Remote Camera vHIT: What is it and how does it fit into my pediatric vestibular test battery?

Kristen L. Janky, AuD, PhD

BOYS TOWN
National Research
Hospital

Conflicts of Interest

- Employee of Boys Town National Research Hospital,
- NIH Grant Recipient,
- Consultant: Natus,
- Consultant: Interacoustics,
- Balance Function Assessment and Management Textbook, Editor,
- Ear & Hearing, Section Editor
- International Pediatric Balance Network, Board Member
- VEDA, Board Member

This webinar will explore:

- Why pediatric vestibular assessment is essential
- How remote camera vHIT works and why it is uniquely suited to infants and young children
- Where it fits within comprehensive pediatric test batteries
- How to interpret results with confidence
- Real pediatric case studies, including infants and children with limited test tolerance

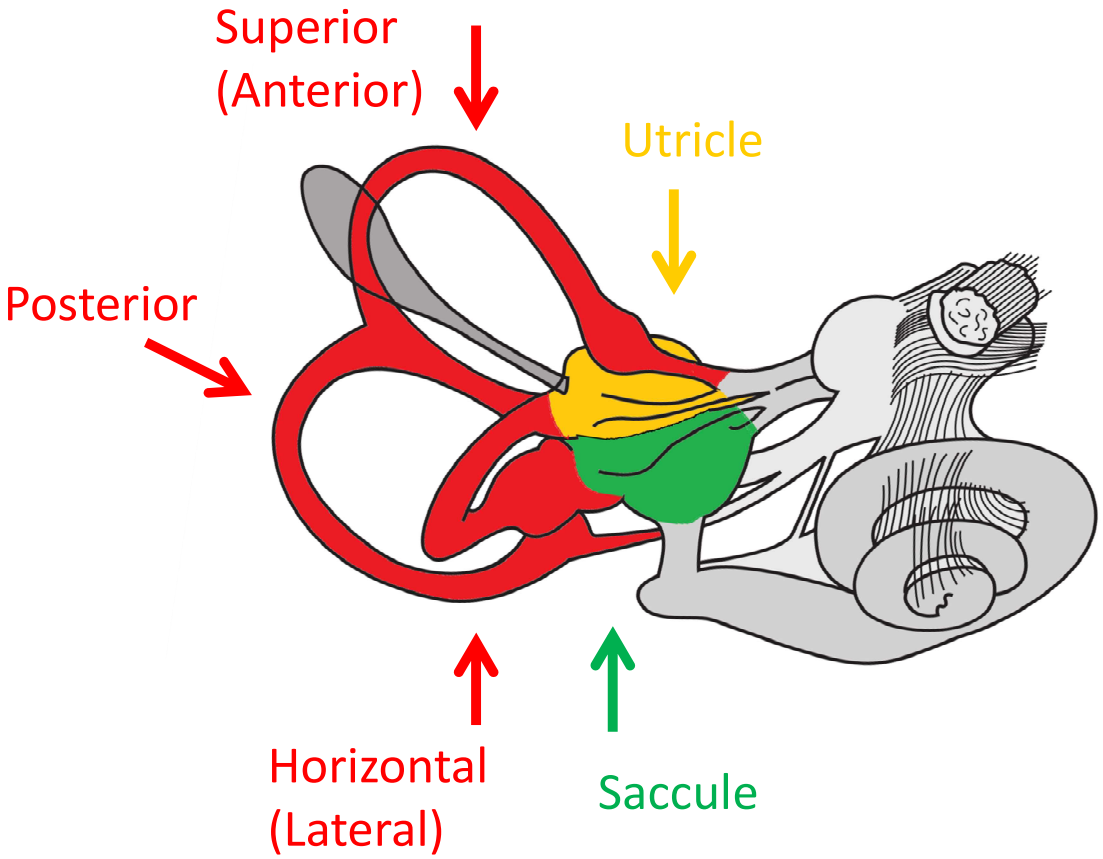
BOYS TOWN
National Research
Hospital

Why pediatric vestibular assessment is essential.




BOYS TOWN
National Research
Hospital

What is the vestibular system?



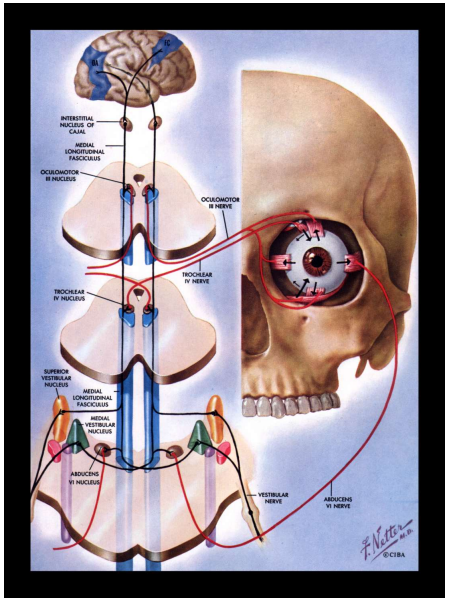
https://openclipart.org/image/2400px/svg_to_png/38287/58294main-The.Brain.in.Space-page-75-ear-vestibular-system.png

BOYS TOWN
National Research
Hospital

Vestibular Reflexes

Vestibulo-ocular

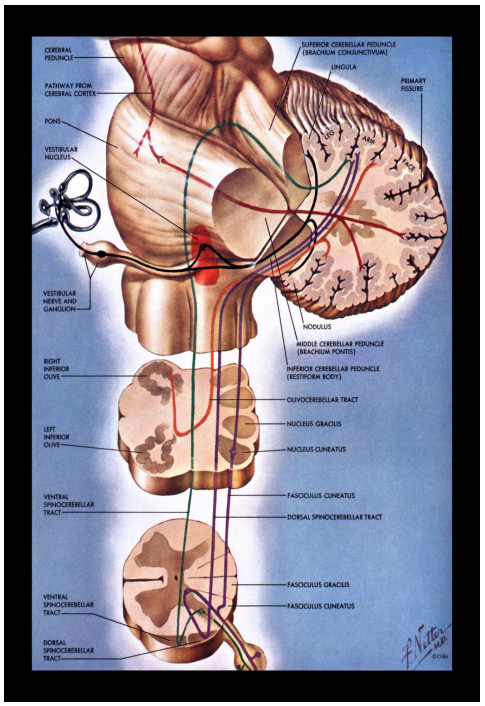
Maintain steady vision during head movements



Jacobson & Shepard, 2008

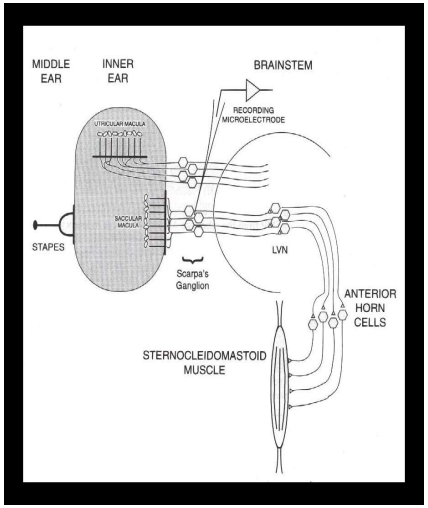
Vestibulospinal

Maintain posture



Vestibulocolic

Righting reflex; stabilizes head



From Halmagyi & Curthoys, In Herdman

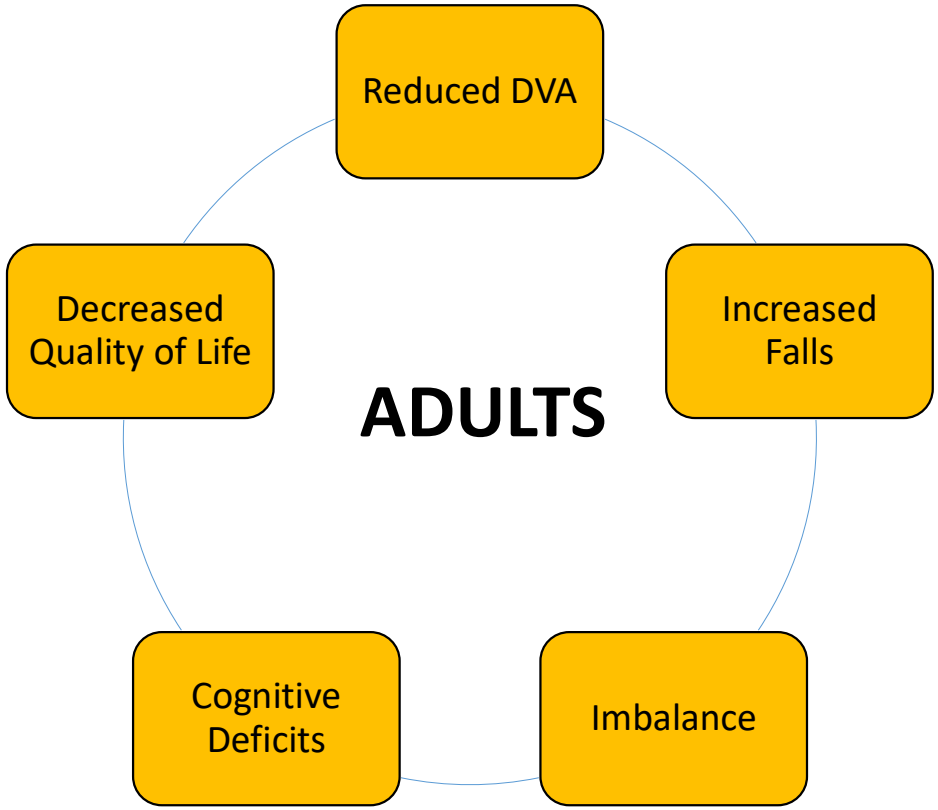
BOYS TOWN National Research Hospital

BOYS TOWN
National Research
Hospital

What happens when the vestibular system isn't functioning?

BOYS TOWN
National Research
Hospital

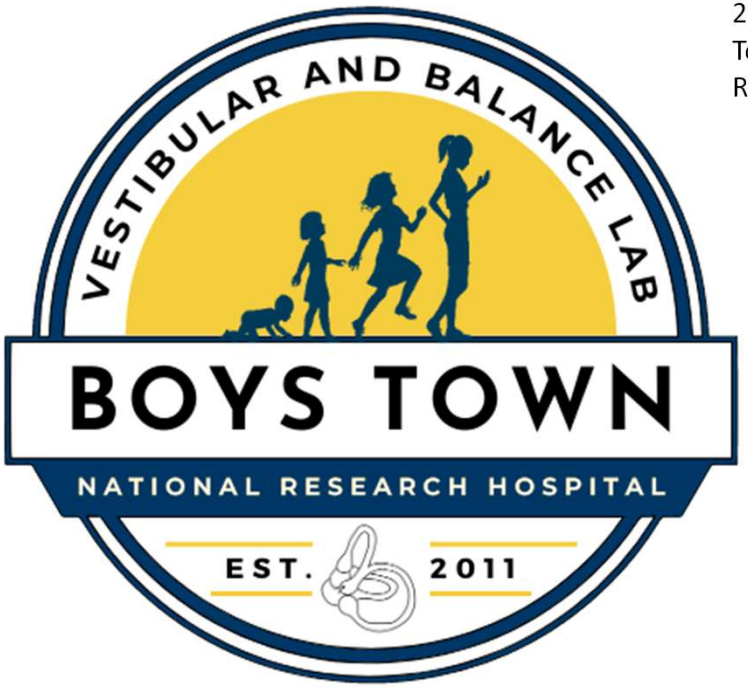
ADULTS are significantly affected by vestibular loss

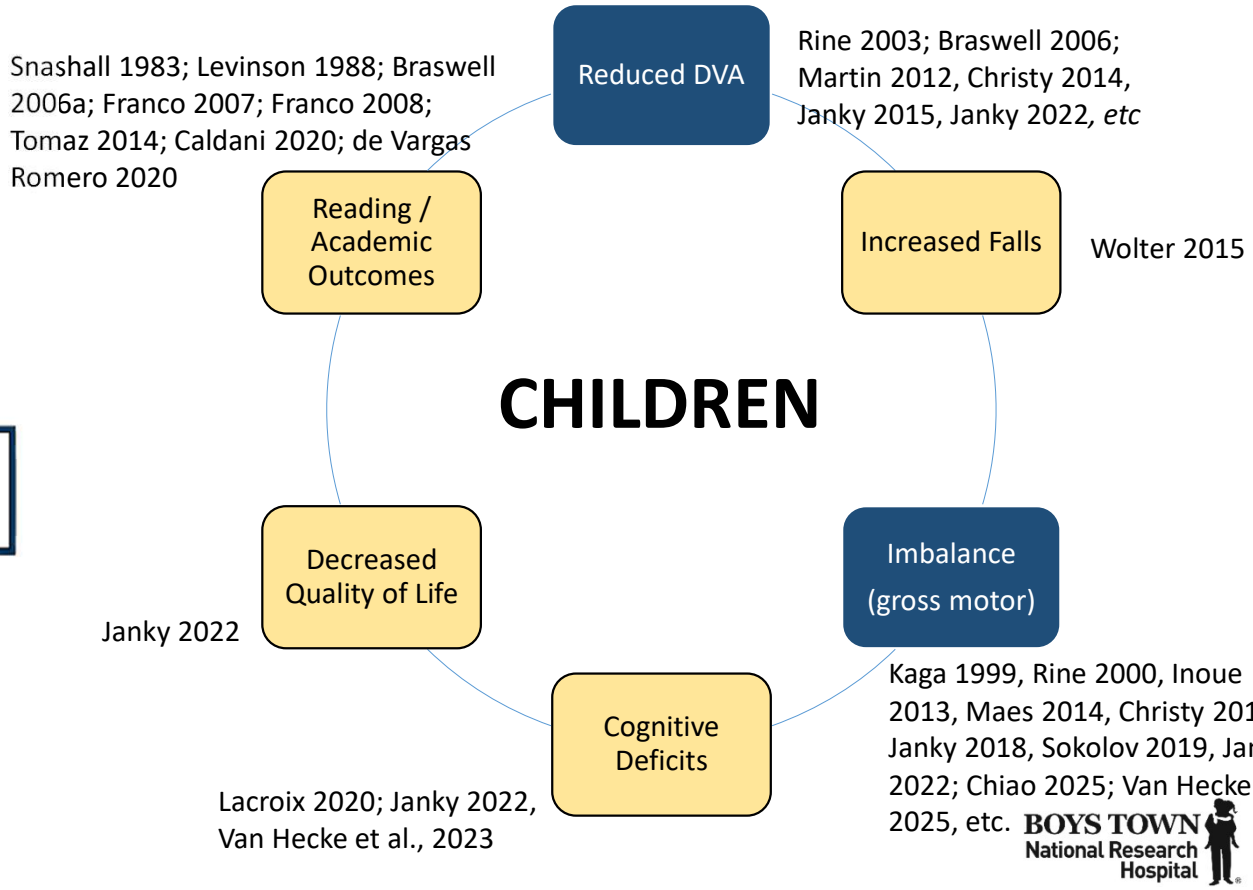


Do children suffer from the same effects of vestibular loss as adults?

