diagnosed with concussion worldwide every year (NIH, 2020)
- People aged 75 years and older have the highest rates of TBI-related hospitalizations (32%) and deaths (28%)

Common Causes of TBIs

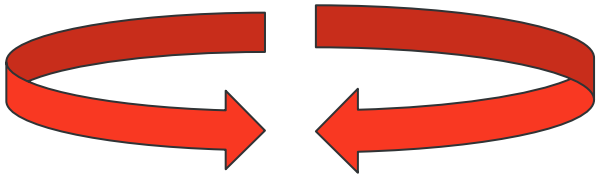
- Motor vehicle accidents
- Sports
- Falls
- Military/combat
- Assault

Types of Injuries

Deceleration Injury



Rotational injury



Pathophysiology of Concussion

- Biomechanically induced brain lesion in the absence of gross anatomic lesions
- Neuronal dysfunction, not structural abnormalities
- Neurometabolic dysfunction: Metabolic chemical changes that take place in the brain

Challenges in Concussion Diagnosis

There is no **one** objective test to determine whether a concussion has occurred.

1. Multi-disciplinary approach
2. Utilizing multiple types of tools and evaluations

No two concussions are the same.

1. Injury mechanism (cause, direct vs. indirect, etc.)
2. Symptom profile / clinical presentation
3. Pre-existing medical conditions
4. Prolonged recovery risk factors (previous concussions, hx of migraines, etc.)

Team-Based Evaluation of Concussion

Neurocognitive Evaluation:

- ImPACT, Sway, King Devick, SCAT

Neurologic Evaluation:

- Symptom pathology, reflexes, balance

Imaging:

- MRI/CT Scan (less common)

Symptom Evaluation:

- Computerized or oral

Diagnosis and Treatment of a Concussion Patient

Audiology

An audiologist's role in vestibular evaluation post-head injury

Where do AuDs fit in?

Common Concussion Symptoms: Audiology

Dizziness

- Spontaneous room-spinning dizziness (objective vertigo)
- Positional vertigo
- Self-spinning dizziness (subjective vertigo)
- Lightheadedness

Oculomotor Dysfunction

- Blurred or double vision
- Difficulty reading
- Sensitivity to light

Balance Issues

- Off-balance
- Tilted
- Pulling/pushing feeling
- More clumsy
- Increased falls

Auditory Complaints

- Difficulty hearing in noise
- Sensitivity to sound
- Tinnitus
- Hearing loss/muffled
- Aural fullness/pressure
- Otalgia

Vestibular Tests

	Test	Purpose	Patient Complaint	Associated with Head Injury
VNG	Oculomotor	Evaluates eye muscle movement and function	Vision complaints	Peripheral or Central disorder/ dysfunction
	Dix-Hallpike/ Lateral head roll	Evaluates for benign paroxysmal positional vertigo	Positional Vertical	BPPV
	Calorics	Evaluates horizontal semicircular canal and superior nerve function	Vertigo, imbalance	Labyrinthine dysfunction, post traumatic hydrops
	Cervical / Ocular VEMP	Evaluates saccular/inferior nerve (cVEMP) and utricle/superior nerve function	Feeling tilted, acceleration / gravity complaints, noise/pressure induced vertigo	Superior canal dehiscence, Labyrinthine dysfunction
	Rotational chair	Evaluates vestibular ocular reflex (low frequencies)	Dizziness with head movements, balance concerns	Central disorder, VOR deficit
	Video head impulse testing	Evaluates vestibular ocular reflex (high frequencies)	Dizziness/blurred vision with head movements	Central VOR deficit

Diagnosis

Audiology Goals

Goals for Audiology Evaluation:

- Assess peripheral auditory system
- Assess peripheral vestibular system
- Evaluate vestibular and ocular reflex pathways for disruption
  - *Identify abnormalities to guide recommendations for therapy/intervention types*
  - *Establish objective baseline to measure and track recovery*

Oculomotor Evaluation

Standardized stimulus, video goggles, compare to age-based norms

- **Convergence**
- Gaze
- Pursuit
  - Horizontal
  - Vertical
  - **Smooth Pursuit Neck Torsion**
- Saccades
- **Saccadometry**
- Optokinetics

Near Point Convergence

Ability of the eyes to focus on an object close to the face without doubling of the target

Can be low tech

~5% of individuals have congenital CI

- (2.25-8.3% - Letourneau et al, 1988; Porcar et al, 1997; Rouse et al, 1999)

Near Point Convergence

Post Head Injury:

- Military: 28-42%
  - Goodrich et al, 2013; Brahm et al, 2009; Stelmack et al, 2009; Capo-Aponte et al, 2012
- Sport: 20-45%
  - Mucha et al, 2014; Pearce et al, 2015; Hutchison et al, 2023
- Adult: 23-42%
  - Suchoff et al, 1999; Ciuffreda et al, 2007; Alvarez et al, 2012
- Children: 49%
  - Master et al, 2016

Smooth Pursuit Neck Torsion Test

- Comparison of smooth pursuit gain in neck neutral versus neck torsion positions
  - Gain
  - $SPNT_{diff}$

$$\text{Gain neutral} - (\text{Gain torsion L} + \text{Gain torsion R})/2$$

- SPNT test has been shown to be reliable tool to evaluate cervical and whiplash disorders

Rosker et al, 2022

Smooth Pursuit Neck Torsion

Post-Head Injury

- Increase in saccadic intrusions
- Reduced gain in neck torsion positions (measured by the $SPNT_{diff}$)
  - Tjell et al, 2002

Clinical Studies using $SPNT_{diff}$

- Whiplash disorder patients - 92% specificity and 72% sensitivity
  - Tjell et al, 2002
- Idiopathic neck pain patients - 70.8% specificity and 50% sensitivity
  - Rosker et al, 2022
- No significant difference between chronic neck patients and healthy controls
  - Janssen et al, 2015

Saccadometry

Saccadometry is an advanced oculomotor test that has more sensitivity to dysfunction post-concussion.

