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Allied Health Media AudiologyOnline

Overcoming Barriers to Video Head Impulse Testing in the Pediatric Population, presented in partnership with Cincinnati Children's

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Overcoming Barriers to Video Head Impulse Testing (vHIT) in the Pediatric Population

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AudiologyOnline

Cincinnati Children's

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Objectives

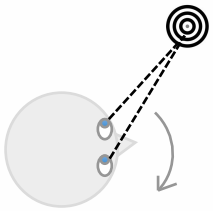
- The learner will be able to describe 3 modifications for ensuring good goggle fit and seat positioning of the child during vHIT testing.
- The learner will be able to identify 2 pediatric focused visual targets for vHIT testing.
- The learner will be able to identify at least two possible abnormal outcomes from vHIT testing and what they might imply clinically.

What is vHIT

- Developed by Halmagyi and Curthoys in 1988
- Looks at the ability of the eye to maintain focus on a target during head movement
- Simulates head movements required for ADLs

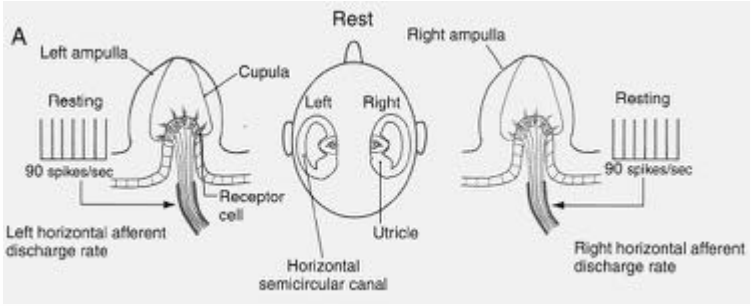
Vestibulo-Ocular Reflex (VOR)

- The VOR allows for *stable gaze* (focused clear vision) while the head is moving by generating *eye movements that are equal and opposite to head movement*



HIT Physiology

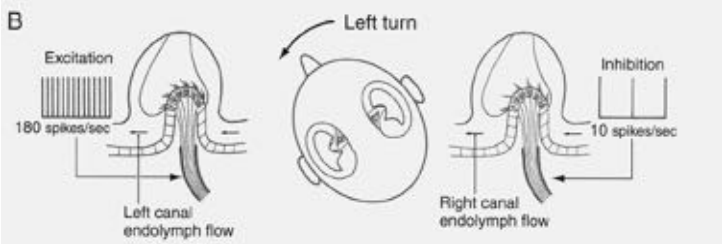
- When the head is at rest
  - Both labyrinths are constantly discharging signals to the brain



HIT Physiology

When the head is turned

- The SCC the head is turned toward ↑ its discharge rate
- The SCC away from the head turn ↓ its discharge rate



Head Impulse Testing

- With unilateral and bilateral vestibular system impairments
  - abnormal "catch-up" (refixation) saccade when the head is thrust in the direction of the impaired SCC
- Studies have shown that catch up saccades can be seen best by the human eye if the caloric weakness is 42.5% or greater.

Perez and Rama-Lopez 2003

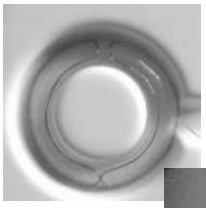
Overt/Covert Saccades

- Overt Saccade: Rapid eye movement made to bring the eye back to the focal point *after* the head movement has stopped (~100 msec after)
- Covert Saccade: Rapid eye movements occurring *during* the head movement in order to keep the eye on the focal point (cannot be seen with the naked eye)

What does vHIT test

- Measures the VOR gain of all 6 semicircular canals
- Determine the presence of overt and/or covert saccades

HIT with the Scleral Search Coil



(Robinson, 1963)

But Yikes!