BOYS TOWN National Research Hospital

Preliminary evidence suggests that children suffer from the same effects of vestibular loss as adults





BOYS TOWN National Research Hospital

Why is pediatric vestibular assessment is essential?

Identifying children with vestibular loss

Initiating Vestibular Rehabilitation

Who is at risk?

BOYS TOWN National Research Hospital

Vestibular testing is recommended in:

1. Children with **severe to profound sensorineural hearing loss**, which justifies testing all children prior to cochlear implantation;
2. Children who pass their newborn hearing screening and **acquire hearing loss or have progressive hearing loss**;
3. Children with **Auditory Neuropathy Spectrum Disorder**
4. Children with any degree of hearing loss and either **dizziness** or **concomitant gross motor delay** due to the known associations between vestibular loss, dizziness and gross motor function.

BOYS TOWN National Research Hospital

How remote camera vHIT works and why it is uniquely suited to infants and young children

BOYS TOWN
National Research
Hospital

Video Head Impulse Testing (vHIT)

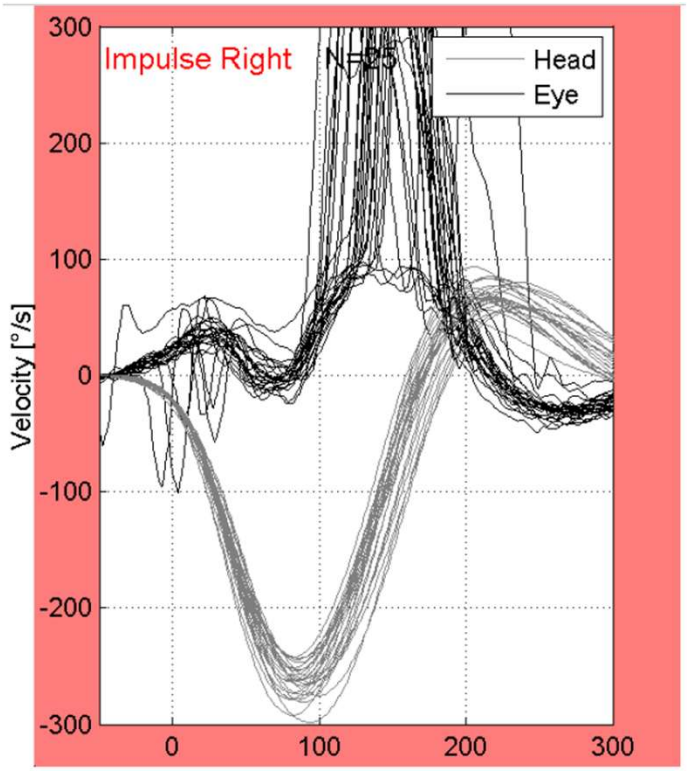
- vHIT is an assessment of individual semicircular canal function and both branches of the vestibular nerve.
  - Horizontal and Anterior canal vHIT:
    - Superior Vestibular Nerve
  - Posterior canal vHIT:
    - Inferior Vestibular Nerve
- Children fixate on a stable visual target
- Camera measures eye velocity, gyroscope measures head velocity
- Goggle vHIT can be completed in children **3+ years**

BOYS TOWN National Research Hospital

vHIT Considerations:

Use 2 factors for interpretation:

1. Gain (Ratio between eye and head movement)
   - 0.7 has been suggested for young children
2. Corrective Saccades:
   - Frequency (50 – 80%)
   - Velocity (> 100)
   - Latency (< 320 ms)
   - Standard Deviation of the latency



Martens 2023; Janky 2018

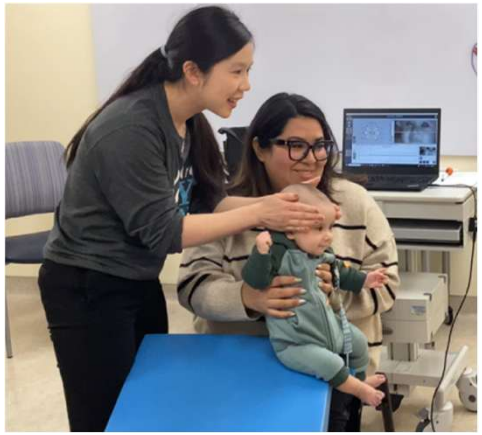
BOYS TOWN National Research Hospital

vHIT: Benefits in children

- Does not induce dizziness.
- Vision is not occluded, so not as scary
- Test administration is fast (10 – 15 minutes)
- Can be completed regardless of middle ear status (PE tubes, perforations, mastoid cavity, etc)
- Ear and canal specific

BOYS TOWN National Research Hospital

vHIT Considerations



- Use Brightly lit room
- Pull up eyelids
- Use foam, ponytail, or bouffant cap for retention
- Children can sit on a parent's lap
- Head Velocity should be > 120 d/s for horizontal canals and 100 d/s for vertical canals
- Age:
  - Many studies report NO CHANGE with age (Janky 2015; Hamilton 2015; Lehnen 2017; Ross 2016)
  - Wiener-Vacher (2017) showed a rapid increase in gain from age 3 to 6 years and then a slow increase up to 16 years
  - Martens et al. (2023) showed lower gain for children < 1 year

Bachman 2018; Janky 2018; Lavender, 2025; Dasgupta et al., 2025

BOYS TOWN National Research Hospital

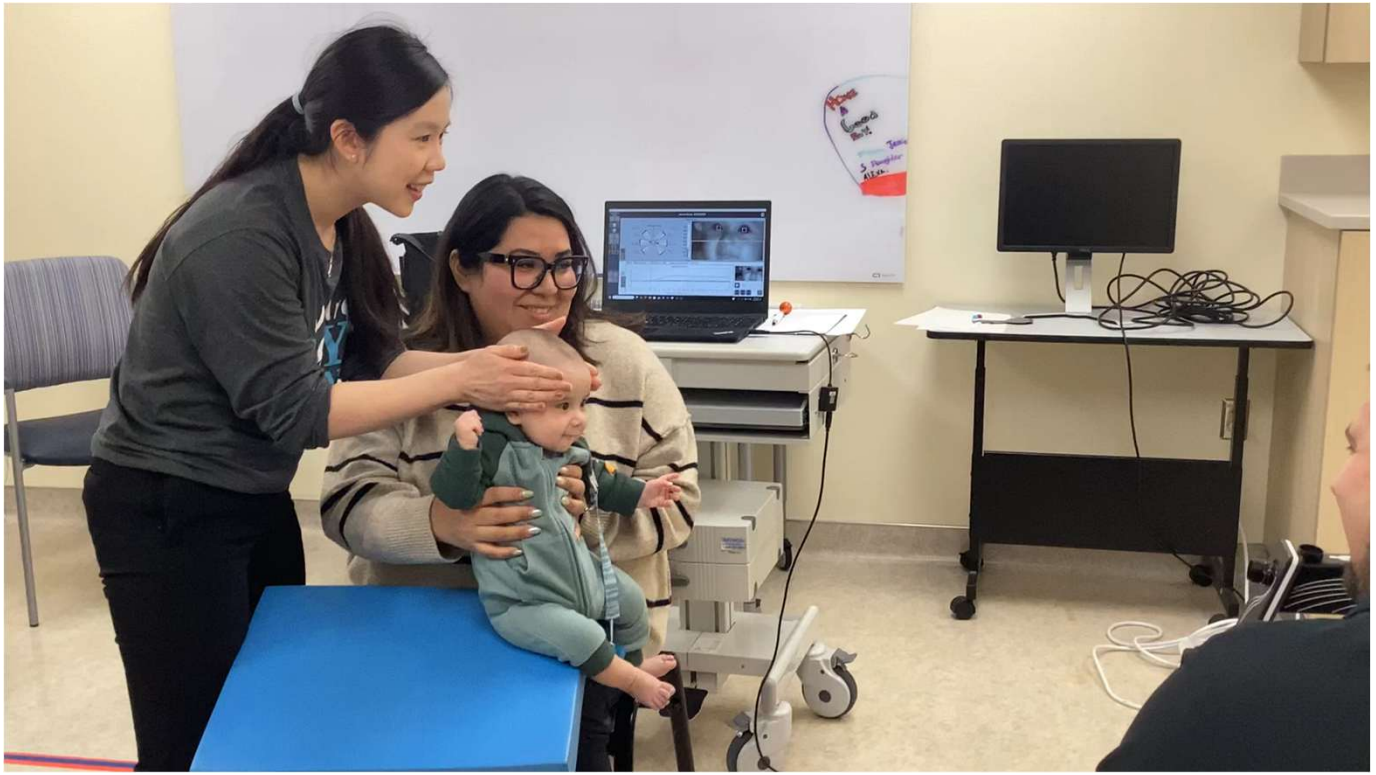
vHIT Considerations

- Compared to adults, vHIT in children:
  - Takes longer due to cooperation
  - Requires more practice
  - Can be more difficult to achieve adequate head velocity for vertical canals (i.e., > 100 d/s)
  - More successful with a test assist (this can be a parent)
  - Young children (< 3 years) cannot wear the vHIT goggles

Dasgupta et al., 2025; Hamilton 2015

BOYS TOWN National Research Hospital

Remote Camera vHIT **for children 6 months+**



BOYS TOWN
National Research
Hospital

Remote camera vHIT can be used in older children and adults

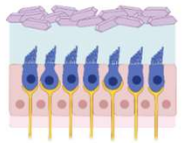
BOYS TOWN
National Research
Hospital

Multidimensional Investigation of Auditory and Vestibular Function in Individuals with Down Syndrome (R01DC021819)

BOYS TOWN National Research Hospital

MPI: Merchant
co-Is: Porter, Janky

1. Deep phenotyping



LINDA CRNIC INSTITUTE HUMAN TRISOME PROJECT GLOBAL DOWN SYNDROME FOUNDATION

MPI: Espinosa
co-Is: Rachubinski, Galbraith

2. Underlying etiologies


Genome


Transcriptome


Proteome


Metabolome

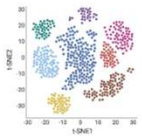

Autoantibodies


Oral and ear microbiomes

Creighton UNIVERSITY

MPI: Steyger
co-I: Sullivan

3. Mouse model

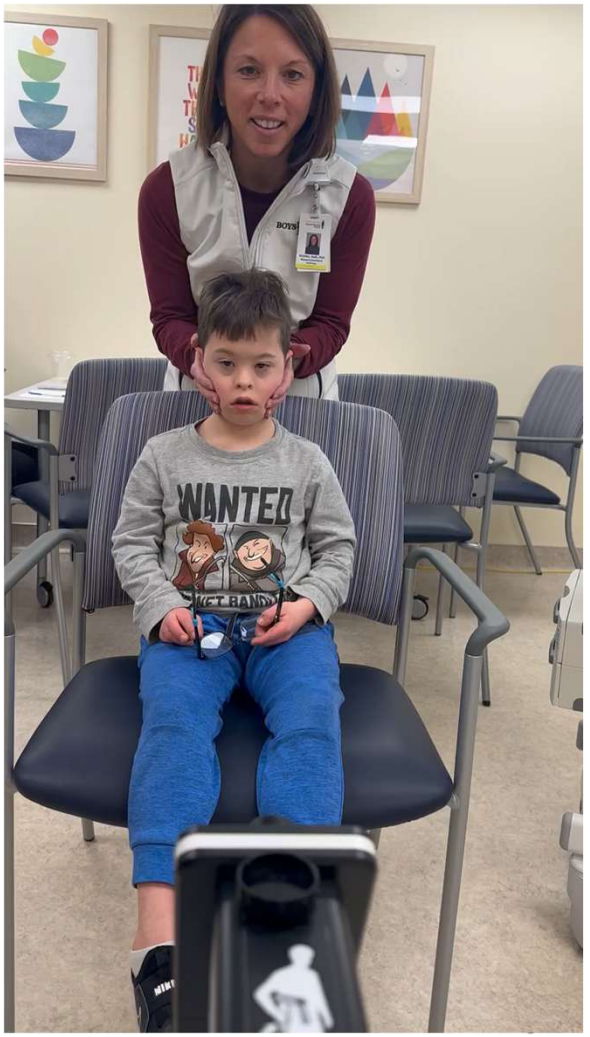


TRANSLATIONAL AUDITORY PHYSIOLOGY & PERCEPTION LAB

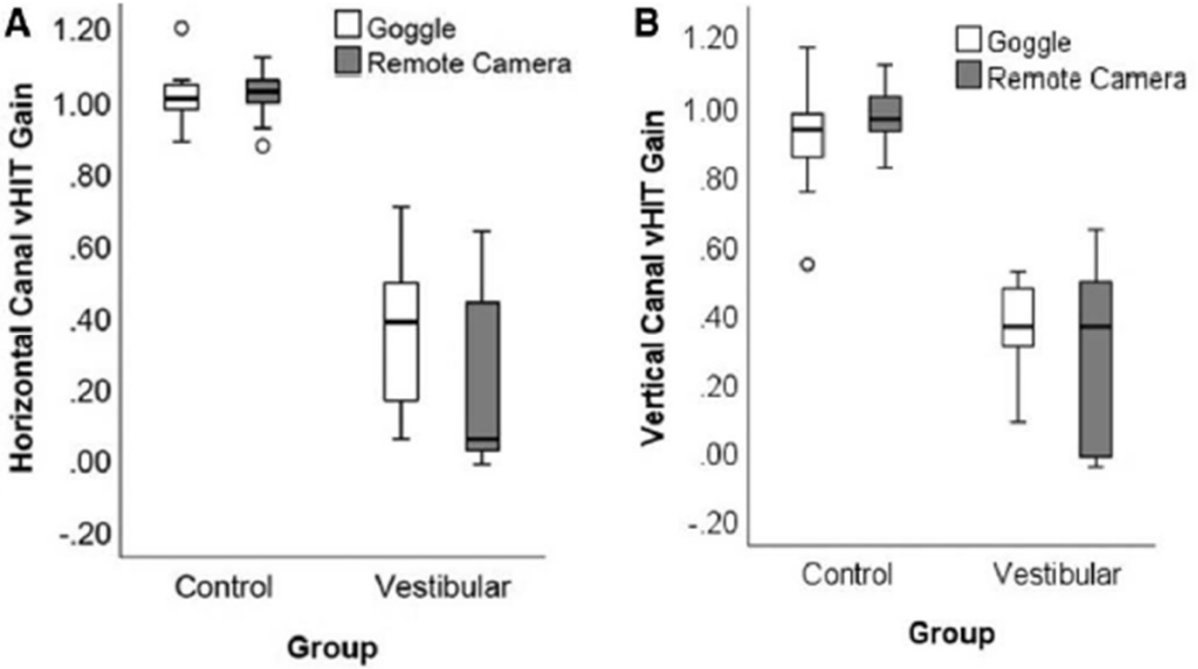
Project INCLUDE

VESTIBULAR AND BALANCE LAB
BOYS TOWN
NATIONAL RESEARCH HOSPITAL
EST. 2011

Gabrielle R. Merchant, AuD, PhD, Heather L. Porter, AuD, PhD, Kristen L. Janky, AuD, PhD


WANTED

Results obtained with a remote-camera device are like those obtained using a standard goggle device.