Saccade testing to distinguish between non-organic and organic visual-field restriction
British Journal of Ophthalmology (bmj.com)

Munoz and Everling, 2004

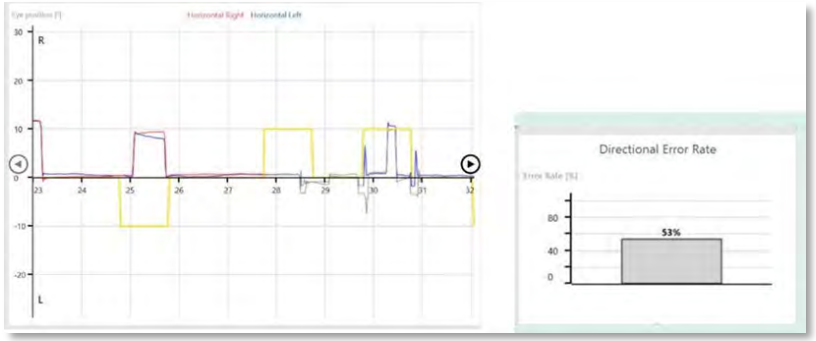
Measurement Parameters

- Eye Position
- Directional Error Rate
- Latency
- Phase
- Velocity

Saccadometry Testing Correlates in Concussion

Post-Head Injury

- Increased directional errors and latency in acute post-head injury
  - Balaban et al 2016; Ting et al, 2016; Ayala and Heath 2020; Johnson et al 2015a and 2015b



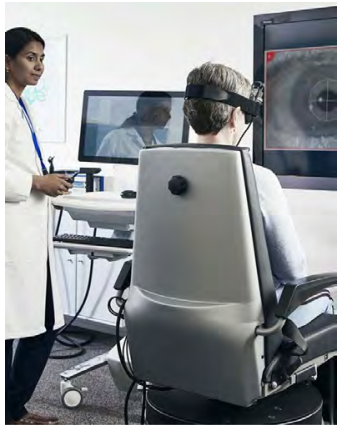
VOR Evaluation

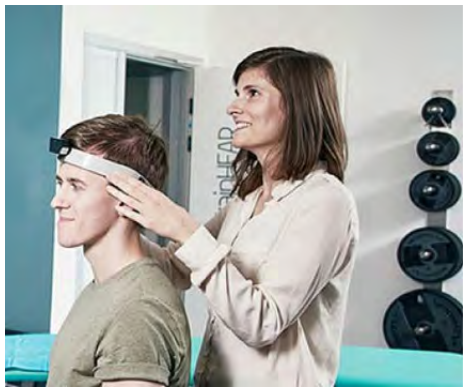
Standardized stimulus, video goggles, compare to age-based norms

low freq

high freq

- Caloric testing
- Rotational testing:
  - SHA
  - VOR Suppression
  - VOR Enhancement
  - Step Testing
- Dynamic Visual Acuity
- Gaze Stabilization
- Video Head Impulse Test

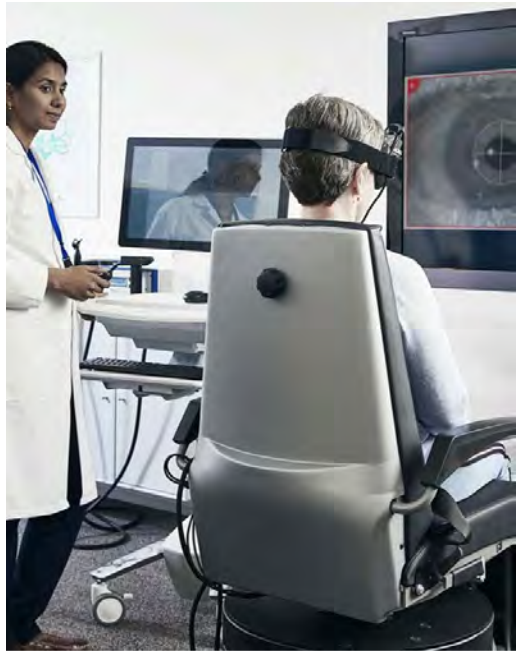




VOR Evaluation – Rotational Studies

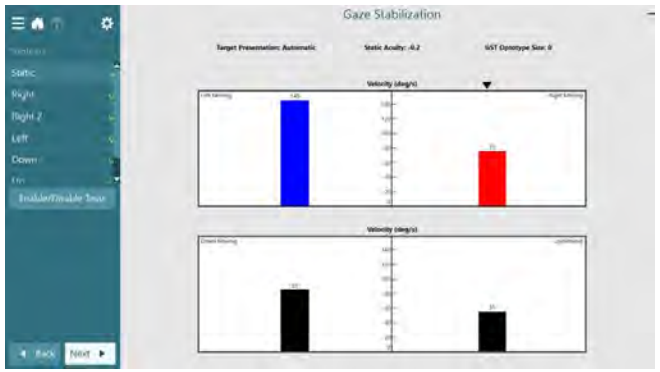
Post-Head Injury

- SHA testing:
  - **Athletes:** no difference (Christy et al, 2019)
  - **Military:**
    - Significant lower gain at .01 Hz in mTBI population (Akin et al 2022)
    - 45.5% abnormality of at least one SHA measure (King et al, 2018)
  - **Pediatrics:**
    - Reduced VOR gain (Zhou and Brodsky, 2015)
    - Normal in 95% of patients (Karl et al, 2021)
- VOR suppression:
  - **Athletes:** significant difference in gain in concussed athletes (Christy et al, 2019)



VOR Evaluation – DVA/GST/vHIT

- vHIT: not sensitive
  - **Sports**: no significant difference (Akathiry et al 2019)
  - **Adults**: no abnormal vHIT in post-concussion adults (Alsheri et al, 2016)
- Dynamic visual acuity testing: sensitive
  - **Children**: 57% abnormal (Zhou and Brodsky, 2015)
  - **Chronic**: significantly worse DVA in concussion patients (D'Silva et al, 2020)
- Gaze stabilization: sensitive
  - **Pediatric/Adult**: abnormal GST in post-concussion (Corwin et al, 2022; Dunlap et al, 2018)
  - **Sports**: asymmetric GST in concussion patients (Honaker et al, 2015)



Diagnosis and Treatment of a Concussion Patient

SLP

A speech language pathologist's role in vestibular evaluation post-head injury

Where do SLPs fit in?