- Coil adhered to eye with contact-like ring
- Coil created magnetic field
- Magnets placed around eye
- Could detect very small eye movements (< 1 deg)
- Great temporal resolution (< 1msec)
- Sensitivity and Specificity of 1.0

vHIT vs. Search Coil

Findings:

1. Gain of the vHIT and search coils was not significantly different.
2. With a sensitivity and specificity of 1.0!
3. Validated for clinical use

H.G. MacDougall, K.P. Weber, L.A., McGarvie, G.M. Halmagyi, and L.S.Curthoys , *Neurology*, 2009 Oct 6;73(14):1134-41.

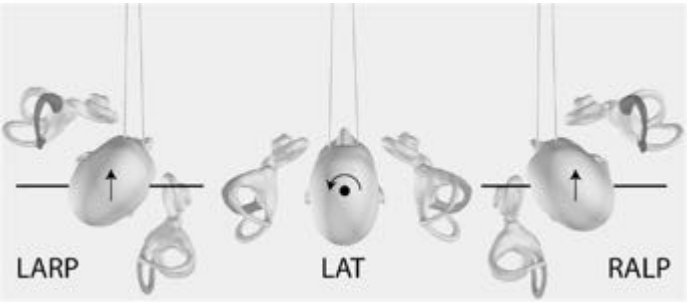
vHIT

- High speed video (frame rate > 200Hz)
- Light weight goggles (minimize slippage)
- Maintain the sensitivity of the scleral search coil

vHIT: How to….

- **Subject Position** – seated at least 1 meter from a 1”x 1” focal sticker on a wall
- **Calibration (in vivo)-** to measure pupil displacement
  - 2 laser dots 15 deg apart on either side of the focal sticker
- **Instructions to patient -** “I am going to be turning your head in different directions. I need you to relax your neck and just keep staring at the sticker on the wall”.

vHIT: How to….



vHIT: How to…. Lateral

- Video 1 Lateral

vHIT: How to…. RALP

- Video 2 RALP

vHIT How to…. LARP

- Add Video 3 LARP

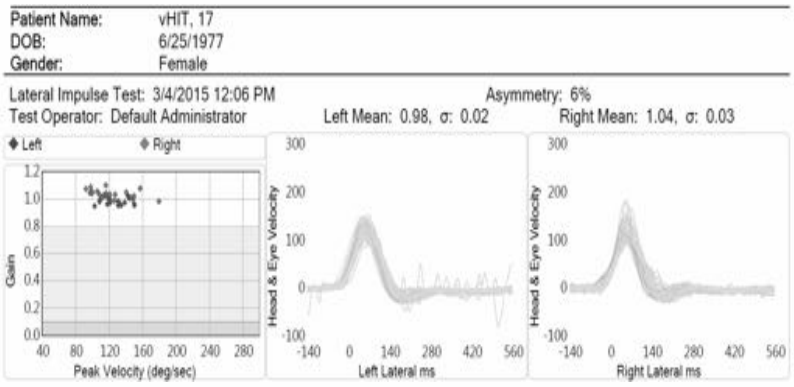
vHIT: Response Parameters

1) Gain: The relation between head movements and eye movements during a head thrust - characterized in velocity. E/H = GAIN

2) Overt Saccade: Rapid eye movement made to bring the eye back to the focal point *after* the head movement has stopped (~100 msec after)

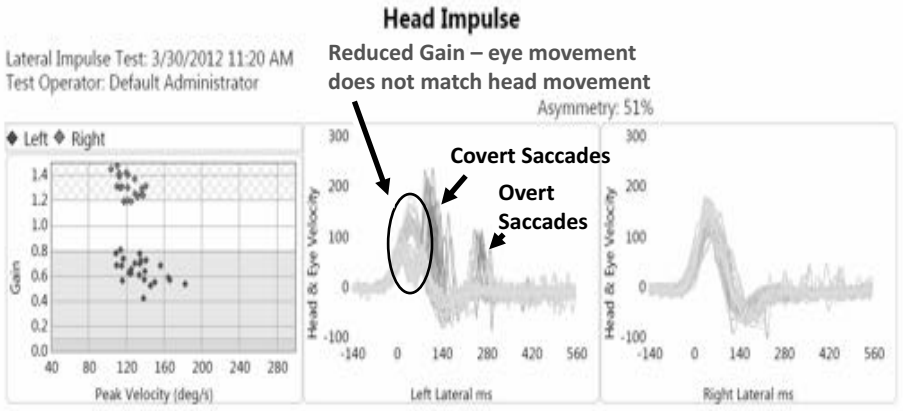
3) Covert Saccade: Rapid eye movements occurring *during* the head movement in order to keep the eye on the focal point (cannot be seen with the naked eye)