Goggle Versus Remote-Camera Video Head Impulse Test Device Comparison

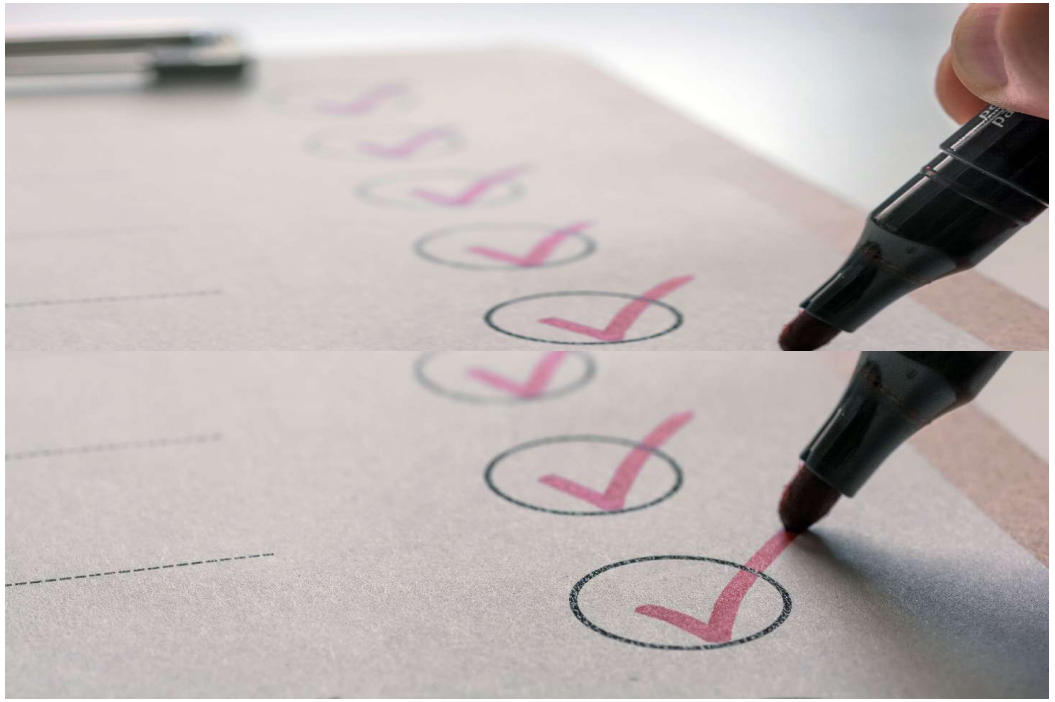
Kristen L. Janky,[1] Jessie N. Patterson,[1] and Casey Vandervelde[1,2]

BOYS TOWN National Research Hospital

Where it fits within comprehensive pediatric test batteries

BOYS TOWN
National Research
Hospital

What protocol are we using with children?



Regardless of age, we attempt the following on all children:

- Audiogram
- Case History
- Bedside
- Assess Canal function
- Assess Otolith Function

BOYS TOWN National Research Hospital

Audiogram

- SNHL is a risk factor for vestibular loss (Verbecque 2017; O'Reilly 2010; Li 2016)
- Children are more likely to have vestibular loss with:
  - Severe-to-profound sensorineural hearing loss (Janky 2018; Martens 2022)
  - Acquired/Progressive Hearing Loss
  - Syndromic Hearing Loss (Wang 2021)
  - And with specific etiologies of hearing loss:
    - Cytomegalovirus (CMV) infection (30 – 60%)
    - Auditory Neuropathy (42-91%)
    - Waardenburg Syndrome (up to 70/80%)
    - Usher Syndrome (~100%, depends on type)
    - Malformations (depends on severity of malformation)
    - Pendred Syndrome
    - Rubella (30 – 40%)
    - Ototoxicity
    - Meningitis (~100%)
    - Usher Syndrome (~100%, Type 1)
    - ANSD, BOR, JLN, Goldenhar, etc

Hearing loss etiology is unknown in ~ 35 – 42% of cases (Sokolov 2019, Cushing 2019) and not all etiologies result in complete vestibular loss (Cushing 2019), suggesting etiology alone is not a sufficient predictor of vestibular loss.

BOYS TOWN National Research Hospital

Case History

Form No.

BOYS TOWN National Research Hospital

Patient Name
DOB or MR#

PEDIATRIC DIZZINESS QUESTIONNAIRE

Gross Motor

Do you have concerns regarding your child's gross motor function? YES NO
Does your child receive Physical Therapy Services for balance: YES NO
Please list the age (in months) your child:
Sat independently: _____months Took first step: _____months
Stood independently: _____months Walked independently (3 steps): _____months
Learned to swim: _____months/years Rode a bike with 2 wheels: _____months/years

Hearing

How many ear infections has your child had? _____ Does your child have tubes? YES NO
Does your child have hearing loss? YES NO
Do you know the etiology/cause of the hearing loss? _____
Age at which the hearing loss began (enter age in months): _____

General Health

Has your child had x-ray studies (MRI, CT of head)? _____
Current Medications: _____
Has your child had an eye exam? YES NO Does your child wear glasses/contacts? YES NO
Does your child have history of: Concussion Motion Sensitivity Headache/Migraine
Other significant health history? _____
Does your child have history of any behavioral / emotional / cognitive concerns? YES NO
If yes, please explain: _____

Dizziness

How does your child describe their dizziness: *(Circle all that apply)*
They are spinning Room is spinning Lightheaded Off balance/Falling Fainting/blacking out
Disoriented
Dizziness is: Constant ____ Intermittent ____ If intermittent, how often do spells occur? _____
How long do spells last? (seconds, minutes, hours, days) _____
Is there any warning a spell is about to start? _____
Does anything bring on the dizziness? *(Circle all that apply)*
Position change Standing quickly Fumes Lack of food Motion Menstrual Periods Exertion
Other: _____
Is there anything that will stop or improve the dizziness? _____
Is there anything that will make the dizziness worse? _____
Has your child seen any other professional for a vestibular evaluation or dizziness? YES NO
If yes, please list: _____
Do you ever see your child's eyes move back and forth in an abnormal way? YES NO
Is there a family history of dizziness or balance concerns? YES NO

Q1. "At what age did your child <u>sit</u> independently?"

- Sat later than 7.25 months
  - sensitivity = 62%,
  - specificity = 81%

Q2. "At what age did your child <u>walk</u> independently?"

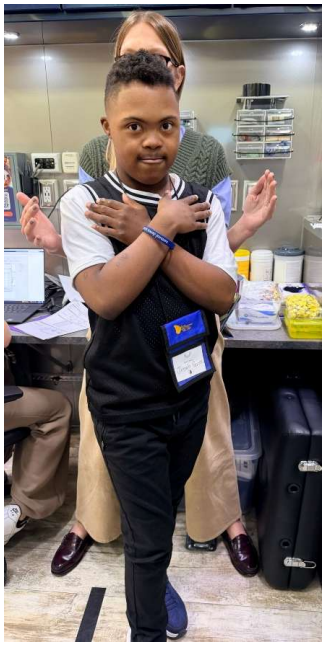
- Walked later than 14.5 months
  - sensitivity = 78%,
  - specificity = 77%

BOYS TOWN National Research Hospital

Bedside Exam (ocular range of motion, HIT, SLS, CTSIB, VINT)

CUT-OFF: corrective saccade
sensitivity = 75%,
specificity = 91%
(Christy et al., 2014)

CUT-OFF: < 4 seconds
sensitivity = 90%,
specificity = 100%
(Janky et al. 2022; Oyewumi et al., 2016)



CUT-OFF: 100 seconds
Sensitivity = 88%
Specificity = 85%
(Christy et al., 2014)

CUT-OFF: nystagmus
Sensitivity =
75% (partial UVL),
90% (caloric weakness > 50%),
98% (total UVL)
Specificity = 94% - 100%
(Dumas et al., 2008, Dumas et al., 2013; Nuti & Mandala, 2005; Ohki et al., 2003; Xie et al., 2013)

BOYS TOWN
National Research
Hospital

Assess Canal Function

Children 6 mos - 3 years

Remote Camera vHIT

Rotary Chair

Children 4+ years

Goggle or remote camera vHIT

Rotary Chair

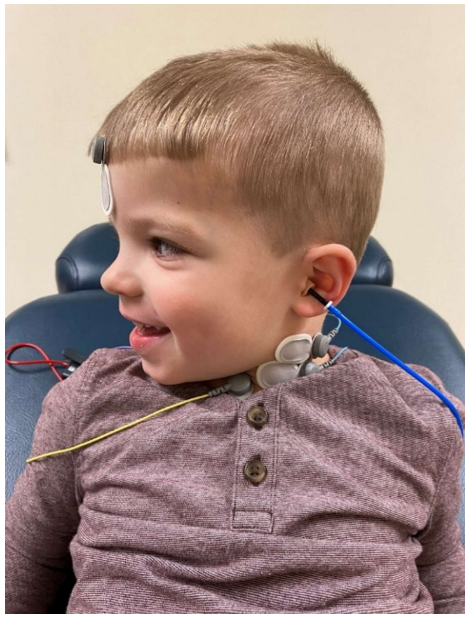
TOWN Research Hospital

Assess Otolith Function

Children 6 mos - 3 years

Bone-conducted cVEMP

Children 4+ years



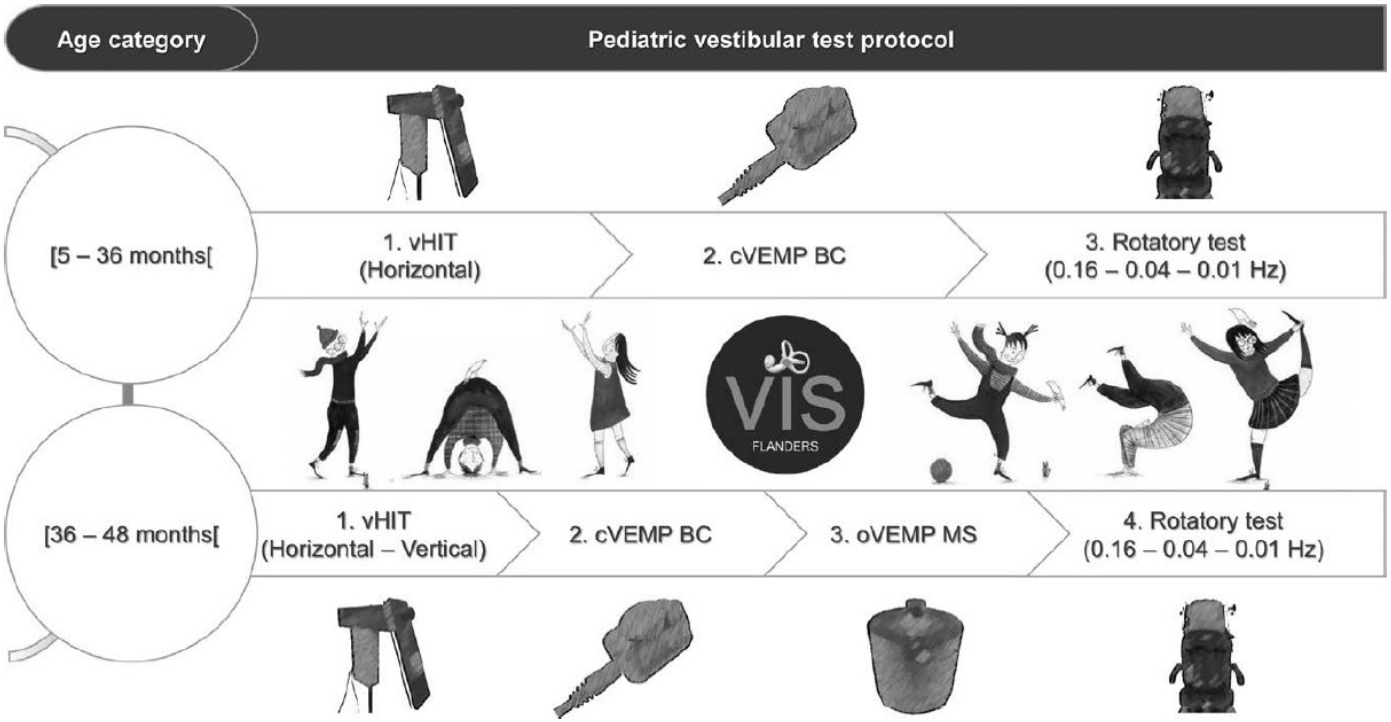
Air/bone-conducted cVEMP

Air/bone-conducted oVEMP

BOYS TOWN National Research Hospital

Pediatric Vestibular Assessment: Clinical Framework

Sarie Martens,[1] Ingeborg Dhooge,[2,3] Cleo Dhondt,[2] Saartje Vanaudenaerde,[3] Marieke Sucaet,[1]
Lotte Rombaut,[3] and Leen Maes[1,3]



BOYS TOWN National Research Hospital

Feasibility

Pediatric Vestibular Assessment: Clinical Framework

Sarie Martens,[1] Ingeborg Dhooge,[2,3] Cleo Dhondt,[2] Saartje Vanaudenaerde,[3] Marieke Sucaet,[1] Lotte Rombaut,[3] and Leen Maes[1,3]

TABLE 2. Success rate of the vestibular test protocol

	Success Rate (Number of Subjects With Successful Results) (%)						
	vHIT		VEMP		Rotatory Test		
Age Category (mo)	Hor SCC	Vert SCC	cVEMP	oVEMP	0.16 Hz	0.04 Hz	0.01 Hz
[5–12]	78.9%		89.5%		68.4%	76.3%	44.7%
n = 38	(30)		(34)		(26)	(29)	(17)
[12–24]	91.9%		81.1%		62.2%	56.8%	35.1%
n = 37	(34)		(30)		(23)	(21)	(13)
[24–36]	97.0%		84.8%		78.8%	72.7%	63.6%
n = 33	(32)		(28)		(26)	(24)	(21)
[36–48]	100.0%	60.0%	96.0%	92.0%	92.0%	96.0%	92.0%
n = 25	(25)	(15)	(24)	(23)	(23)	(24)	(23)
[5–48]	91.0%		87.2%		73.7%	73.7%	55.6%
n = 133	(121)		(116)		(98)	(98)	(74)

%, percentage of subjects with successful results; cVEMP, cervical Vestibular Evoked Myogenic Potentials; Hor, horizontal; n, number of subjects; oVEMP, ocular Vestibular Evoked Myogenic Potentials.; SCC, semicircular canals; VEMP, Vestibular Evoked Myogenic Potentials; Vert, vertical; vHIT, video Head Impulse Test.