Common Concussion Symptoms: SLP

Attention

- Multitasking
- Alternating and divided attention
- Sustained attention / “concentration”
- Highly distractible

Executive Dysfunction

- Thought organization
- Planning
- Problem solving
- Reasoning and judgment

Memory

- Auditory memory
- Reading recall
- Short-term and delayed recall

Language

- Word finding
- Similarities
- Analogies

Cognitive-Communication Referral Guidelines for Adults

Cognitive Communication Evaluation

Test area	Examples
Immediate Memory	List learning, story memory
Delayed Memory	List recall and recognition, story recall and recognition, figure recall
Expressive language - spoken	Divergent naming, confrontation naming, convergent naming
Attention	Digit span, coding
Visuospatial/constructional	Clock drawing, line orientation
Processing speed	Stroop task, trail making

Cognitive Communication Assessments

- Repeatable Battery for the Assessment of Neuropsychological Status Update (RBANS)
- Cognitive Linguistic Quick Test (CLQT)
- Scales of Cognitive and Communication Ability for Neurorehabilitation (SCCAN)
- Scales of Cognitive Ability for Traumatic Brain Injury (SCATBI)

Informal/Qualitative Measures

- Patient Reported Outcome Measures (PROM)
- Metacognition and self-awareness
- Independent strategy use
  - Counting on fingers
  - Closing eyes
  - Quiet/silent rehearsal

Treatment Tools

- WALC books
- Constant Therapy app
- Tactus apps
- Smartphone apps for external memory tools (timers, alarms, calendar, etc.)
- Honeycomb speech
- MedBridge HEP
- Brain training apps (Lumosity)
  - Check the research
- Ask each patient what they want to achieve

Strategy Training

- Rehearsal
  - Out loud or whispered
  - Silent
- Chunking/grouping
- Visualization
- Mnemonics or sentences

Ask your patient! Make sure to offer a variety of strategies and recommend ones that work best for various tasks. Let them choose their favorites and what they find most effective.

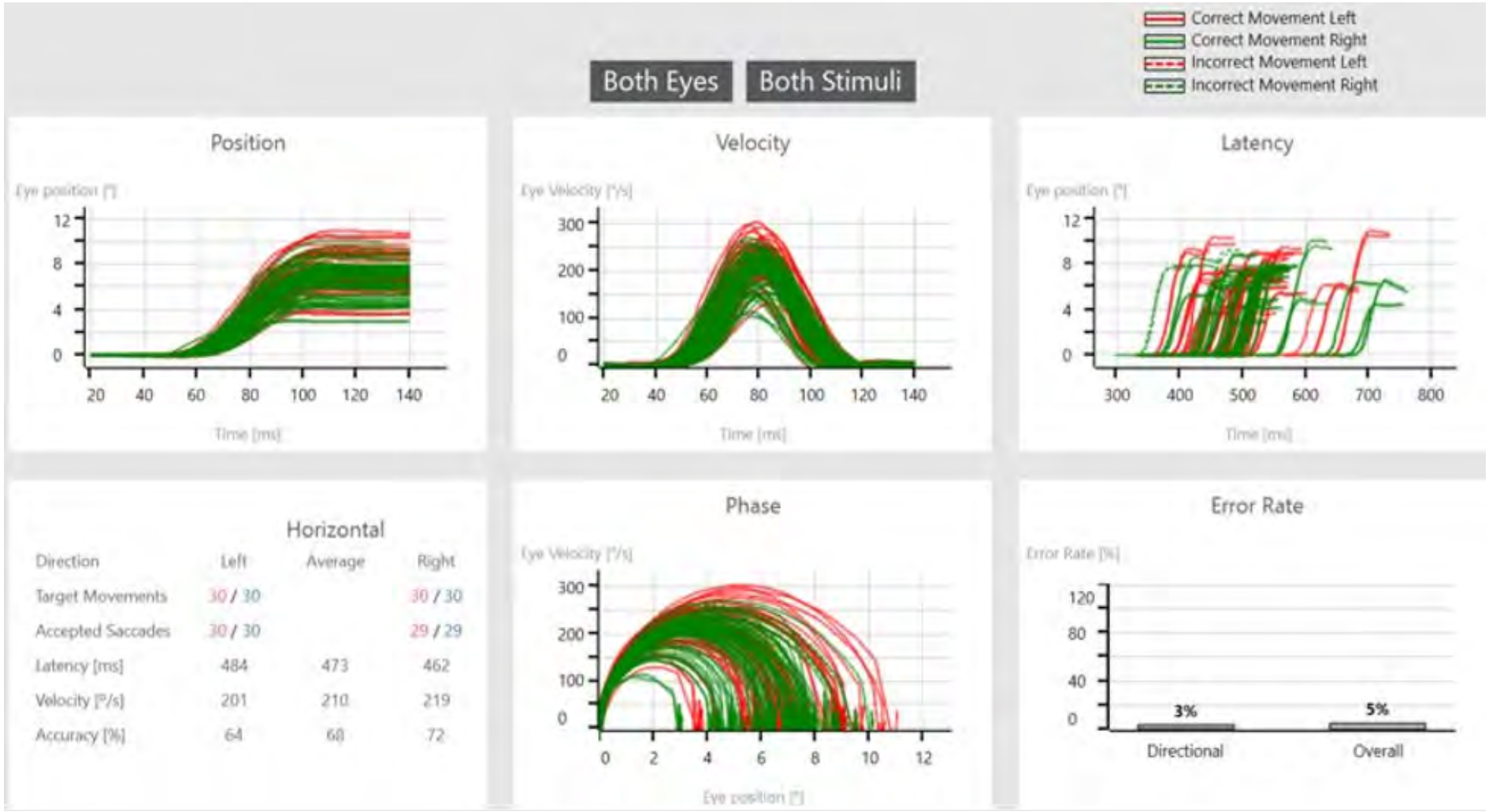
Treatment Sample #1: Stroop task

RED	BLUE	GREEN	BLUE	BLACK
YELLOW	GREEN	ORANGE	GREEN	RED
PINK	BLACK	BROWN	YELLOW	GRAY
BLUE	RED	GREEN	PINK	BROWN
ORANGE	BLACK	BLUE	GREEN	RED