vHIT Interpretation: Normal LSCCs



Normal gain for adults: Mean: 0.96 Range 0.79 – 1.20
Curthoys, MacDougall, et al. (2016) – Sydney Clinic Norms

vHIT Interpretation: Unilateral Loss

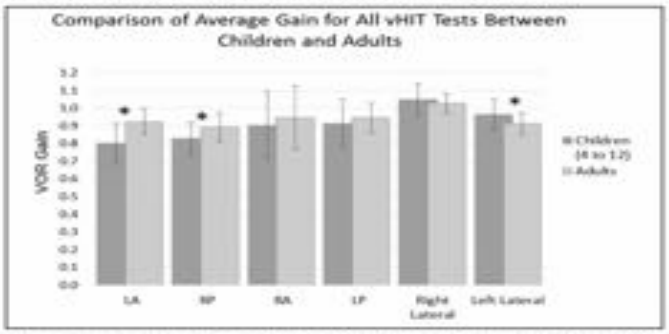


vHIT Interpretation

- Reduced gain on its own is not sufficient evidence of an abnormal canal response. Should see catch up saccades, too.
- Catch up saccades are identified by *direction*, *timing*, *velocity* & *consistency*
  - **Direction:** Abnormal catch up saccades occur in the ***SAME*** direction as the VOR (if seen in opposite direction – this is usually spontaneous nystagmus)
  - **Timing:** 1st catch up saccade occurs w/in ~70-270 msec after the onset of head movement
  - **Velocity:** Catch up saccades that are substantially smaller than the peak head velocity are not abnormal. Saccade needs to be bigger than ½ the head velocity
  - **Consistency:** Abnormal catch up saccades occur for almost every head impulse toward the side of lesion

Normative data: CCHMC, in review

Comparisons of the pediatric and adult VOR gain measures revealed a statistical significance ($p < 0.05$) for the LA, RP, and left lateral vHIT tests.



Average gain comparisons between adults (n=11) and children 4-12 years (n=30) for all vHIT tests. LA= Left Anterior; RP= Right Posterior; RA= Right Anterior; LP= Left Posterior. *p< 0.05

Normative Data

- Average VOR gains for healthy subjects across studies of adults and children

SCC	LA	RP	RA	LP	Right Lateral	Left Lateral
Children (Bachmann et al., 2015)	0.80 ± 0.11 (0.58 - 1.02)	0.83 ± 0.09 (0.65 - 1.01)	0.90 ± 0.19 (0.53 - 1.28)	0.91 ± 0.14 (0.65 - 1.19)	1.04 ± 0.09 (0.87 - 1.22)	0.96 ± 0.09 (0.79 - 1.14)
Adults (Kidd et al., 2014)					1.04 ± 0.11 (0.82 - 1.26)	0.98 ± 0.10 (0.78 - 1.18)
Adults (Curthoys et al., 2016)	0.96 ± 0.12 (0.71 - 1.20)	0.98 ± 0.15 (0.68 - 1.28)	0.95 ± 0.12 (0.70 - 1.19)	0.92 ± 0.17 (0.58 - 1.26)	1.00 ± 0.07 (0.86 - 1.14)	0.92 ± 0.06 (0.80 - 1.04)

Normative Data

- Test time comparison

Test Time

Age Group (years)	Lateral	LARP	RALP
4-6	2:00 ± 0:46	3:23 ± 2:18	2:47 ± 1:40
7-9	1:32 ± 0:22	2:01 ± 0:47	1:32 ± 0:40
10-12	1:18 ± 0:21	2:02 ± 1:27	1:40 ± 0:43
Adults	1:24 ± 0:30	1:49 ± 1:00	1:26 ± 0:46

Mean ±SD test time for each vHIT test by age group.