BOYS TOWN National Research Hospital

Feasibility

How I Do It

Vestibular Assessment in the Pediatric Population

Cleo Dhondt, MSc; Ingeborg Dhooge, PhD, MD; Leen Maes, PhD

TABLE II.
Representation of the Proportion of Children Across the Different Age Categories in Which Each Test Could Be Successfully and Reliably Conducted

			Success Rate (%)				
Age Category	No. of Subjects	Median Age (mo)	vHIT*	cVEMP	oVEMP	Rotatory Test	Caloric Test
5 months–1 year	18	7.0	72.2	100.0		88.9	
1 year–2 years	8	17.0	100.0†	100.0		62.5	
2 years–3 years	8	29.0	85.7†	75.0		50.0	
Total group < 3 years	**34**	**10.5**	81.3	94.1		73.5	
3 years–4 years	8	44.0	100.0	100.0	100.0	100.0	62.5
4 years–5 years	8	54.5	87.5	100.0	100.0	100.0	85.7‡
5 years–6 years	8	67.5	100.0	100.0	100.0	100.0	100.0
Total group >3 years	**24**	**54.5**	95.8	100.0	100.0	100.0	82.6

BOYS TOWN National Research Hospital

Rotary Chair

- Expensive
  - For both practitioners and patients
- Wear goggles/electrodes
- Overall vestibular responsiveness
- 15 minutes
- Lower feasibility

Remote Camera vHIT

- Less expensive
  - For both practitioners and patients
- Do not wear goggles/electrodes
- Ear and canal specific vestibular function
- 5 minutes
- Higher feasibility

BOYS TOWN National Research Hospital

Vestibular Infant Screening–Flanders: What is the Most Appropriate Vestibular Screening Tool in Hearing-Impaired Children?

Sarie Martens,[1,4] Leen Maes,[1,2,4] Cleo Dhondt,[3] Saartje Vanaudenaerde,[2] Marieke Sucaet,[1] Els De Leenheer,[2,3] Helen Van Hoecke,[2,3] Ruth Van Hecke,[1] Lotte Rombaut,[2] and Ingeborg Dhooge[2,3]

VEMP is recommended as a first-tier screen; however, are any children missed by using cVEMP?

- YES
  - 4.6% of children are missed using cVEMP alone
  - 1.5% of children are missed using vHIT alone
- These data suggest that
  - The tests are complimentary
  - If 1 test is normal and there are risk factors, keeping going

BOYS TOWN National Research Hospital

You never know when will be your last test…

Remote Camera vHIT

Bone-conducted cVEMP

Rotary Chair

BOYS TOWN National Research Hospital

Is RC-vHIT ever unsuccessful?

Congenital nystagmus

Not sitting still

Crying

BOYS TOWN National Research Hospital

What protocol are we using with children?

- Screen all kids with unilateral/bilateral severe-to-profound hearing loss and acquired hearing loss secondary to meningitis, CMV, or any cochleovestibular anomalies.
- Screening will occur with remote camera vHIT, bone conducted cVEMP and/or rotary chair.
- For any child that fails, we would recommend
  - A yearly PT evaluation
  - A follow-up assessment at age 3 – 4 for additional testing (cVEMP, oVEMP, vHIT/RC, gross motor screen).

- If abnormal, schedule consult with vestibular rehab.

BOYS TOWN National Research Hospital

How to interpret results with confidence

BOYS TOWN
National Research
Hospital

frontiers in Neurology

ORIGINAL RESEARCH
published: 07 September 2017
doi: 10.3389/fneur.2017.00434

Video Head Impulse Tests with a Remote Camera System: Normative Values of Semicircular Canal Vestibulo-Ocular Reflex Gain in Infants and Children

Sylvette R. Wiener-Vacher[1,2] and Sidney I. Wiener[3]*

[1] Vestibulometry Unit, ORL Department, Robert Debré University Hospital, Paris, France, [2] INSERM U-1141, Robert Debré University Hospital, Paris, France, [3] Center for Interdisciplinary Research in Biology (CIRB), College de France, CNRS, INSERM, PSL Research University, Paris, France

OPEN ACCESS

Edited by:
Thyra Langhagen, German Center for Vertigo, Germany

Reviewed by:
Christoph Helmchen, University of Luebeck, Germany
Ted Raphan, Brooklyn College (CUNY), United States
Klaus Jahn, Schön Klinik Bad Aibling, Germany

***Correspondence:**
Sylvette R. Wiener-Vacher
sylvette.wiener@gmail.com
orcid.org/0000-0001-9410-3884

Specialty section:
This article was submitted to Neuro-Otology, a section of the journal Frontiers in Neurology

Received: *21 April 2017*
Accepted: *08 August 2017*
Published: *07 September 2017*

Citation:
Wiener-Vacher SR and Wiener SI (2017) Video Head Impulse Tests with a Remote Camera System: Normative Values of Semicircular Canal Vestibulo-Ocular Reflex Gain in Infants and Children. Front. Neurol. 8:434. doi: 10.3389/fneur.2017.00434

The video head impulse test (VHIT) is widely used to identify semicircular canal function impairments in adults. But classical VHIT testing systems attach goggles tightly to the head, which is not tolerated by infants. Remote video detection of head and eye movements resolves this issue and, here, we report VHIT protocols and normative values for children. Vestibulo-ocular reflex (VOR) gain was measured for all canals of 303 healthy subjects, including 274 children (aged 2.6 months–15 years) and 26 adults (aged 16–67). We used the Synapsys® (Marseilles, France) VHIT Ulmer system whose remote camera measures head and eye movements. HITs were performed at high velocities. Testing typically lasts 5–10 min. In infants as young as 3 months old, VHIT yielded good inter-measure replicability. VOR gain increases rapidly until about the age of 6 years (with variation among canals), then progresses more slowly to reach adult values by the age of 16. Values are more variable among very young children and for the vertical canals, but showed no difference for right versus left head rotations. Normative values of VOR gain are presented to help detect vestibular impairment in patients. VHIT testing prior to cochlear implants could help prevent total vestibular loss and the resulting grave impairments of motor and cognitive development in patients with residual unilateral vestibular function.

Keywords: balance disorders, vertigo, vestibular, vestibulo-ocular reflex, child development, gaze stabilization

INTRODUCTION

An important function of the vestibular system is to stabilize gaze during head movements. Semicircular canal function can be evaluated by measuring the vestibulo-ocular reflex (VOR) to head rotation. The VOR stabilizes gaze by synchronously rotating the eyes in the opposite direction of head movement. The head impulse test (HIT) is a widely used clinical test of the adequacy of the compensatory eye movements in response to application of a sudden, small amplitude head rotation in the plane of each pair of semicircular canals while the patient maintains gaze on a fixed target (1, 2). Severe vestibular canal function loss is characterized by visual observation by

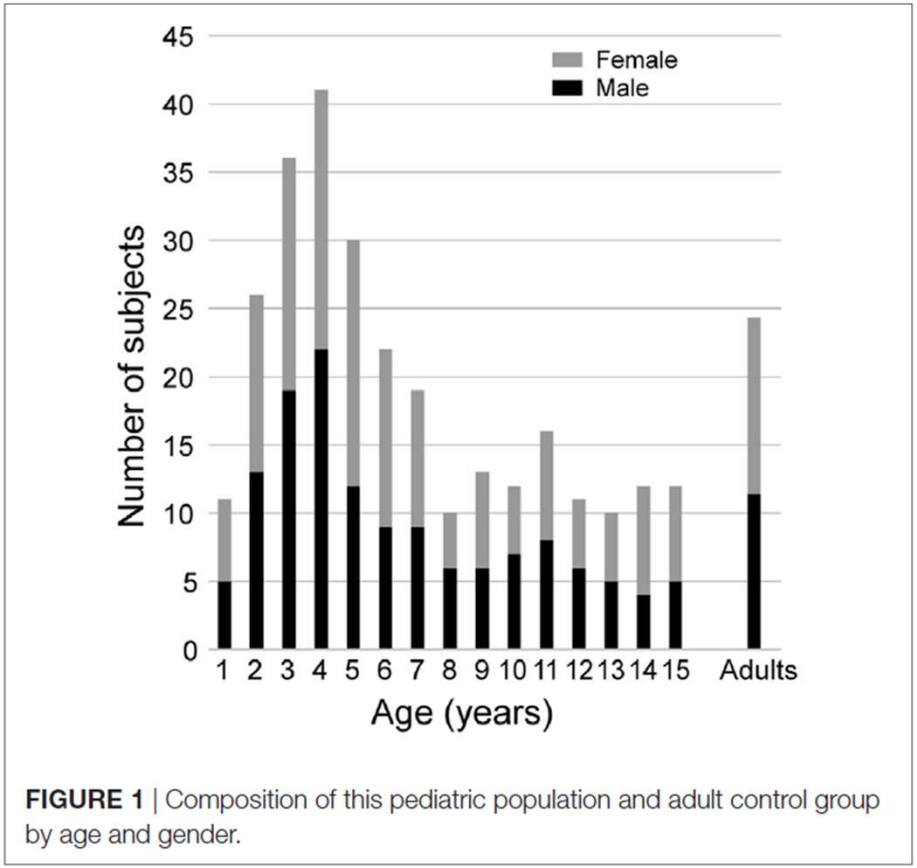


FIGURE 1 | Composition of this pediatric population and adult control group by age and gender.

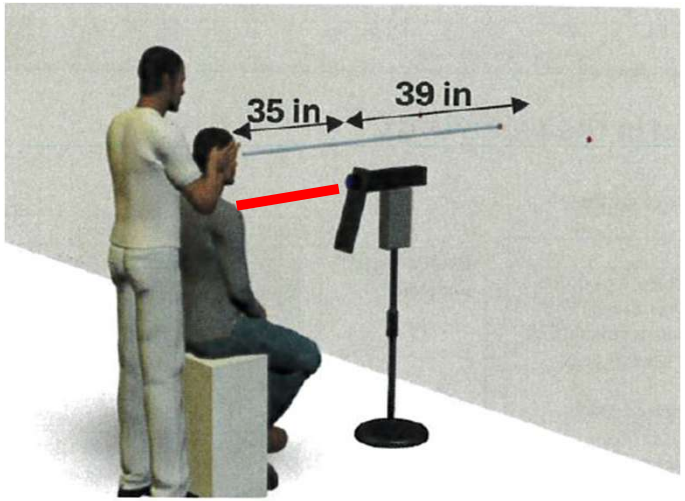
BOYS TOWN National Research Hospital

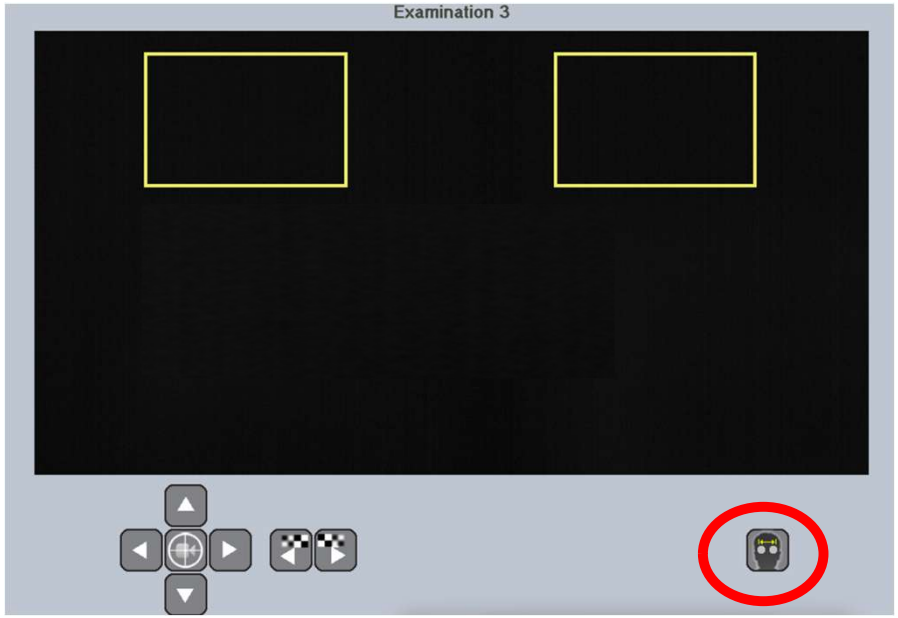
TABLE 1 | Normative values of vestibulo-ocular reflex gain as a function of age (CI = Confidence limit).