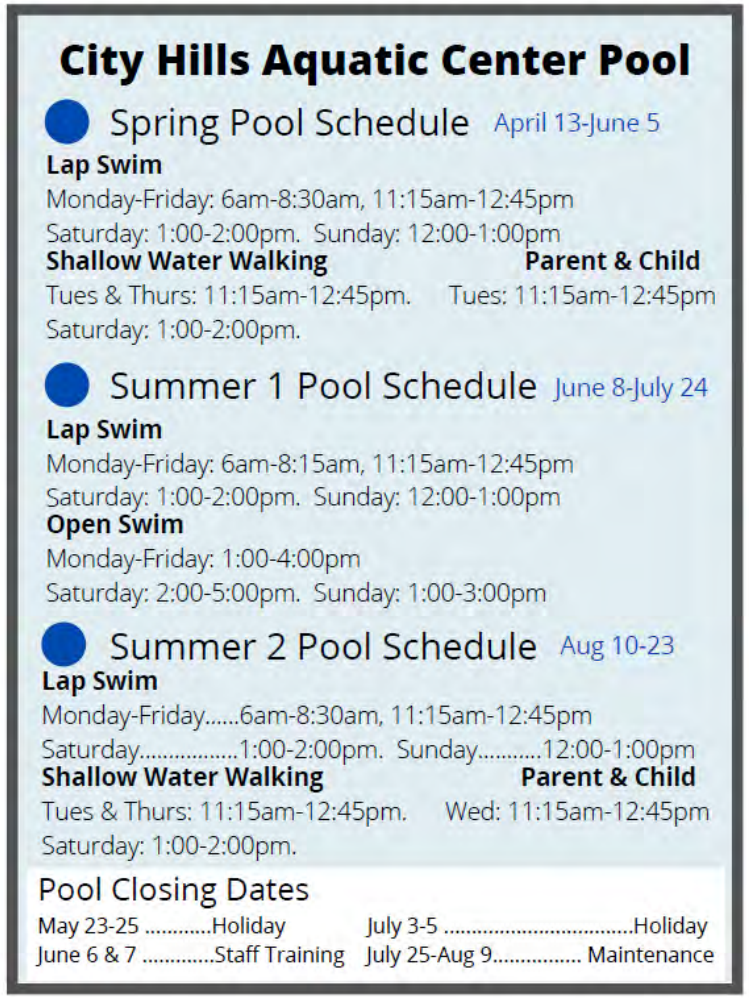
Treatment Sample #1: Stroop task

RED	BLUE	GREEN	BLUE	BLACK
YELLOW	GREEN	ORANGE	GREEN	RED
PINK	BLACK	BROWN	YELLOW	GRAY
BLUE	RED	GREEN	PINK	BROWN
ORANGE	BLACK	BLUE	GREEN	RED

Stroop and Saccadometry



Treatment Sample #2: Reading Comprehension



City Hills Aquatic Center Pool

Spring Pool Schedule April 13-June 5

Lap Swim
Monday-Friday: 6am-8:30am, 11:15am-12:45pm
Saturday: 1:00-2:00pm. Sunday: 12:00-1:00pm

Shallow Water Walking
Tues & Thurs: 11:15am-12:45pm.
Saturday: 1:00-2:00pm.

Parent & Child
Tues: 11:15am-12:45pm

Summer 1 Pool Schedule June 8-July 24

Lap Swim
Monday-Friday: 6am-8:15am, 11:15am-12:45pm
Saturday: 1:00-2:00pm. Sunday: 12:00-1:00pm

Open Swim
Monday-Friday: 1:00-4:00pm
Saturday: 2:00-5:00pm. Sunday: 1:00-3:00pm

Summer 2 Pool Schedule Aug 10-23

Lap Swim
Monday-Friday.....6am-8:30am, 11:15am-12:45pm
Saturday.....1:00-2:00pm. Sunday.....12:00-1:00pm

Shallow Water Walking
Tues & Thurs: 11:15am-12:45pm.
Saturday: 1:00-2:00pm.

Parent & Child
Wed: 11:15am-12:45pm

Pool Closing Dates

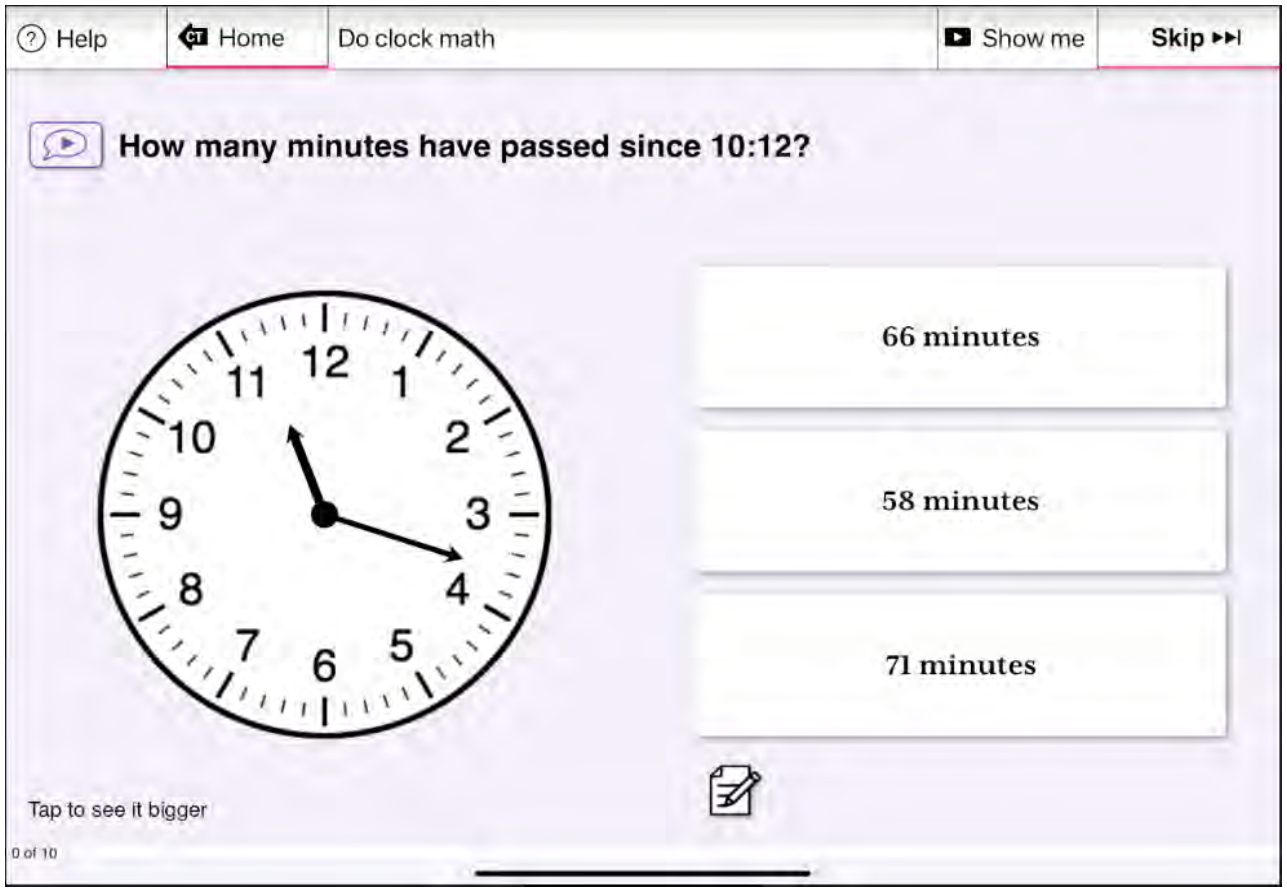
May 23-25 .....Holiday
June 6 & 7 .....Staff Training
July 3-5 .....Holiday
July 25-Aug 9..... Maintenance