Normative Data

- Conclusions
  - VOR gains for children are not different from adults for Lateral Impulses and testing in the RALP plane
  - VOR gains are lower in children for LARP testing
  - There is more variability in VOR gains for anterior canal testing (RA & LA)
    - Most likely due to larger pupil size in the pediatric population compared to adults
    - Pupil more likely to be obscured by the eyelid during impulses for RA & LA

Challenges and Solutions

Positioning: Challenges

- Stabilizing
  - Feet do not touch the ground, fidgety, head in motion, risk moving their whole body if not stable during an impulse
- Comfort
  - Motivation to continue testing is tied to patient comfort, not wanting to sit on chair independently

Positioning: Solution
Adjustable Chair with Food Support

Positioning: Solution
Use of Footstool

Positioning: Solution
Sitting on Parent's Lap

Video 4 Parent's Lap

Positioning: Solution
Criss-cross applesauce

Goggle Placement: Challenges

- Difficulty tolerating goggles
- Retention
- Pupil size and eyelid interference

Goggle Placement: Solution

Instructions

- Video 5 Goggle Instructions

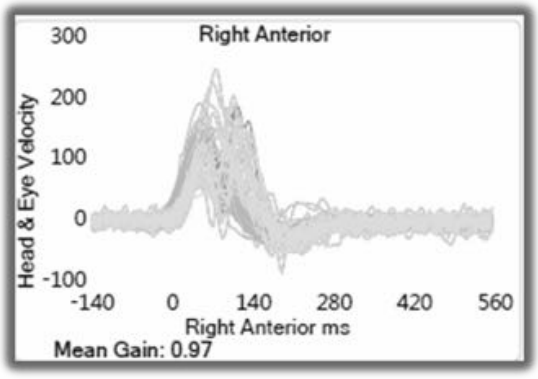
Goggle Placement: Solution
Retention

Goggle Placement: Solution
Retention

Goggle Placement: Solution
Eye Technique

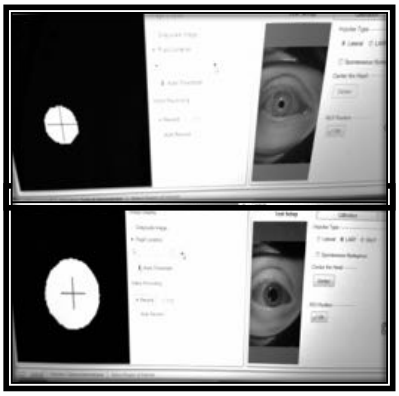
- Video 6 Eye Technique

Eyelid Artifact

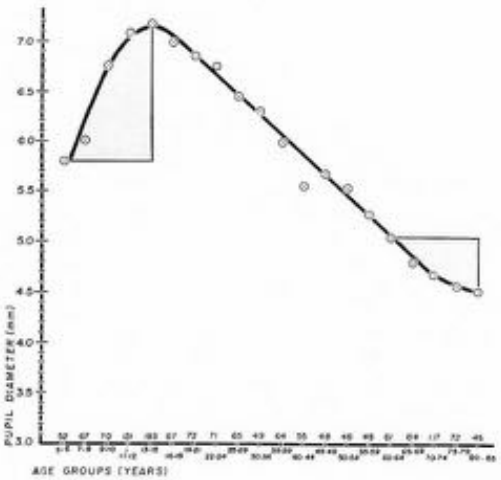


Pupil Size: Adult vs. Child

Difference in pupil diameter between a 47 y.o. subject (top) and a 10 y.o. subject (bottom)