Age group	Anterior canal			Lateral canal			Posterior canal		
	Mean gain	95% CI lower	95% CI upper	Mean gain	95% CI lower	95% CI upper	Mean gain	95% CI lower	95% CI upper
1	0.95	0.88	1.02	0.90	0.85	0.97	0.87	0.82	0.92
2	0.95	0.92	0.98	0.88	0.86	0.90	0.89	0.86	0.92
3	0.95	0.93	0.97	0.91	0.89	0.92	0.93	0.91	0.95
4	0.98	0.96	0.99	0.95	0.93	0.96	0.96	0.94	0.97
5	0.97	0.95	0.99	0.95	0.93	0.97	0.96	0.94	0.98
6	0.98	0.96	1.00	0.96	0.94	0.98	0.94	0.92	0.96
7	0.98	0.96	1.00	0.97	0.95	0.99	0.96	0.94	0.98
8	1.02	1.00	1.04	0.98	0.95	1.00	0.98	0.96	1.00
9	1.00	0.99	1.01	0.98	0.94	1.01	0.98	0.96	1.00
10	0.99	0.97	1.02	0.98	0.95	1.01	0.98	0.96	1.00
11	1.00	0.98	1.02	1.01	0.98	1.03	1.00	0.97	1.02
12	1.02	0.98	1.05	0.99	0.96	1.01	0.99	0.96	1.02
13	1.02	0.98	1.05	1.00	0.98	1.02	1.03	0.99	1.06
14	1.03	1.00	1.06	1.01	0.98	1.04	1.02	0.99	1.05
15	1.02	0.99	1.05	1.02	1.00	1.04	0.99	0.96	1.02
Adult	1.03	1.01	1.05	1.02	1.00	1.04	0.99	0.97	1.01

Clean data is better than noisy data

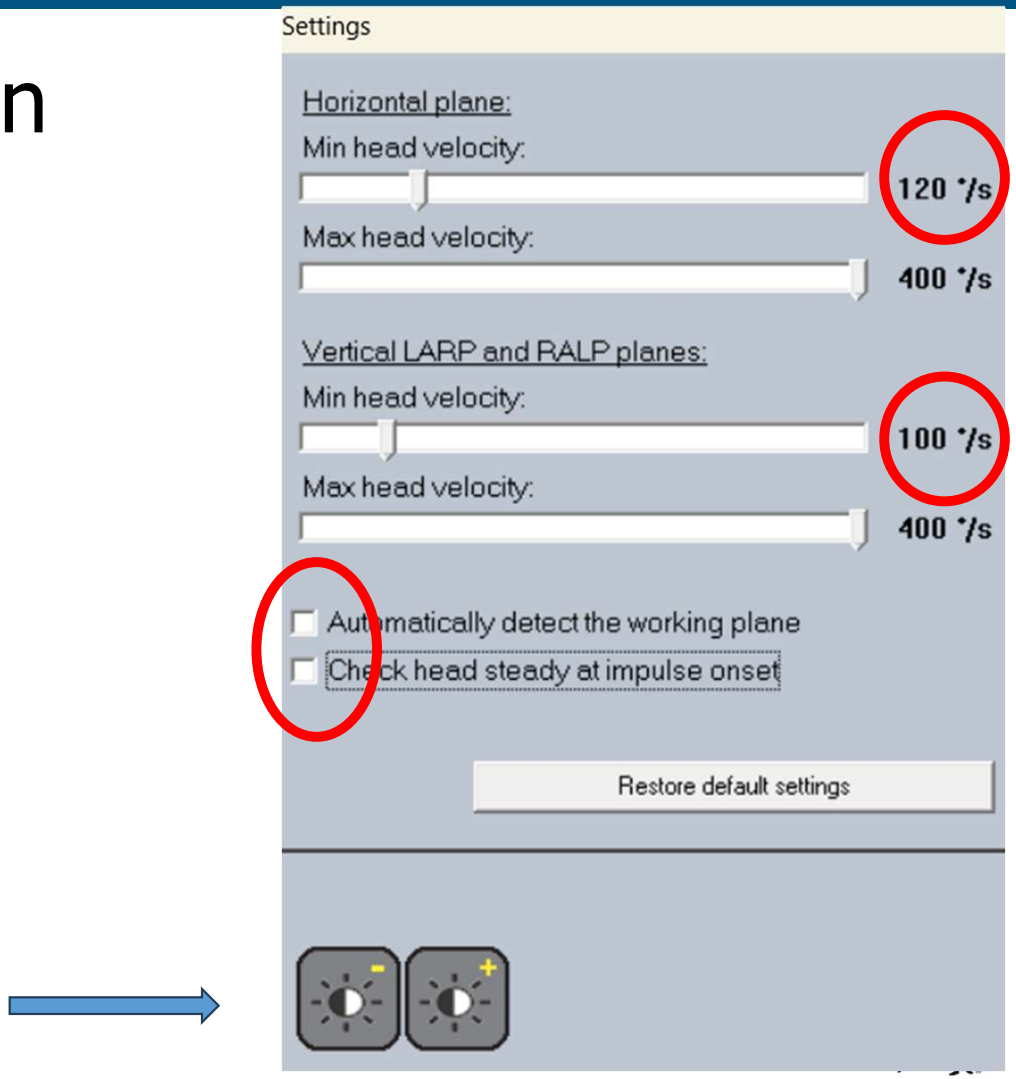
- Distance matters
  - Distance between the eyes
  - Distance from the camera
  - Distance to the target





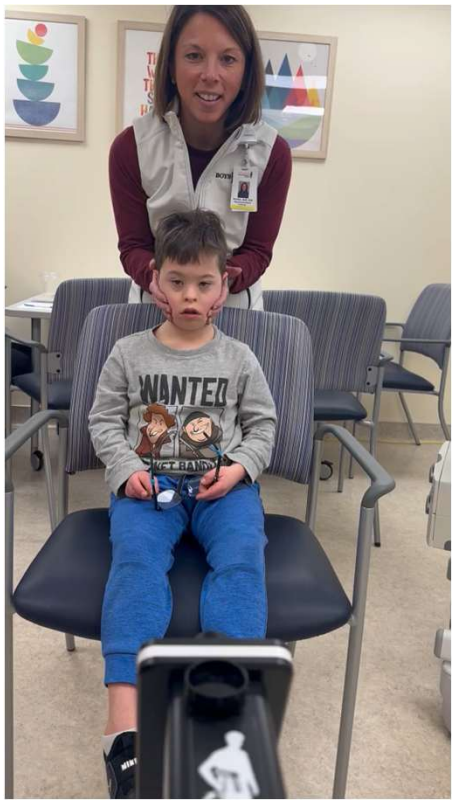
BOYS TOWN National Research Hospital

Clean data is better than noisy data



Clean data is better than noisy data

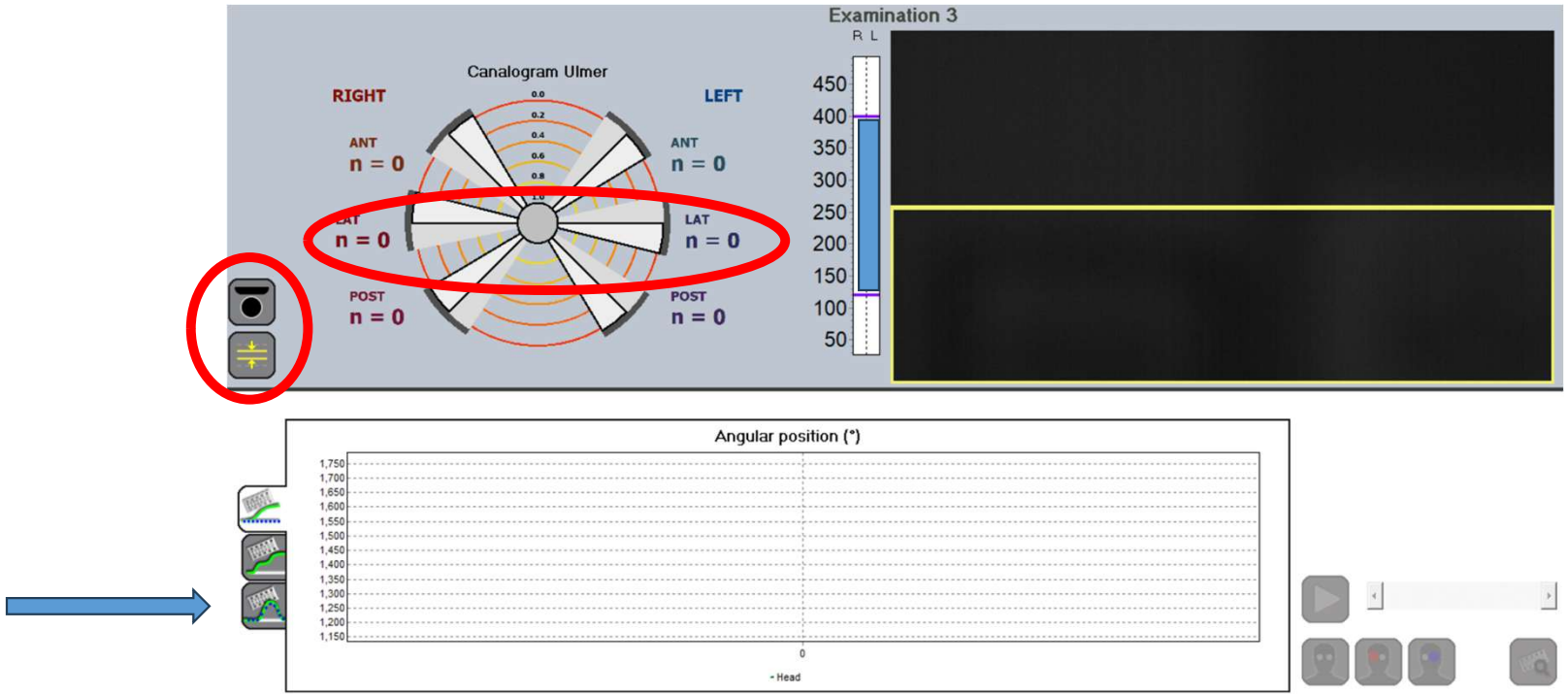
- Maintain steady gaze on target
  - Interesting target to sustain attention
    - Often use an iphone
  - Have a test assist (can be a parent)



BOYS TOWN
National Research
Hospital

Noisy data is better than no data

- Can alter sensitivity



BOYS TOWN National Research Hospital

Noisy data is better than no data

The VHIT software offers two tools to adjust head impulse collection selectivity.

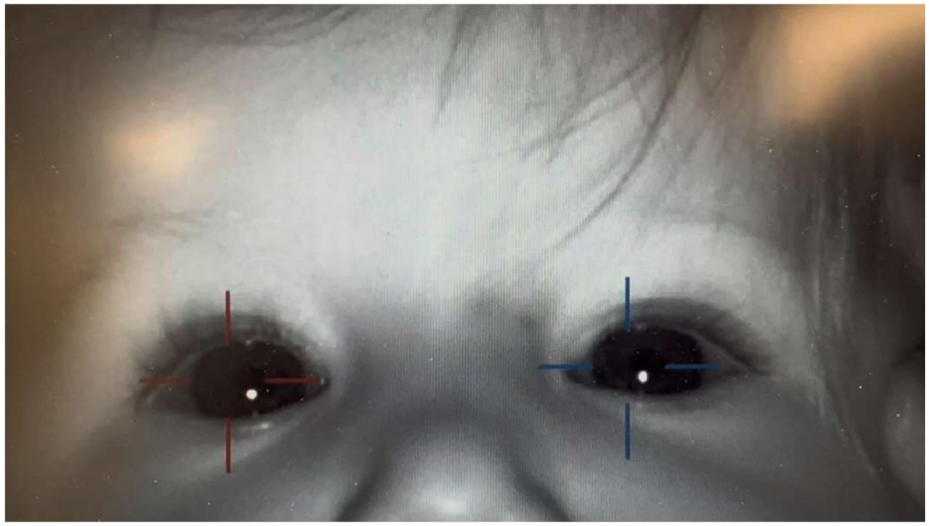
	Icon	Description
High selectivity		In this mode, a very high level of detail is extracted from the video image. This mode offers the maximum acquisition of HIT sequence which do not require manual correction. This should be your preferred mode
Standard selectivity		In this mode, selection of HIT movements is more flexible. More sequences will be acquired and sometimes more manual correction would be required than in high selectivity mode. This mode may be useful when pupil detection is difficult, as with heavily made-up eyes, or drooping eyelids.

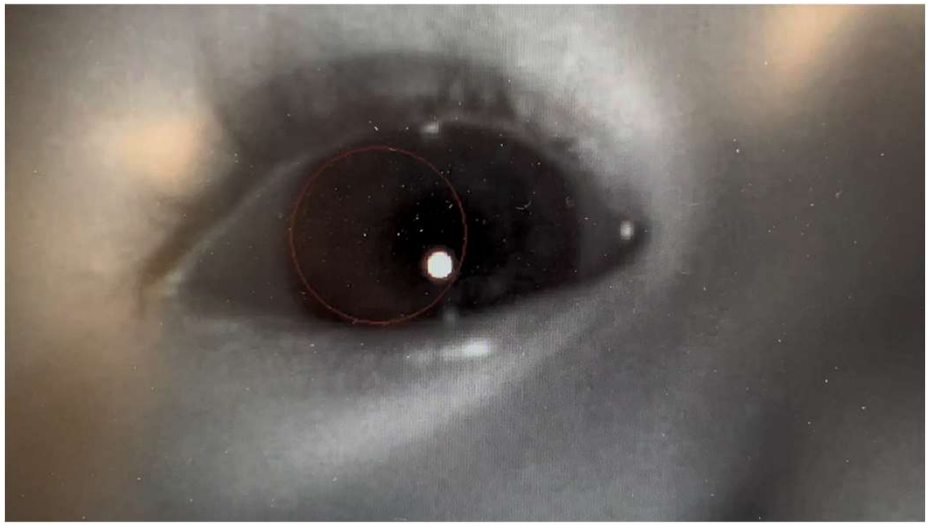
	Icon	Description
Eyelid cover rejected		This mode rejects impulses where eyelid cover happened in the time area used for calculations. This mode guarantees that nothing interferes with patient vision to fixate the target. This mode is activated by default and is the one to prefer
Eyelid cover accepted		This mode allows to accept impulses presenting eyelid cover. This mode can be useful for particular cases: systematic blinking reflex of patient, low eyelids, ptosis …

To reject/accept the eyelid cover cases, click on the button. For more information on eyelid cover please refer to corresponding section.