Schedule Management: Reading Comprehension
Honeycomb Speech Therapy: Activity Studio

- How many different calendar sessions does this include?
- How many different swim types are offered in each session?
- How did the Lap Swim schedule change from spring to summer?
- What can you do in the pool on Aug 1?
- You have a free Sunday in July - what options do you have to use the pool?
- Your friend is looking for Parent & Child swim, ideally 6-8 weeks. The child is in school full-time until June 10. Is there a good option?

Source: Honeycomb Speech

Treatment Sample #3: Processing speed, mental math/working memory



Source: Constant Therapy clinician app

Auditory Processing Disorder (APD)

"The efficiency and effectiveness by which the central nervous system utilizes auditory information. It encompasses the perceptible processing of auditory information in the central nervous system and the neurobiological activity that underlies that processing and gives rise to electrophysiological auditory potentials"
(ASHA, 2005)

What is it?

- Central auditory system has trouble processing what's heard
- Social communication disability, not a hearing problem

Common Deficits/Complaints

- Difficulty understanding speech in background noise
- Need to use captions/subtitles
- Misunderstanding messages
- Tinnitus
- Sound sensitivity
- Responding inconsistently or inappropriately
- Frequently asking for repetition, saying “huh” or “what”
- Taking longer to respond
- Difficulty following instructions, especially multistep and/or oral
- Difficulty localizing sound

Geffner, D., & Swain, D. R. (2022)

Evaluation of Auditory Processing Disorder, by AuD

- Staggered Spondaic Word (SSW)
- Phonemic Synthesis (PS)
- SCAN-3
  - Auditory Figure Ground (background noise)
  - Filtered Words
  - Competing Sentences
  - Time Compressed Sentences
- Auditory Skills Assessment (ASA)
- Ear advantage

Test Results

- **Decoding**
  - Quickly and accurately process speech
  - Deficit: communication or school problems like reading accuracy, phonics, articulation, receptive language
- **Organization**
  - Inability to sequence and organize auditory information, difficulty following oral and multistep directions
- **Integration**
  - Inability to combine auditory and visual information together, difficulty reading
- **Tolerance Fading Memory**
  - Difficulties with reading comprehension, short term memory, and processing out background noise
- **Ear advantage**
  - Mathematical difference between the right ear raw score and left ear raw score
  - Indicates hemispheric dominance for language and neurologically-based language/learning disorders

Treatment Targets

- Listening in background noise
- Dichotic listening
- Short-term recall/working memory
- Strategy learning/reinforcement
- Phoneme instruction and discrimination
- Phonological and phonemic awareness (especially blending and segmenting)

Treatment Targets: Older children through adult age

- **Listening in background noise**
- **Dichotic listening**
- **Short-term recall/working memory**
- Strategy learning/**reinforcement**
- Phoneme instruction and discrimination
- **Phonological and phonemic awareness (especially blending and segmenting)**

Common Treatment Programs

- Buffalo Model
- Listening and Communication Enhancement (LACE)
- CAPDOTS
- FastForWord
- Interactive Metronome
- AngelSound
- ARIA
- Acoustic Pioneer apps: Insane Earplane, Zoo Caper Skyscraper

Treatment Sample #1: Background Noise
(WINT, Buffalo Model)

Treatment Sample #2: Dichotic Listening
(DOT, Buffalo Model)

Treatment Sample #3: Sound Blending (Phonemic Synthesis, Buffalo Model)

Treatment Options Post-Concussion from Audiology Clinic

- Cognition
  - Audiologist
    - Hearing Aid Evaluation
    - Tinnitus/SS Counseling
    - Auditory Processing Disorder Evaluation
    - F/u vestibular testing
  - SLP
- Hearing Issues
  - Physical Therapy
    - Vestibular/Balance rehabilitation
- Dizziness/Balance Issues
  - Neurology
    - Imaging
    - Migraine management
    - Medical evaluation
  - Ear, Nose, Throat
  - Cardiology
    - Tilt table test
    - Cardiovascular Recovery
- Oculomotor Issues
  - Neuro-optometry
    - Vision Therapy
    - Prism Lenses

Case Studies

Case Study 1: History and Complaints

- Sound sensitivity, difficulty with background noise, reduced ability to multitask, easily distracted/irritated by noise
- Daily headaches
- Disrupted sleep
- History of dyslexia and vision issues (completed vision therapy)
- Weekly episodes of vertigo/imbalance (30-60 sec each)
- Worsened balance (currently in balance therapy for 3 weeks)
- Quick head and eye movements provoke dizziness

14 y/o female

3 concussions reported 2-3 years prior to visit: MVA, fall, soccer

Injury Characteristics

She reported two concussions in 2020. The first was in October 2020 where she had a head injury secondary to soccer. The second occurred in November 2020 due to a fall. She noted one head injury in September 2021, secondary to a motor vehicle accident where she hit the front of her forehead.