Pupil Size



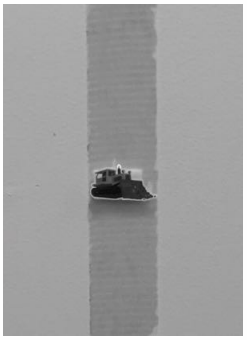
Jacobson (2002)

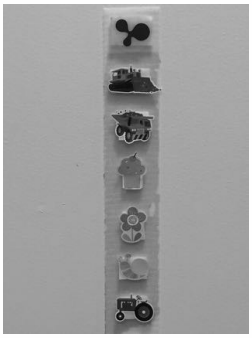
Attention/Motivation: Challenges

- Difficulty maintaining focus on target
- Easily bored

Attention/Motivation: Solution
Child Friendly Stickers

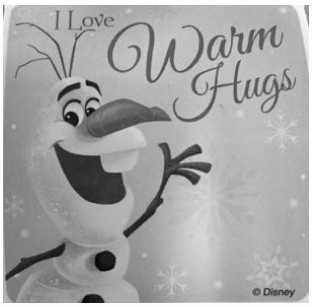
- Use a variety of stickers
- Ask the child questions about the sticker





Attention/Motivation: Solution

- Character Sticker 2 X 2



Attention/Motivation: Solution
Video

- vHITvideo

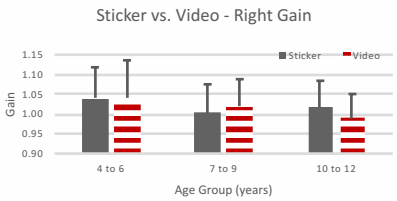
vHIT Video Study

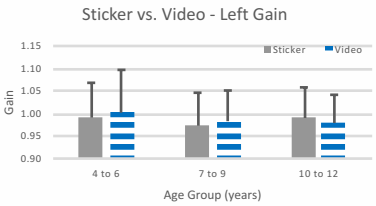
- Research to compare use of video vs. sticker
- 1 inch sticker vs 4 inch video
- Stationary target vs moving target

vHIT Video Study

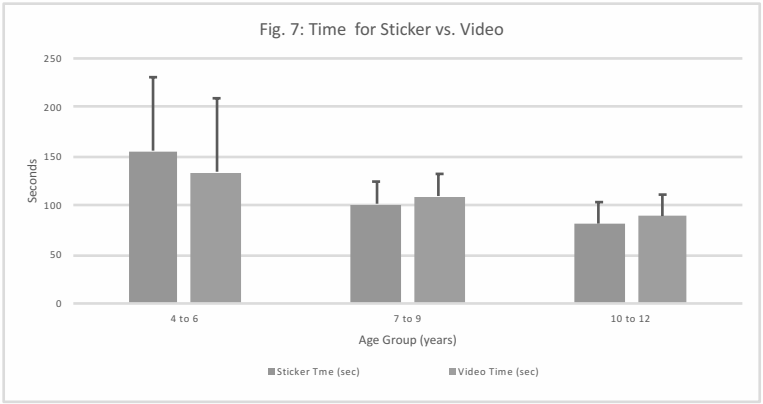
- Data Points:
  - Effect on gain
  - Time study
  - Asymmetry
  - Saccades generated from video?