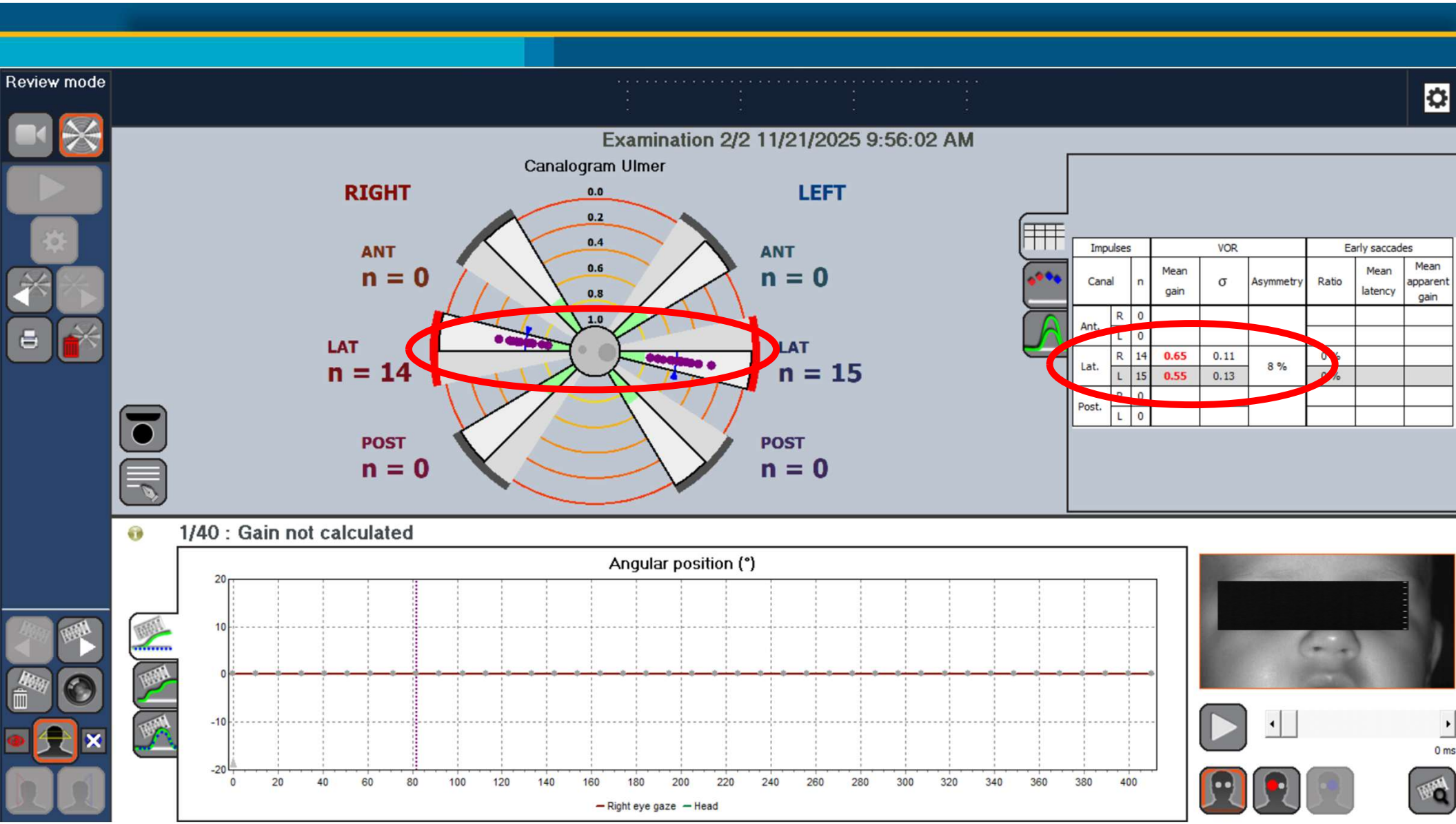
BOYS TOWN National Research Hospital

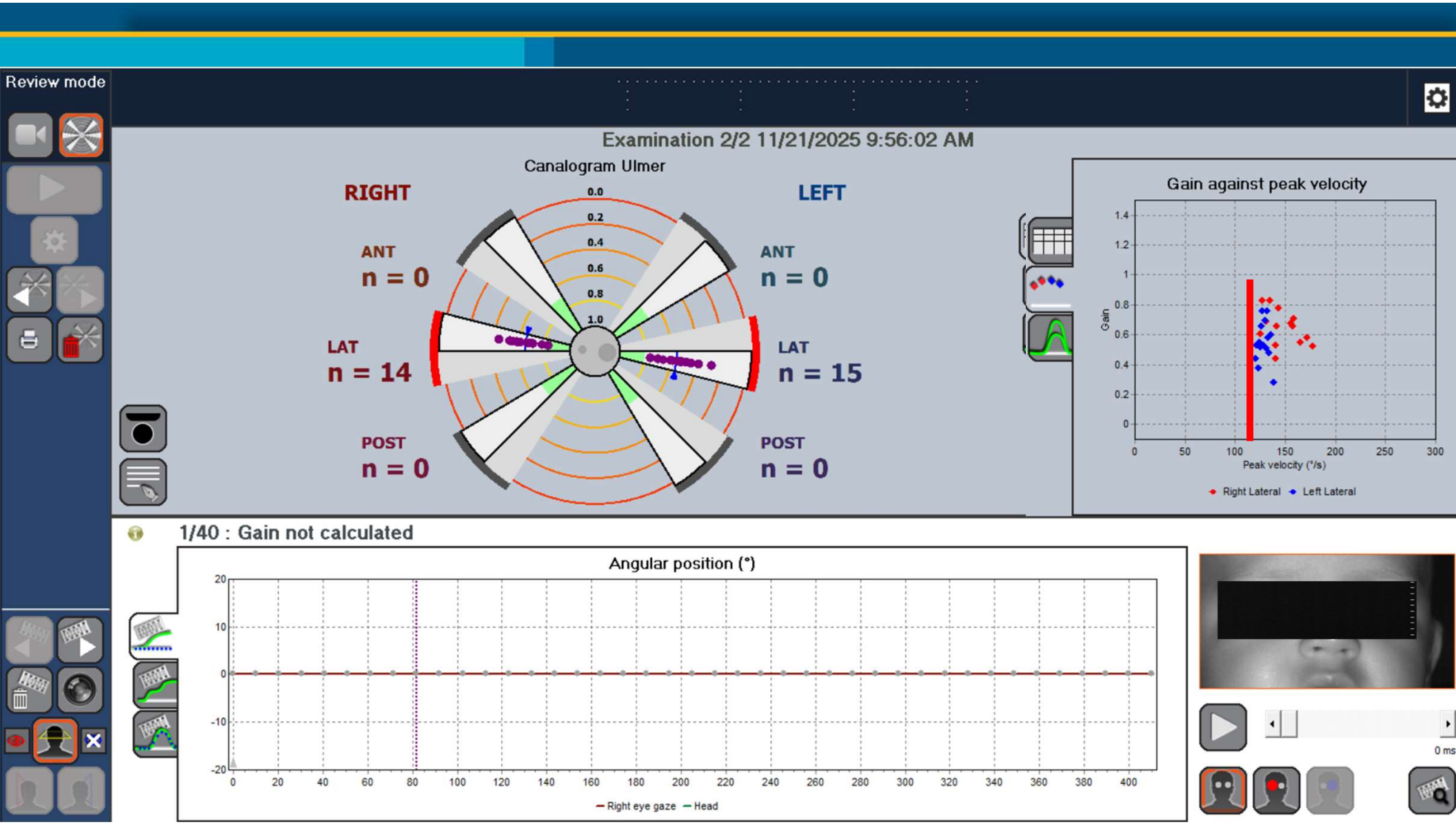
Even no data can be analyzed





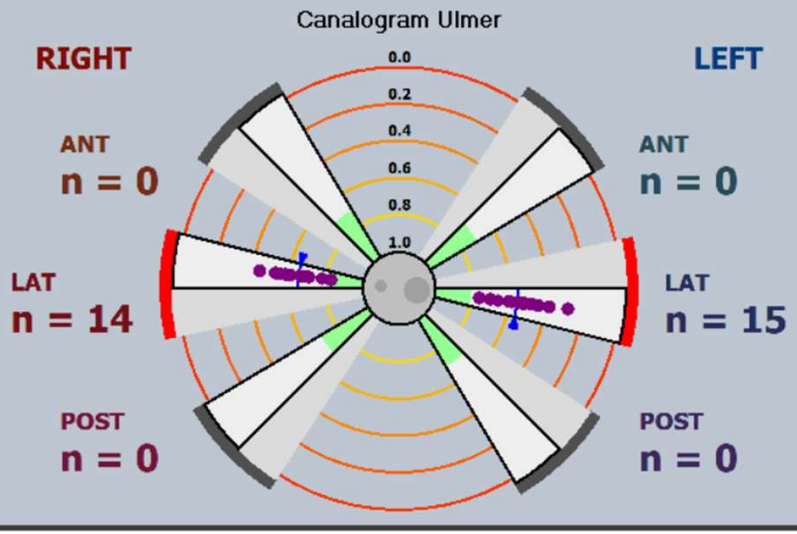
BOYS TOWN
National Research
Hospital

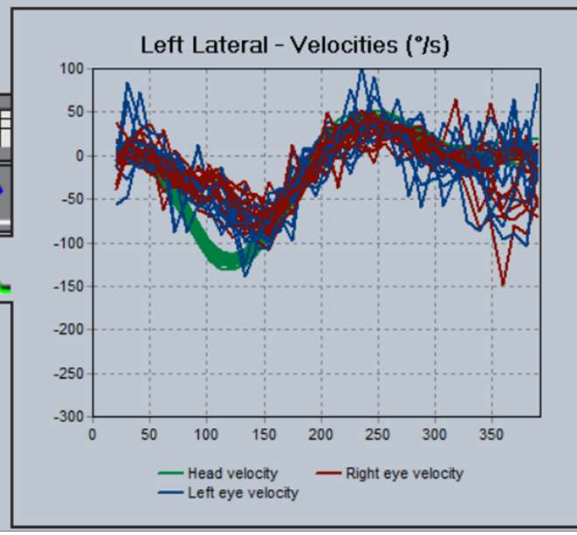

Review mode
Examination 2/2 11/21/2025 9:56:02 AM
Canalogram Ulmer
RIGHT
LEFT
ANT
n = 0
ANT
n = 0
LAT
n = 14
LAT
n = 15
POST
n = 0
POST
n = 0
0.0
0.2
0.4
0.6
0.8
1.0
Impulses
VOR
Early saccades
Canal
n
Mean gain
σ
Asymmetry
Ratio
Mean latency
Mean apparent gain
Ant.
R 0
L 0
Lat.
R 14
0.65
0.11
8 %
L 15
0.55
0.13
Post.
R 0
L 0
1/40 : Gain not calculated
Angular position (°)
20
10
0
-10
-20
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
Right eye gaze
Head
0 ms


Review mode
Examination 2/2 11/21/2025 9:56:02 AM
Canalogram Ulmer
RIGHT
LEFT
ANT
n = 0
ANT
n = 0
LAT
n = 14
LAT
n = 15
POST
n = 0
POST
n = 0
0.0
0.2
0.4
0.6
0.8
1.0
Gain against peak velocity
Gain
Peak velocity (°/s)
Right Lateral
Left Lateral
1/40 : Gain not calculated
Angular position (°)
Right eye gaze
Head
0 ms

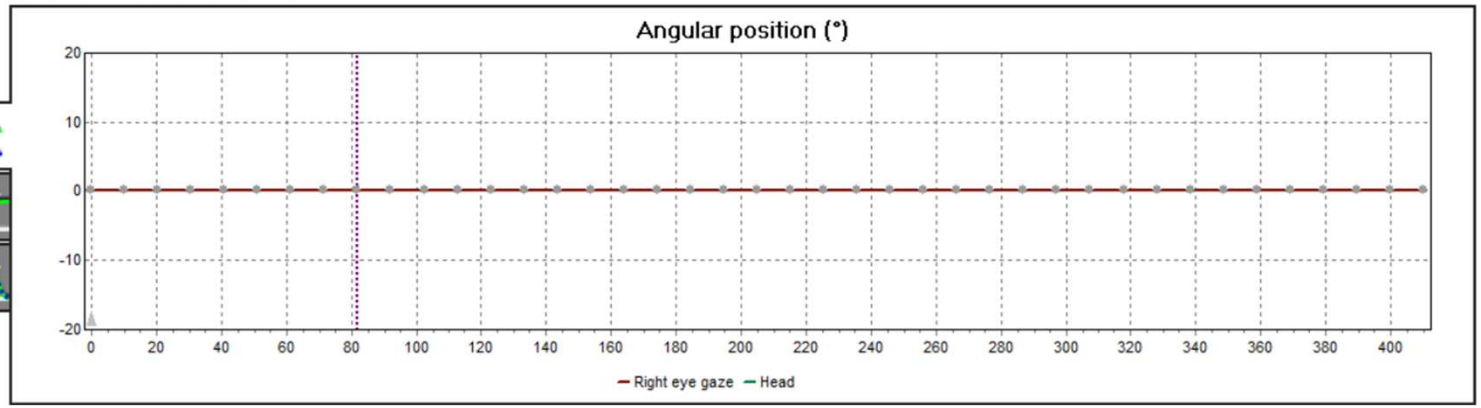
Review mode

Examination 2/2 11/21/2025 9:56:02 AM





1/40 : Gain not calculated

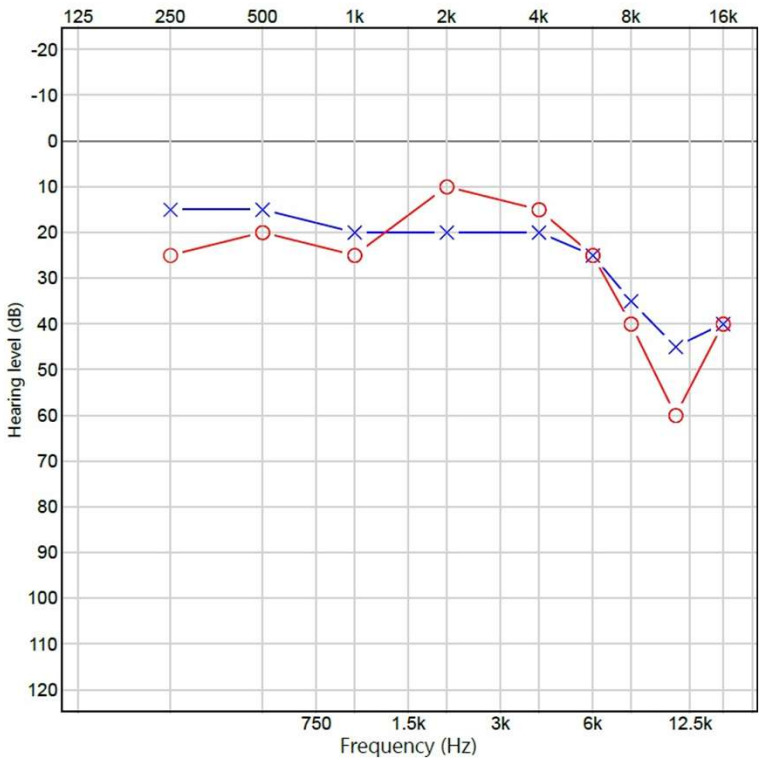


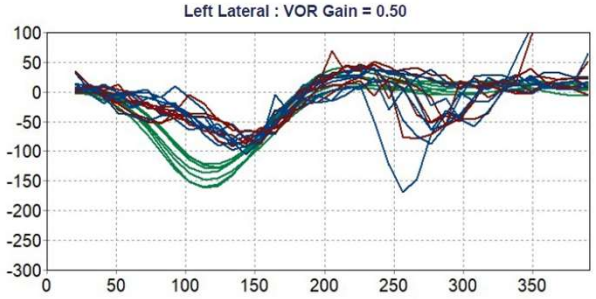
0 ms

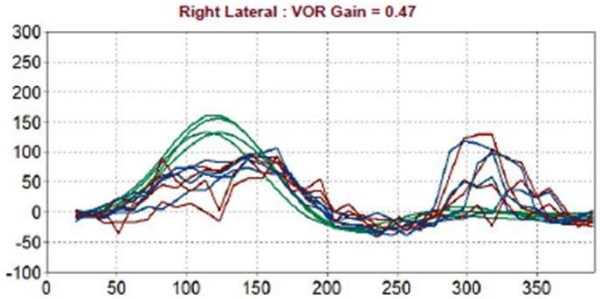
Pediatric case studies, including infants and children with limited test tolerance