Otologic Symptoms

She reported vertigo and imbalance (1-2 times a week) lasting 30-60 seconds. Focusing on one thing can resolve her dizziness. Looking up from reading, quick head movements, and standing up quickly can provoke her dizziness. She trips often; and her mother noted she has always been clumsy. She reported longstanding motion sickness. She is currently in vestibular therapy and has been in therapy for approximately 2-3 weeks. She reported neck issues.

She reported everyday sounds are painful and annoying. She reported difficulty listening in loud environments. Her mother reported reduced ability to multi-task. She is easily distracted by noise. She denied hearing changes, tinnitus, and other otologic symptoms.

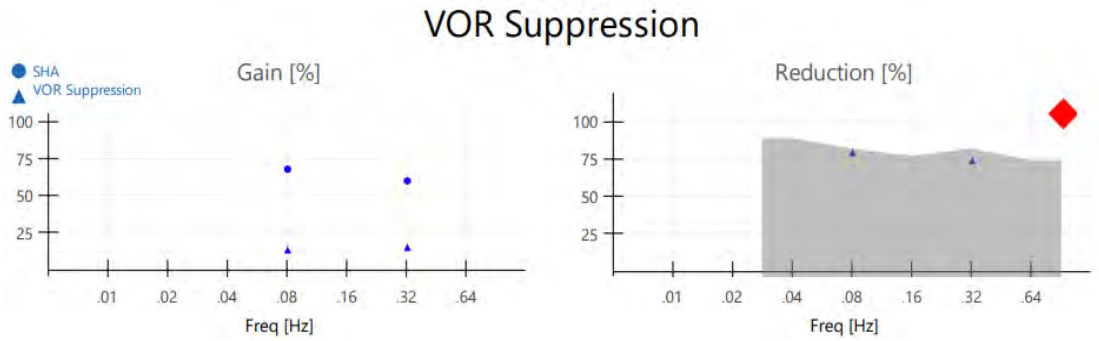
Other Post-Concussive Symptoms

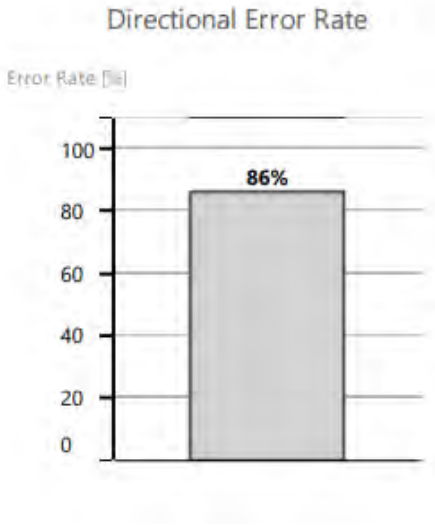
She feels her depth perception. She denied oscillopsia in noise. She has a history of dyslexia. She has a significant history of vision issues and has completed a lot of vision therapy. She has a headache daily, which is worsened by cognitive activity, light, sound, and screen time. Sleep has been disruptive throughout the night. She has increased irritability to noise and sound.

Case Study 1: Vestibular

Abnormal findings - Eval 1:

- **Balance**
  - Sway on eyes closed, dynamic surface
  - Fail headshake
- **VOR**
  - Reduced dynamic visual acuity
  - Abnormal VOR suppression in rotational chair testing at .08 and .32 Hz
- **Oculomotor**
  - Saccadic pursuit
  - Increased directional error rate (86%) in anti-saccade testing
- **Questionnaires**
  - Post-Concussion Symptom Scale (65)
  - GAD-7: 8 (mild self reported anxiety)
  - PHQ-9: 11 (moderate self-reported depression)





Vestib Recommendations

Continue vestibular therapy

APD testing

Follow up for re-test

Abnormal findings:

1. **Abnormal balance performance** – inability to stand on foam with eyes closed.
2. **Reduced dynamic visual acuity** – (reading numbers while turning head) blurred vision while the head is in movement. This is a functional assessment of the vestibulo-ocular reflex, which is critical for preventing dizziness while head is in motion. Abnormal for horizontal and vertical head movements.
3. **Anti-saccades** (going opposite direction of the dot)– high level test of the frontal cortex – disrupted following head injury. Normal error rate in teens is below 20%. You had an 86% error rate today.
4. **Abnormal reduction of VOR gain in rotational testing** – indicative of "central" origin of dizziness; may be consistent with history of headache.

Considerations in recovery:

- History of previous head injury and anxiety are known to prolong recovery from head injury
- Uncontrolled headaches can also slow recovery

Recommendations:

- Continue vestibular therapy
- Consider auditory processing disorder testing
- Follow up in our office in 3-4 weeks to re-assess findings

Case Study 1: Vestibular Follow Up (After APD Test)

Abnormal findings - Eval 2:

- **Balance / VOR**
  - Deferred due to patient's symptoms…. follow up was after APD testing and she was drained!
- **Oculomotor**
  - Pursuit within normal limits
  - Increased directional error rate (92%) in anti-saccade testing - increased from 86%
- **Questionnaires**
  - Post-Concussion Symptom Scale (82) - increased from 65

Case Study 1: APD

- Deficit areas: decoding, integration, organization, and tolerance fading memory
- No ear advantages found

	Score	Age Norm	%ile rank
SSW	76	<6 allowed	
PS	17	>23 norm	
Auditory Figure Ground +0	5		0.1

- Therapy: completed 13 sessions catered to her deficit areas
  - Did not attend retest
  - Subjective report of improved background noise processing: now able to go into crowds, where before she and her family had to avoid large gatherings
  - Affect: beginning of therapy, easily frustrated and irritated by sound work. End of therapy, much higher tolerance and calmer affect
  - Fewer migraines

Case Study 2: History and Complaints

- Previous history: migraines, anxiety, depression
- Negative CT and MRI
- Constant headaches, light and sound sensitivity, difficulty concentrating in noise
- Dizziness and nausea helped via weekly physical therapy
- Increased neck pain
- Currently on light duty at work (4 hours a day)