Video Study Findings: Lateral Canal Gain

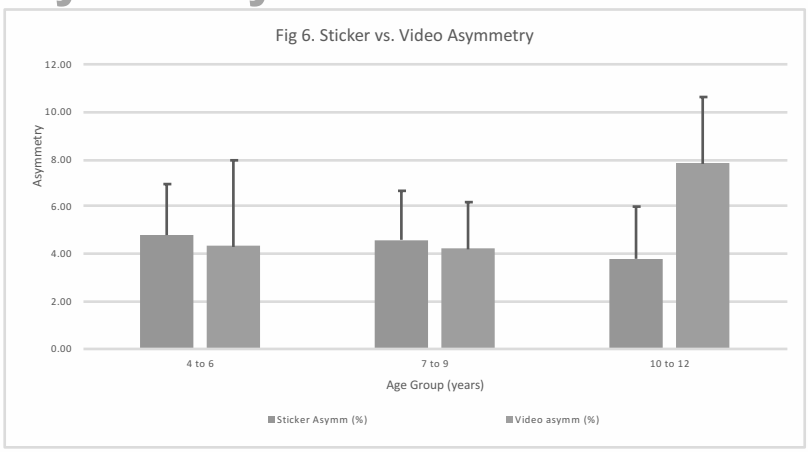




Video Study Findings: Time for sticker vs. video Testing

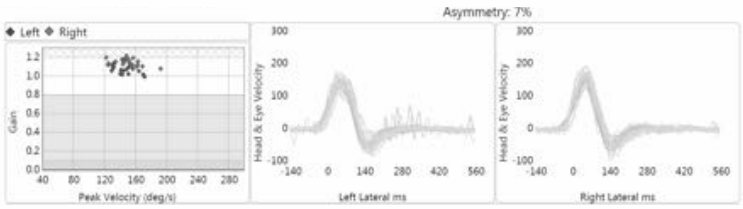


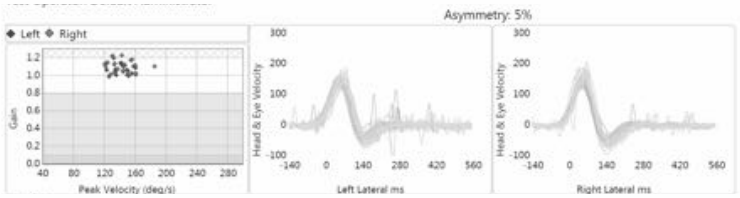
Video Study Findings: Asymmetry



Video/Sticker comparison

- Sticker
- Video

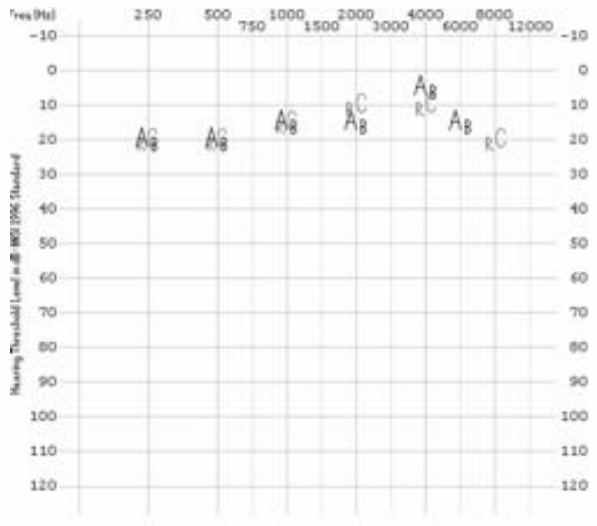




Case Studies

Case Study 1: History

- SNHL bilaterally
- Bimodal user (HA left/CI right)
- Dizziness since age 5 (prior to implantation)
- Increase in intensity and frequency over past 6 months
- Recent decrease in hearing as well
- CMV cannot be ruled out
- Symptoms described as “I fall to the floor”, “everything is spinning” and “I feel sick to my stomach”
- Head movements (looking up and down) can bring on an episode
- Previously received vestibular rehab-did well and discontinued services-episodes returned
- Treated multiple times for BPPV with no relief