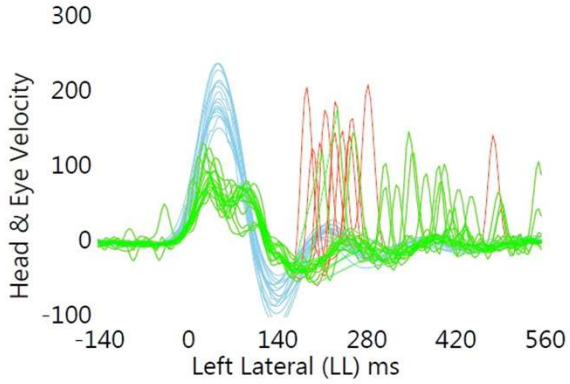
BOYS TOWN
National Research
Hospital

Case #1: Individual with Down syndrome

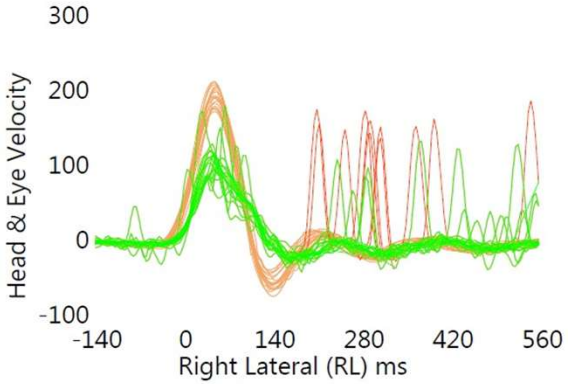








Mean Gains: 0.49

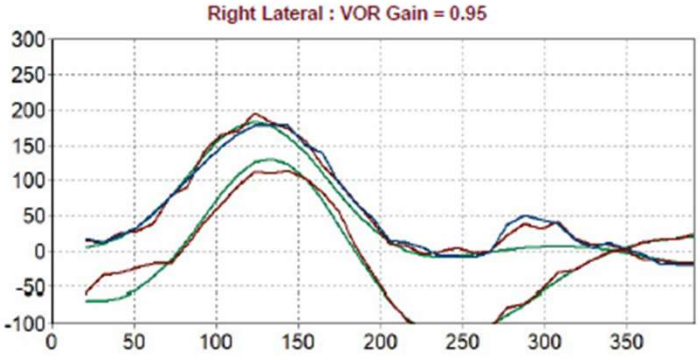


Mean Gains: 0.59

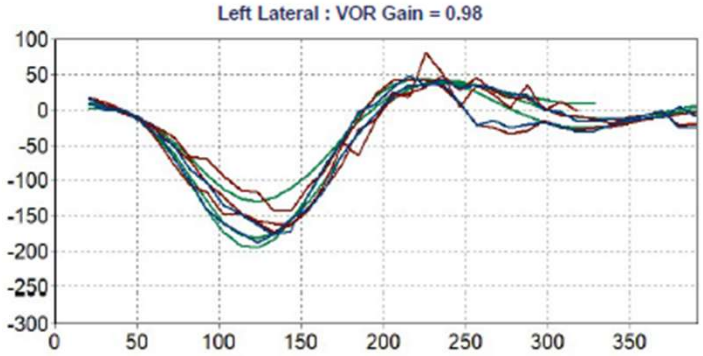
BOYS TOWN
National Research
Hospital

Case #2: 4-year-old; suspect autism spectrum disorder

- History of bilateral, profound sensorineural hearing loss.
- Would not tolerate traditional vHIT



Impulses			VOR		
Canal		n	Mean gain	σ	Asymmetry
Ant.	R	0			
	L	0			
Lat.	R	2	0.95	0.08	1 %
	L	3	0.98	0.05	
Post.	R	0			
	L	0			

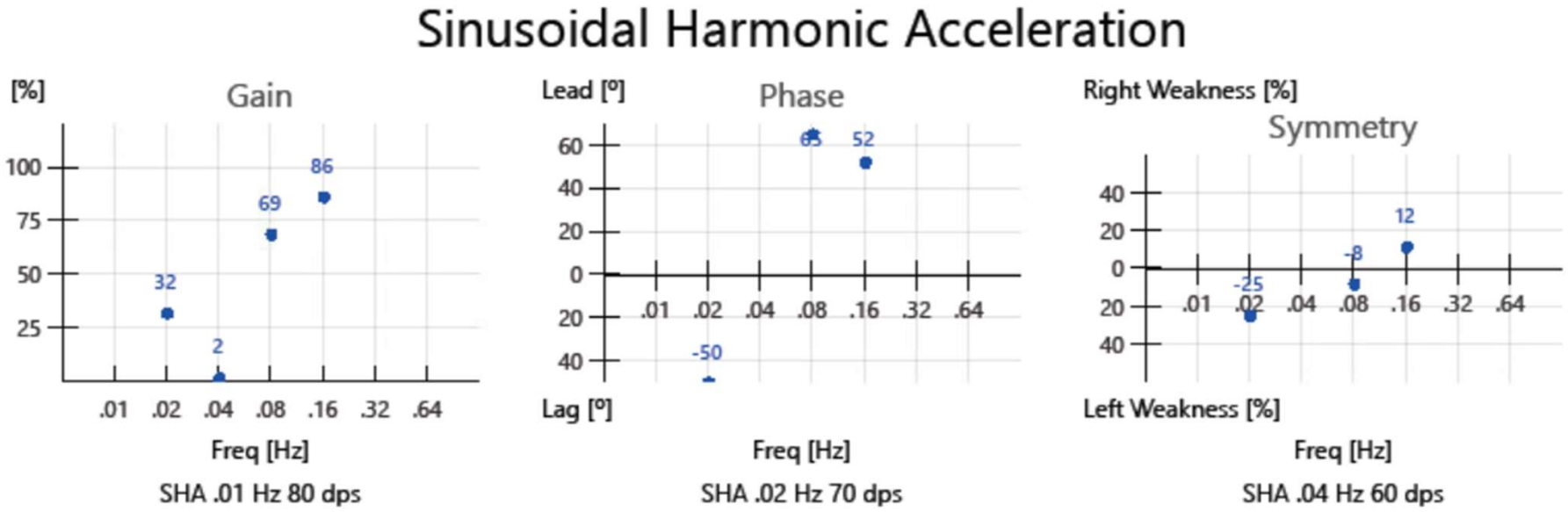


BOYS TOWN National Research Hospital

Case #3: Cochlear implant candidate

- bilateral, profound sensorineural hearing loss.
- Sat independently at 8 - 9 months and at age 12 months is pulling himself up to standing.
- MRI noted bilateral cochlear and vestibular dysplasia, but normal bilateral cochlear nerves. Specifically, the vestibules were noted to be fused with markedly hypoplastic lateral semicircular canal; however, the superior and posterior semicircular canals were noted to be normal.
- Aside from the hearing loss, mom denies any additional significant medical history.

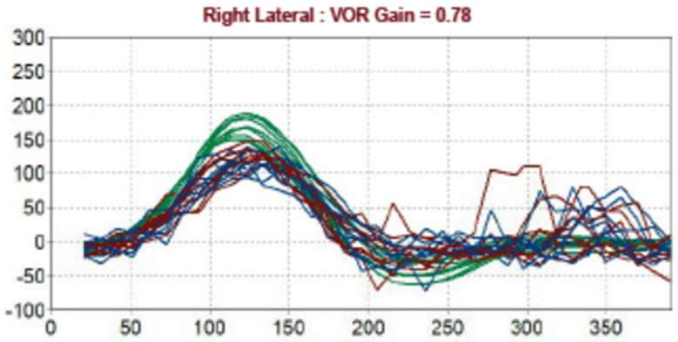
Case #3



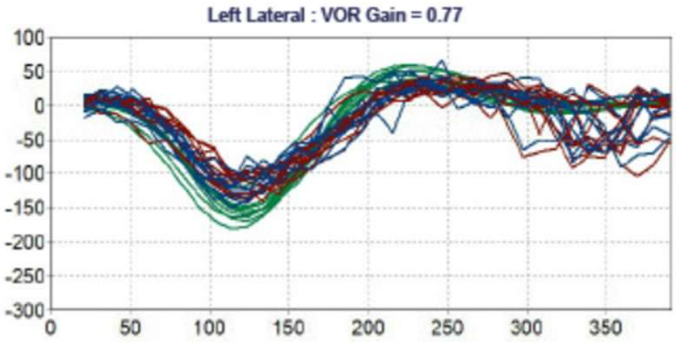
IMPRESSIONS: Rotary chair noted normal gain with abnormal phase at all test frequencies, thus not ruling out unilateral peripheral vestibular involvement;

BOYS TOWN National Research Hospital

Case #3



Impulses			VOR		
Canal		n	Mean gain	σ	Asymmetry
Ant.	R	0			
	L	0			
Lat.	R	9	0.78	0.11	0 %
	L	10	0.77	0.08	
Post.	R	0			
	L	0			



IMPRESSION: remote camera vHIT noted essentially normal function of both lateral semicircular canals.

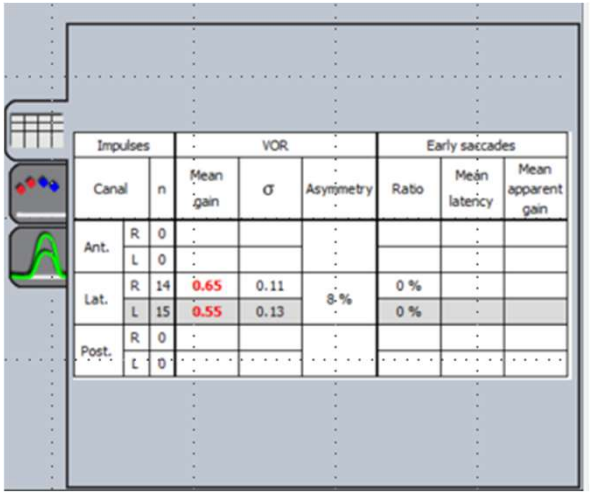
Monitor and reassess if concerns arise

BOYS TOWN National Research Hospital

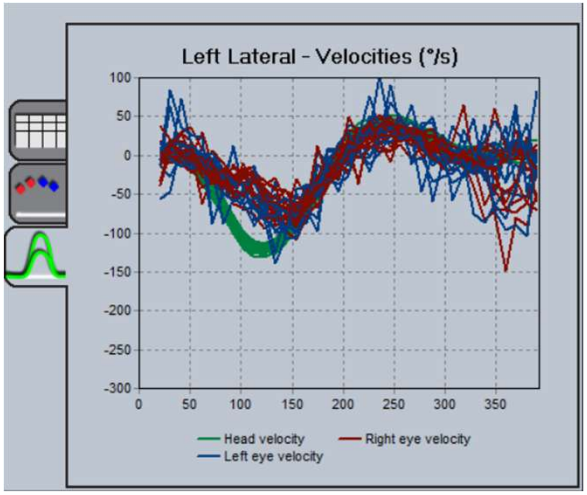
Case #3: Bilateral cochlear implants placed

- A few months following cochlear implant placement mom reports issues with head tilt and imbalance.
- Symptoms were accompanied by an issue with the processor; therefore, she was uncertain if the symptoms were related to the processor or if there was some vestibular involvement that occurred following implantation.
- Symptoms resolved within weeks.
- Outside of this brief period of symptoms, concerns for balance or dizziness were denied.

Case #3



Impulses			VOR			Early saccades		
Canal		n	Mean gain	σ	Asymmetry	Ratio	Mean latency	Mean apparent gain
Ant.	R	0						
	L	0						
Lat.	R	14	0.65	0.11	8 %	0 %		
	L	15	0.55	0.13		0 %		
Post.	R	0						
	L	0						



- **IMPRESSIONS**: Reduced gains bilaterally with 0.65 in the right horizontal canal and 0.55 in the left horizontal canal, representing a significant change from previous testing.