27 y/o female

Head injury at work when punched by patient between the eyes

No LOC

Case Study 2: Vestibular

Abnormal findings - Eval 1:

- **Balance**
  - Normal
- **VOR**
  - Reduced dynamic visual acuity (horizontal head movements)
  - Normal SHA, VOR Suppression, Step testing
- **Oculomotor**
  - Saccadic pursuit (vertical)
  - Spontaneous right-beating nystagmus, increased in gaze right
  - Upbeating nystagmus post-headshake, supine, head right and head left
- **Questionnaires**
  - Post-Concussion Symptom Scale (89)
  - Dizziness Handicap Inventory (68 - severe impact on daily living)
  - GAD-7: 19 (severe self reported anxiety)
  - PHQ-9: 23 (severe self-reported depression)

Vestib Recommendations

- APD evaluation
- Misophonia/SS consultation
- Neurology for upbeating nystagmus - clinical correlation
- Follow up for re-test

4. **Sound Sensitivity Complaints:**
    - Superior canal semicircular dehiscence was ruled out, as indicated by normal audiometric findings and present VEMP studies.
    - As ---------- indicated difficulty hearing and concentrating in noise, I recommended that she complete an Auditory Processing Disorder Evaluation with my colleague, [redacted]. As she works in a noisy and active environment, APD needs to be ruled out so she can be exposed to auditory stimuli longer at work. This appointment was scheduled for ----------.
    - Due to her emotional response (anger, irritation, frustration) to every day sound, I recommended a consultation with our misophonia and sound sensitivity expert, [redacted]. She will see her on ----------.
5. I will follow up with -------- on---------- to retest abnormal findings and assess subjective symptoms.

Case Study 2: Vestibular Follow Up

Abnormal findings - Eval 2:

- **Oculomotor**
  - Vertical pursuit saccadic at high frequencies
  - Upbeating nystagmus still present
- **Questionnaires**
  - Post-Concussion Symptom Scale (88)
    - previously 89

SUMMARY AND RECOMMENDATIONS:

1. Previously abnormal results (spontaneous nystagmus, dynamic visual acuity) were within normal limits.
2. *Post-Head Injury Objective Evidence*:
   - The patient demonstrated an up-beating nystagmus in multiple positions (post-headshake; supine). **I will defer to you for evaluation and any medical recommendations.**
   - Vertical pursuit was saccadic at high frequencies.
3. *Post-Head Injury Subjective Evidence*:
   - Post-Concussion Symptom Scale Score: 88/168
     - This is considered a moderate rating of symptoms.
     - Previously, she was an 89/168.
   - The patient reported dizziness and blurred vision with headshaking activities.
4. At this time, I do not need to see ---------- for follow-up unless she has a change in her symptoms of dizziness or balance.
5. **Physical therapy** could be beneficial to help desensitize the patient to everyday head movements and return her to normal work status with minimal symptoms.
   - Physical therapy would be most beneficial following stabilization of her headaches/migraines.
   - Anxiety and depression may also limit progress in therapy, if not managed appropriately.
6. I recommended continuation of treatment with my colleague, [redacted] for sound sensitivity complaints, as well as therapy for her auditory processing disorder.

Recommended:

- Neurology for migraine management, clinical correlation of UB nystagmus
- Management for anxiety/depression
- Physical therapy for desensitization after migraine managed
- Sound sensitivity consultation
- APD therapy due to qualified test results

Case Study 2: Cognition and APD

- APD test: deficits in decoding, organization, integration, tolerance fading memory, R ear advantage on competing sentences
- Cognitive evaluation: deficits in short and long-term auditory memory, alternating attention, reading recall

- Completed 11 sessions of APD therapy and 10 sessions of cognitive therapy
- PASS APD retest and met all of her cognitive goals

PRE	Score	Age Norm	%ile rank
SSW	22	<6 allowed	
PS	22	>23 norm	
Auditory Figure Ground +0	26		16

POST	Score	Age Norm	%ile rank
SSW	3	<6 allowed	
PS	25	>23 norm	
Auditory Figure Ground +0	26		16

Case Study 3: History and Complaints

- History of anxiety and 6 previous concussions
- Noise causes nausea, lightheadedness, sound sensitivity, difficulty concentrating
- Short-duration headaches
- Slowed processing, poor sleep
- Imbalance with eyes closed in the shower
- Increased anxiety
- Completing vestibular therapy exercises with her athletic trainer

22 y/o female

Head injury when she was hit in the head (with a ball) at soccer practice

No LOC

Injury Characteristics

She reported a direct head injury on 9/13/21 during practice when she was hit on the head. She reported a ball was hit on the front of her face. She reported she is a goalie on the soccer team. She reported immediate dizziness and nausea. She denied loss of consciousness and seizures following this head injury. The following risk factors for prolonged recovery were identified in her case history: 6 previous concussions (with previously headaches and sleep disruptions) and anxiety.

Otologic Symptoms

She reported episodes of lightheadedness and imbalance, which occur in response to increased stimulation and with significant visual stimulation. She also has noticed imbalance in the shower with her eyes closed, which she feels is progressively getting better. She endorsed noisy situations can increase nausea, lightheadedness and annoyance. This has been true in the classroom environment (loud professors) and in social situations (music). She also noted increased difficulty concentrating in background noise. She denied hearing changes, otalgia, otorrhea, tinnitus and other otologic symptoms. She endorsed aural fullness following cognitive stimulation. She denied numbness and tingling in her legs and feet, as well as neck and back issues. She is currently not doing physical activity/exercise/practicing besides walking her dog.

Other Post-Concussive Symptoms

She reported short-duration headaches, which are provoked with significant cognitive activities/homework. She has noticed her auditory processing time is delayed, as it has been taking her longer to understand and process what someone has said to her. She noted irregular sleep patterns and has been utilizing Tylenol PM to help her sleep. She still notes disruption to her sleep. She also has noticed that her anxiety has increased following this head injury.