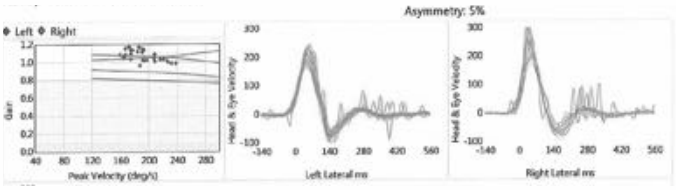


Case Study 1: Test Results

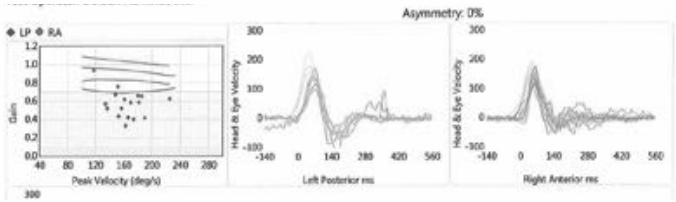
- Rotary-SHA low gain in low frequencies, clockwise asymmetry and phase leads at all test frequencies
- No post headshaking or positional nystagmus
- Dix-Hallpike with vision not occluded was normal. Rotary and up beating noted in the head right position with vision occluded
- Normal cVEMPs and Calorics
- Abnormal DVA screening
- vHIT results ???

Case Study 1: vHIT Findings

Horizontal

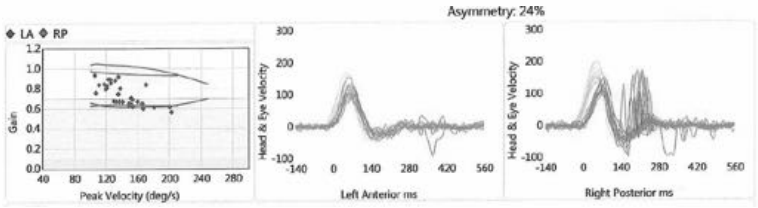


RALP



Case Study 1: vHIT Findings

LARP



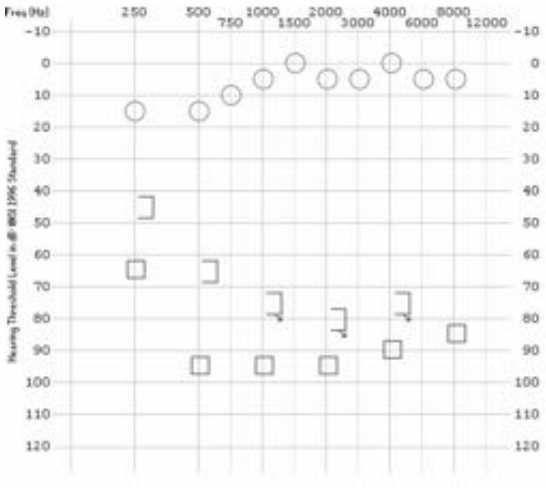
Case Study 1

- Follow-up for vestibular rehab for habituation exercises.

Case Study 2

- 9 year old female
- balance and falls since toddlerhood
- falls have become more evident as she gets older -involved in more activities i.e. gymnastics.
- Falls are random, some days worse than others
- takes stairs one at a time rather than alternating her feet.
- learned to ride a bicycle without training wheels within the past year (likes scooter better)
- known severe to profound sensorineural hearing loss in the left ear and normal hearing in the right ear. Uses CROS hearing aid.
- Other significant history: congenital CMV, thyroid issues, and developmental delays.

Case Study 2:



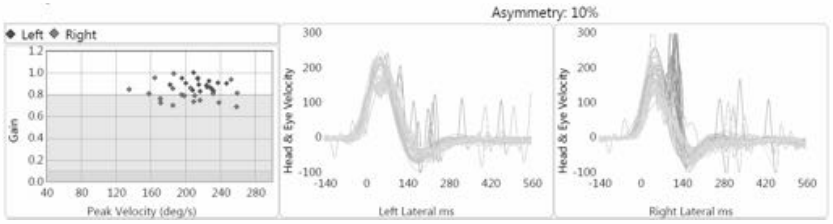
Case Study 2

- Vestibular Rehab eval:
- 1. Stand on firm surface with the eyes open: **30 seconds, no sway**
- 2. Stand on firm surface with the eyes closed: **13 seconds, stepping reaction**
- 3. Stand on compliant surface (foam) with the eyes open: **11 seconds, moderate sway followed by stepping reaction**
- 4. Stand on compliant surface (foam) with the eyes closed: **0 seconds**