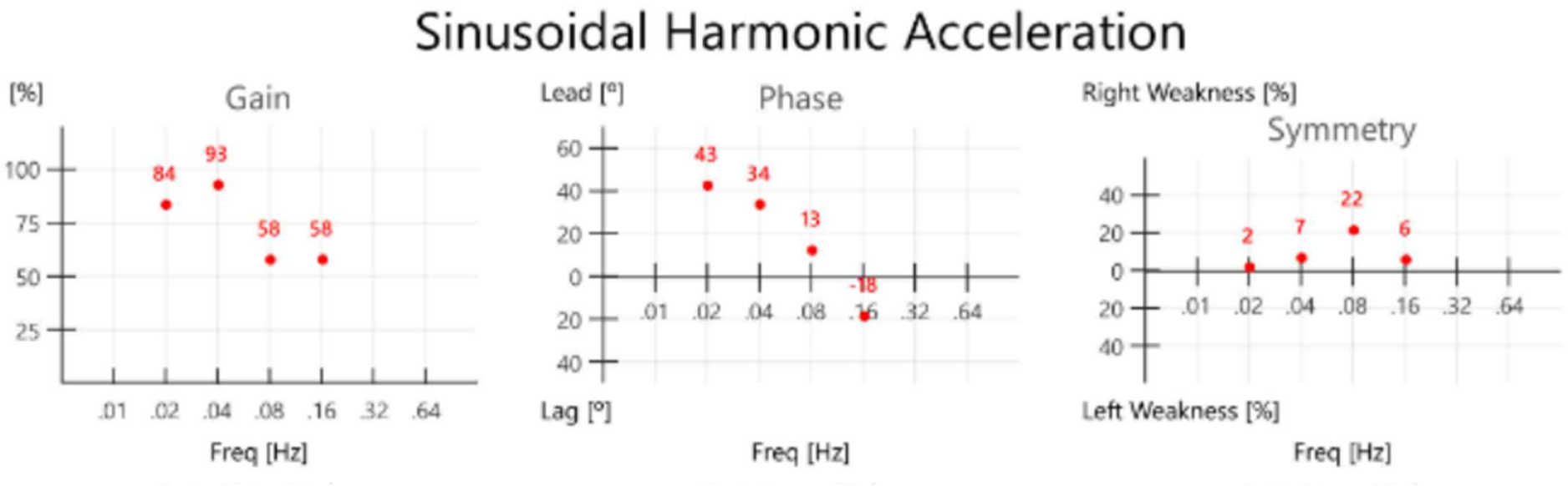
BOYS TOWN National Research Hospital

Case #4: Pediatric Hearing Clinic

- History of congenital CMV,
- Bilateral sensorineural hearing loss
- Bilateral placement of cochlear implants
- Prior to CI, rotary chair testing noted a phase lead suggestive of unilateral peripheral vestibular involvement without localization to the right or left ear.
- Testing was recommended today to confirm the presence of vestibular involvement
- Medical history is significant for focal seizures. A head ultrasound demonstrated ventriculomegaly with multiple focal calcifications.

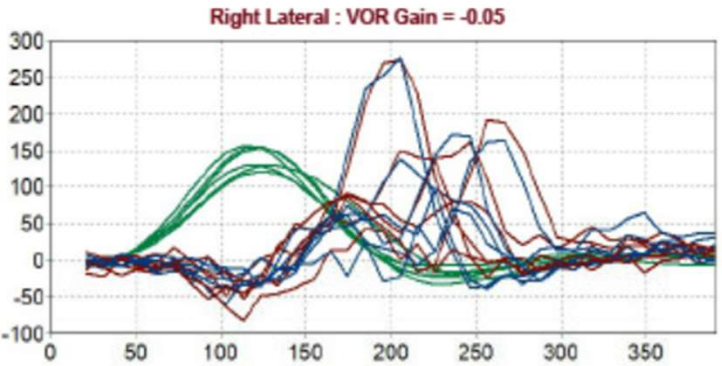
BOYS TOWN
National Research
Hospital

Case #4: Age 8 months

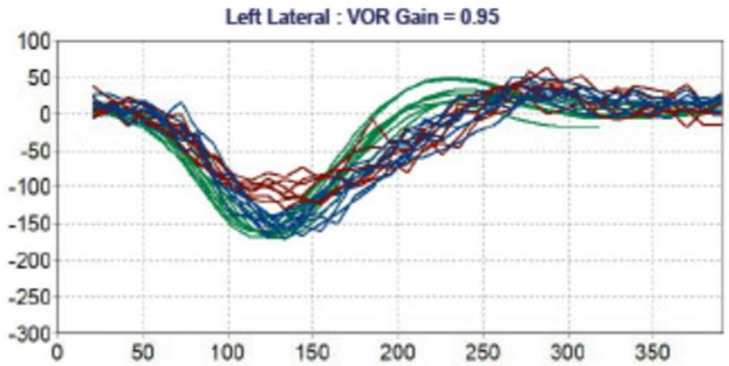


BOYS TOWN National Research Hospital

Case #4: Age 4 years



Impulses			VOR		
Canal		n	Mean gain	σ	Asymmetry
Ant.	R	0			
	L	0			
Lat.	R	6	-0.05		100 %
	L	8	0.95	0.04	
Post.	R	0			
	L	0			



IMPRESSIONS: Right vestibular involvement

Because vestibular involvement can be progressive with congenital CMV consider reassessment in the next few years or sooner if concerns arise. Cervical VEMP could be completed to assess integrity of the inferior vestibular nerve and saccule. He is a good candidate for vestibular rehabilitation.

BOYS TOWN National Research Hospital

BOYS TOWN
National Research
Hospital

The Laryngoscope

Case Report

Clinical Utility of Remote Camera Video Head Impulse Testing Children Less Than 3 Years

Kristen L. Janky, AuD, PhD; Jessie Patterson, AuD, PhD; Elizabeth A. Kelly, MD

The purpose of this case report is to highlight both the feasibility and clinical utility of remote camera video head impulse testing (vHIT) in children <3 years. Five cases are described where remote camera vHIT was used to quantify ear specific semicircular function in children at risk for vestibular dysfunction. Remote camera vHIT is a helpful clinical tool for quantifying ear specific semicircular function in children between 6 and 31 months. Remote camera vHIT is feasible and provides ear specific information regarding semicircular canal function, which can be used to augment or validate the presence of vestibular dysfunction in children <3 years.

Key Words: pediatric, vestibular, video head impulse test.

***Laryngoscope*, 00:1–6, 2024**

INTRODUCTION

In children <3 years, delayed gross motor milestones are an initial indicator of vestibular dysfunction.[1] Vestibular dysfunction is more prevalent in children with sensorineural hearing loss (SNHL), particularly SNHL that is severe-to-profound, early onset, or associated with congenital cytomegalovirus (CMV).[2] Thus, vestibular testing is recommended in children with gross motor delay, SNHL, or both.

Recently, bone-conducted cervical vestibular evoked myogenic potential (cVEMP) testing has been recommended as a first-tier vestibular screen for infants who fail their newborn hearing screening, resulting in vestibular testing being completed in children <12 months.[2] However, vestibular dysfunction can be missed in 4.6% of children using cVEMP alone[3] and semicircular canal function is a better predictor of functional outcomes,[4] suggesting that both semicircular canal and otolith assessment are warranted.

Rotary chair has been the gold standard for semicircular canal assessment in children <3 years; however, remote camera video head impulse testing (RC-vHIT) was recently introduced in infants.[5] The benefits of RC-vHIT are that it provides information about individual semicircular canal function and is less expensive and requires less physical space compared with rotary chair. RC-vHIT is feasible in infants; however, the clinical utility is unknown as it is only being utilized in a handful of clinics and laboratories worldwide. Pediatric vestibular testing is not a standard practice; therefore, the purpose of this case report is to highlight the feasibility and clinical utility of RC-vHIT in children <3 years.

CASE REPORTS

In all cases, RC-vHIT (Synapsis, Italy) was completed with the child seated on the parent's lap, 90 cm from the camera. The examiner stood behind the child and performed head impulses (10–20° head displacement, peak head velocity between 120 and 300°/s, and peak head acceleration between 1000°/s^2 and 2500°/s^2). A minimum of five head impulses were collected for each canal. The main outcomes were gain and frequency of compensatory saccades. RC-vHIT is not FDA approved; therefore, parents of all children provided informed consent (22-09-XP).

Case 1

Twenty-month-old male with bilateral, mild SNHL and gross motor delay. At 20 months, he is standing independently and walking with assistance. Medical history is significant for birth at 33 weeks, 20-day neonatal intensive care unit (NICU) stay, and diagnosis of Cornelia de Lange syndrome and torticollis. Normal bone-conducted cVEMP responses were obtained at 11 months (Fig. 1A); however, due to significant gross motor delay, additional testing was recommended. Rotary chair demonstrated normal gain with phase lead and rightward asymmetry, consistent with unilateral vestibular dysfunction (Fig. 1B). Due to concerns about nystagmus morphology, findings were validated with RC-vHIT, which was

From the Boys Town National Research Hospital (K.L.J., J.P., E.A.K.), Omaha, Nebraska, U.S.A.

Editor's Note: This Manuscript was accepted for publication on June 03, 2024.

The authors have no funding, or financial relationships to disclose.

All authors are employees at Boys Town National Research Hospital.

All authors have approved the final version and are accountable for all aspects of the manuscript. This work is not being considered for publication elsewhere. This work will be presented at the American Balance Society Meeting, Scottsdale, AZ on Thursday, February 29, 2024.

Send correspondence to Kristen L. Janky, Boys Town National Research Hospital, 555 N. 30th St. Omaha, NE 68131. Email: kristen.janky@boystown.org

DOI: 10.1002/lary.31580

Additional case studies?

BOYS TOWN National Research Hospital

Areas of Development

- Improved understanding of the relationship between RC-vHIT, VEMPs, and rotary chair across different pathologies
- Quantification of compensatory saccades using RC-vHIT
- Manipulation and review of the waveforms

BOYS TOWN National Research Hospital

Conclusion

- Remote camera vHIT is
  - a helpful clinical tool for quantifying ear specific semicircular function in children, particularly 6 – 36 months
  - feasible
  - provides complimentary, ear specific information regarding semicircular canal function, which can be used to augment or validate the presence of vestibular dysfunction in children.

BOYS TOWN National Research Hospital

We’ve been pleasantly surprised by the data we’ve been able to collect

BOYS TOWN
National Research
Hospital

VEDA

PROFESSIONAL MEMBER

Vestibular Disorders Association

Join Our Vestibular Community

International Pediatric Balance Network

Promoting excellence in balance care in children

VISION/MISSION

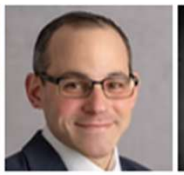
- Uniting professionals in pediatric balance and vestibular disorders
- Promoting research and education to enhance understanding and care
- Developing evidence-based guidelines for assessment and management
- Facilitating collaboration through an online community and networking tools
- Raising awareness across pediatric disciplines

BOARD MEMBERS

Sylvette Wiener-Vacher
ENT, FRANCE

Leen Maes
AUD,
BELGIUM

Ruth Van Hecke
AUD, BELGIUM



Jacob Brodsky
ENT, US

Jennifer B. Christy
PT, US

Sharon Cusing
ENT, CANADA

Josine Widdershoven
ENT, THE NETHERLANDS

Kirsten Janky
AUD, US

Soumit Dasgupta
NEUROTOLOGIST, UK

Alfarghal Mohamad
AUD, SAUDI ARABIA

WEBSITE (IPBN.NET)

DO YOU WANT TO JOIN? PLEASE LET US KNOW!

INFO@IPBN.NET

Questions?

kristen.janky@boystown.org

BOYS TOWN
National Research
Hospital

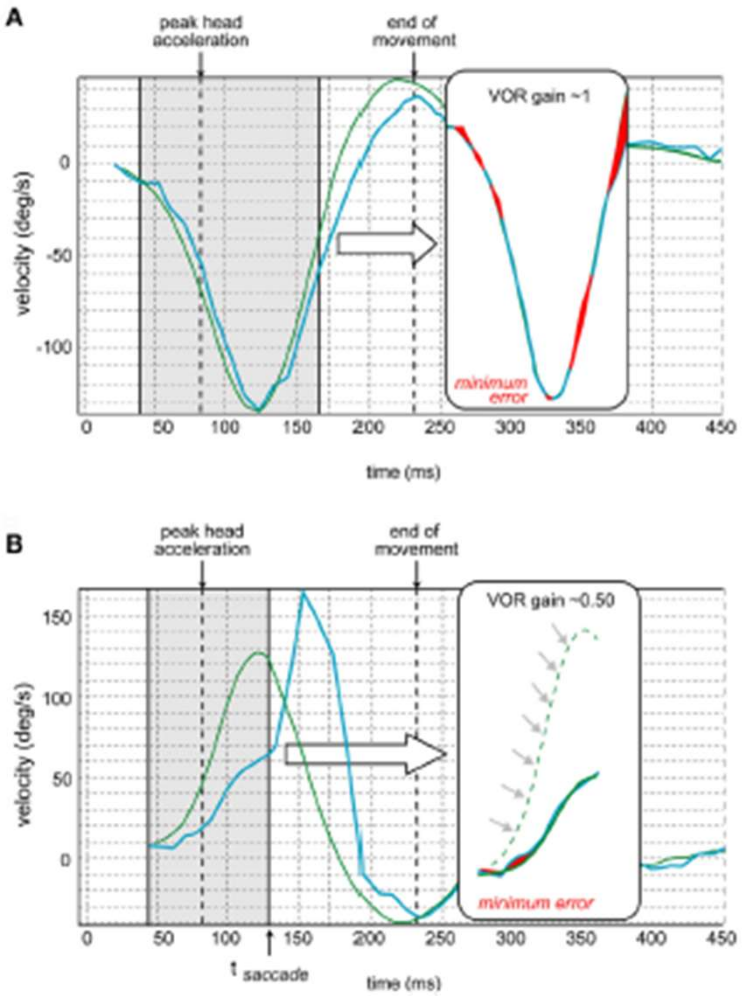


FIGURE 4 | Vestibulo-ocular reflex (VOR) gain calculation [also see Ref. (13)]. **(A)** The traces of the eye movement (in blue) and head movement (in green) velocities are juxtaposed. The program determines the time of the peak head acceleration. Then the gain is calculated over the period from 40 ms before to 80 ms after the peak head acceleration for each impulse. First, the curves of eye and head velocities are aligned by shifted them in time and amplitude to minimize their differences (*via* a least square method by varying two parameters: gain and latency). The red shaded areas in the insets correspond to this minimized error. The resulting aligned traces appear in the inset. **(B)** In case of a corrective saccade (not occurring in normal subjects but characteristic of pathological cases), the same calculation is performed but the period analyzed (in brackets) ends at the time of the onset of the saccade ($t_{saccade}$) that corresponds to the inflection point of the eye velocity. The resulting aligned traces appear in the inset. This schematic is from a different canal where the velocity is opposite that of **Figure 4A** (adapted from images provided by Synapsys®).

BOYS TOWN National Research Hospital