Case Study 3: Vestibular

Abnormal findings - Eval 1:

- **Balance**
  - Abnormal on dynamic surface, eyes closed + headshake
- **VOR**
  - Dizziness in DVA testing
  - Normal RC, vHIT, normal DVA
- **Oculomotor**
  - Abnormal convergence
  - Anti-saccade directional error rate (26%)
- **Questionnaires**
  - Post-Concussion Symptom Scale (27)
  - GAD-7: 7 (mild self reported anxiety)
  - PHQ-9: 10 (moderate self-reported depression)

1. There was no significant evidence of peripheral vestibular damage or involvement, as indicated by present and symmetric VEMPs (cervical and ocular), vHIT, normal rotational studies, and lack of any spontaneous or provokable nystagmus in VNG testing.
2. *Post-Head Injury Objective Evidence:*
   - Convergence insufficiency was observed. This is the ability of the eyes to focus on an object close to the face (within 5-7 cm). It is recommended that ------- complete exercises for near point convergence.
   - Balance performance was abnormal with eyes closed on a foam surface. This is a high-level balance task for athletes.
   - **Exercises through her athletic trainer focused on convergence, balance, and VOR exercises could be beneficial to help alleviate her symptoms of dizziness/balance issues.**
3. *Post-Head Injury Subjective Evidence:*
   - Post-Concussion Symptom Scale Score: 27/168
     - This is considered a mild rating of subjective symptoms.
   - Horizontal dynamic visual acuity testing was within normal limits, however, provoked symptoms of lightheadedness and dizziness.
4. **Sound Sensitivity Complaints:**
   - Cervical and ocular VEMP testing, along with audiometric findings were not indicative of semicircular canal dehiscence, a common post-head injury cause for sound sensitivity.
   - Due to her complaints of difficulty processing speech in the presence of background noise, I recommended that she complete an evaluation for Auditory Processing Disorder. This is a very common issue post-head injury (approximately 70% of my head injury patients are diagnosed with APD) and can be easily intervened to improve symptoms.
     - She was scheduled for an evaluation on ----------.
5. **Risk Factors for Prolonged Recovery:**
   - We discussed how she has the following risk factors for prolonged recovery: previous history of concussions (6) and anxiety.
6. I will see ------ on ---------- to check in on her abnormal findings (Step testing, convergence, CD-VAT, balance).

Vestib Recommendations

- APD evaluation
- Directed exercises for her athletic trainer
- Consider management of anxiety/depression
- Follow up for re-test

Case Study 3: Vestibular Follow Up

Abnormal findings - Eval 2:

- **Balance**
  - Normal balance performance
- **VOR**
  - No dizziness in DVA
- **Oculomotor**
  - Convergence WNL
- **Questionnaires**
  - Post-Concussion Symptom Scale (13)- Previously 27

Recommendations:

- Continue exercises, as needed for symptoms. Stay active with cardiovascular and weight-lifting exercises.
- She is still struggling with adequate sleep and fatigue issues. I recommended a sleep specialist at the University of Kansas Medical Center.
- If continued eye issues, consider consultation with optometry. She will call if she experiences eye fatigue or pain.

No need for follow up unless changes in dizziness or new head injury.

Case Study 3: APD

- APD test: deficits in decoding, organization, integration, tolerance fading memory, R advantage for competing sentences

- Completed 9 sessions of APD therapy
- PASS on APD retest
- Pt reported she wanted to continue practicing, so audiologist recommended some resources for home practice (LACE)

PRE	Score	Age Norm	%ile rank
SSW	9	<6 allowed	
PS	24	>23 norm	
Auditory Figure Ground +0	30		50

POST	Score	Age Norm	%ile rank
SSW	2	<6 allowed	
PS	24	>23 norm	
Auditory Figure Ground +0	34		75

Questions on Case Studies?

Conclusions

- Concussion patients present with a number of symptoms post-concussion, which necessitate interdisciplinary professionals working together to provide best care for the patient.
- Audiologists and speech-language pathologists play a large role in post-concussion diagnosis and rehabilitation. There are a number of well-documented post-concussion abnormalities within our scopes.
- Auditory Processing Disorder is a common post-concussion abnormality that can manifest as a variety of symptoms (sound sensitivity, disruption to background noise filter, inability to concentrate with multiple sources of noise, etc.).

QUESTIONS

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References

- American Speech-Language-Hearing Association. (n.d.). Central Auditory Processing Disorder. https://www.asha.org/practice-portal/clinical-topics/central-auditory-processing-disorder/
- Cochrane, G. D., Christy, J. B., Almutairi, A., Busettini, C., Swanson, M. W., & Weise, K. K. (2019). Visuo-oculomotor Function and Reaction Times in Athletes with and without Concussion. *Optom Vis Sci*, 96(4), 256-265. https://doi.org/10.1097/OPX.0000000000001364
- Geffner, D., & Swain, D. R. (2022). 20Q: Auditory Processing: What You Always Wanted to Know. *SpeechPathology.com*, Article 20535. Available at www.speechpathology.com
- Kolakowsky-Hayner, S. A., & Reyst, H. (2019). *The Essential Brain Injury Guide*. Brain Injury Association of America.
- American Speech-Language-Hearing Association. (n.d.). Cognitive-Communication Referral Guidelines for Adults. https://www.asha.org/slp/cognitive-referral/
- Munoz, D. P., & Everling, S. (2004). Look away: the anti-saccade task and the voluntary control of eye movement. *Nature Reviews Neuroscience, 5*(3), 218-28. https://doi.org/10.1038/nrn1345
- Patricios, J. S., Schneider, K. J., Dvorak, J., et al. (2023). Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport–Amsterdam, October 2022. *British Journal of Sports Medicine, 57*, 695-711.
- Rosker, Vodicar, Kristjansson. (2022). Oculomotor performance in patients with neck pain: Does it matter which angle of neck torsion is used in smooth pursuit eye movement test and is the agreement between angles dependent on target movement amplitude and velocity? *Musculoskeletal Science and Practice, 59*, 102535. https://doi.org/10.1016/j.msksp.2022.102535
- Zhou, G., & Brodsky, J. R. (2015). Objective vestibular testing of children with dizziness and balance complaints following sports-related concussions. *Otolaryngology-Head and Neck Surgery, 152*(6), 1133-1139. https://doi.org/10.1177/0194599815576720