Case Study 2

- Audiology Vestibular Eval:
- **Rotary Chair**: Sinusoidal harmonic acceleration revealed low gain at 0.02 -0.32 Hz. Phase leads were recorded at all test frequencies. Step velocity testing was normal.
- **Videonystagmography**: left beating nystagmus post headshaking. Bithermal and alternating air caloric irrigations were bilaterally weak with no asymmetry.
- **Cervical VEMPs**: Absent left VEMP.
- **Ocular VEMPs:** Absent bilaterally.

Case Study 2



Case Study 2

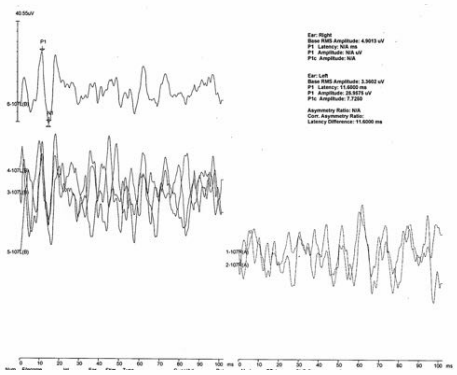
- Vestibular rehabilitation for substitution exercises
- Discussion: CMV can affect both inner ears, even though hearing was still intact on one side

Case study 3

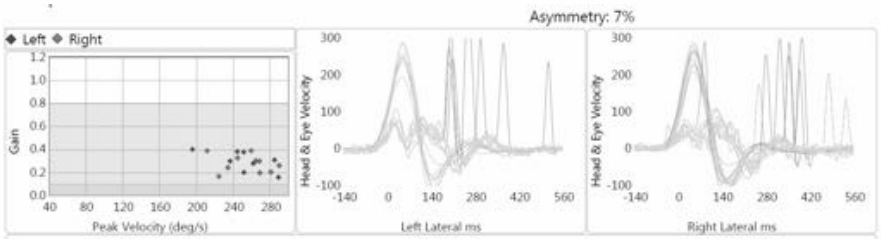
- 8 y.o. female
- significant bilateral sensorineural hearing loss, greater in the right ear, which was identified at the age of 4 years.
- enlarged vestibular aqueducts (EVA)
- hyperopic astigmatism in both eyes and esotropia, wears glasses
- Dx with hypotonia as an infant and was evaluated for a possible mitochondrial defect.
- Her mother reported that she has always been clumsy.
- She was a late walker, age of 2.5 years.
- She reportedly loves roller coaster rides, but does not ride a bike or roller skate (can only ride a 3-wheeled scooter.)
- She also stated that 3-4 times per year, usually in the winter and spring, she will wake up coughing and will eventually start vomiting.
- She described these episodes as "my eyes feel wobbly and I throw up".

Case Study 3

- Absent calorics for ice water
- Absent VOR for all rotary chair frequencies
- VEMPs:



Case Study 3



Case Study 3

- Vestibular rehab for substitution exercises and help with ADL's

Case Study 4

- 13 y.o. male
- Two episodes of dizziness that he describes as "loss of balance, room was kind of moving side to side and it's like I had motion sickness."
- First episode occurred in the summer which happened after a shower. Had to sleep right after and the symptoms were gone when he woke up the next day.
- Second episode occurred in the fall, again after a shower. He reportedly fell down into his bed, and he stated that his symptoms were still present after he woke up the next day.
- There is a family history of migraines (mother who takes medication as needed).
- He reports an occasional sinus headache (once every two months).
- Has poor hydration due to school not allowing water bottles in the classroom.
- His mother also reports that he had motion sickness younger in life and used to vomit in the car.

Case study 4

- Normal VNG
- Normal Rotary chair testing
- Prolonged VEMP on both sides

Case Study 4

Case Study 4

- He was sent back to Neurology, suspected migraine variant prolonged VEMP's and high gain on vHIT