Cochlear Implant Failure

- Children with bilateral vestibular impairment were 8 times more likely to have CI failure
  - Likely linked to increase in falls due to balance deficit

TABLE 3. *Vestibular end-organ test results*

Test	Patients Without CI Failure (n = 165) No. (%)	Patients With CI Failure (n = 22) No. (%)	χ^2 *P* Value	Odds Ratio (95% CI)
Horizontal semicircular canal				
Abnormal caloric stimulation test	78 (47.3)	18 (81.8)	0.004	4.2 (1.4–13.0)
Bilateral areflexia	29 (17.6)	14 (63.6)	<0.0001	8.2 (3.1–21.4)
Abnormal video head impulse testing/high-frequency rotational chair response	57 (34.5)	16 (72.7)	0.001	5.7 (2.1–15.9)
Saccular function				
Abnormal VEMP	76 (46.1)	18 (81.8)	0.003	5.3 (1.7–16.2)
Bilaterally abnormal VEMP	32 (19.4)	11 (50.0)	0.001	4.2 (1.6–10.4)

Pediatric Superior Canal Dehiscence

Epidemiology of Dizziness and Balance Problems in Children in the United States: A Population-Based Study

Chuan-Ming Li, MD, PhD[1], Howard J. Hoffman, MA[1], Bryan K. Ward, MD[2], Helen S. Cohen, EdD, OTR[3], and Rose Marie Rine, PT, PhD[4,5]

- A multistage, nationally representative, probability sample of children (n = 10,954; aged 3-17 years) was examined based on the 2012 National Health Interview Survey Child Balance Supplement.
- Prevalence of dizziness and balance problems was 5.3% (3.3 million US children).
- 36.0% of children with dizziness and balance problems were seen by healthcare professionals during the past year and 29.9% received treatment.

J Pediatr. 2016 Apr;171:240-7.e1-3.

Identifying Vestibular Function in Children

- Children will rarely present to the physician with complaints of dizziness or vertigo
  - Limited communication abilities
  - Impairments are compensated for quickly
- This can lead to impairments being overlooked or dismissed.
- It is now possible to determine if functional balance deficit exists, localize the impairment and refer for intervention.

Why does this matter?

- "Kids just compensate"
  - What is needed for compensation (in adults)
    - Strong postural muscles, good vision, stable lesion, and a normal brain

- Effects on gross motor development
- Effects on reading
- Effects on CI failure

Dizziness Handicap for Children?

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

The development of the vanderbilt pediatric dizziness handicap inventory for patient caregivers (DHI-PC)

Devin L. McCaslin [a,*], Gary P. Jacobson [a], Warren Lambert [b], Lauren N English [a], Alison J Kemph [a]

[a] Vanderbilt University School of Medicine, Department of Hearing and Speech Sciences, Division of Vestibular Sciences, Nashville, TN, United States
[b] Vanderbilt Kennedy Center for Evaluation & Program Improvement, Nashville, TN, United States

DHI-P- (40 item)

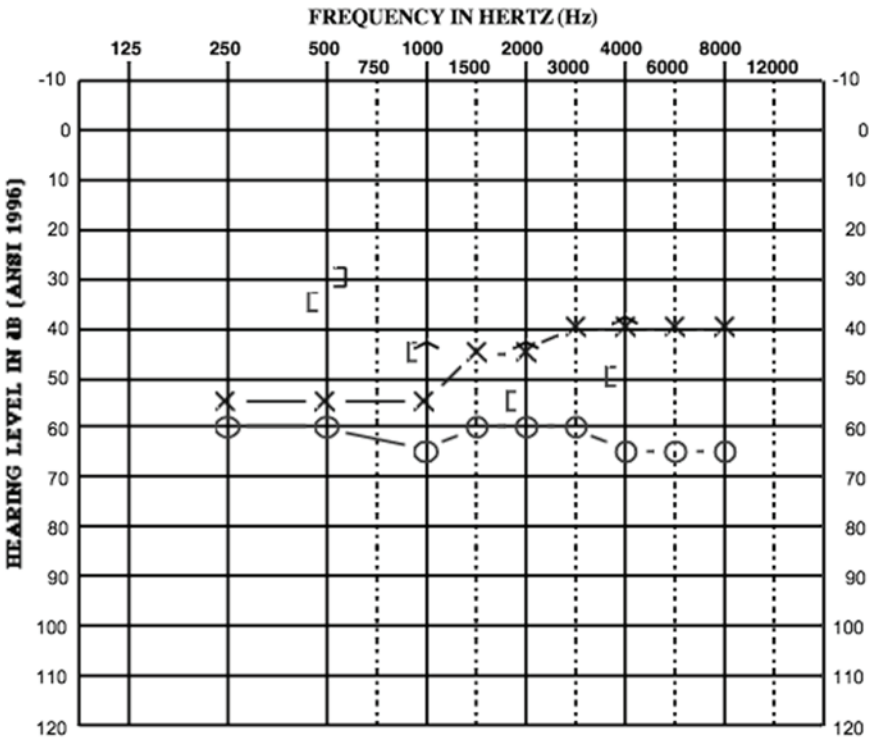
NAME: DATE:

PEDIATRIC DIZZINESS HANDICAP INVENTORY (DHI
(Age 5-12)

Instructions: The purpose of this questionnaire is to identify difficulties that your child may be experiencing because of your dizziness or unsteadiness. Please answer "yes", "no", or "sometimes" to each question. **Answer each question as it pertains to your child's dizziness problem only**.

	Yes (4)	Sometimes (2)	No (0)
Does looking up increase your child's problem?			
Does performing more ambitious activities like sports or active play, (running, jumping, etc.) increase your child's problem?			
Do quick movements of your child's head increase his/her problem?			
Does turning over in bed increase your child's problem?			
Because of your child's problem, is it difficult for him/her to walk unassisted?			
Does bending over increase your child's problem?			
Do other people ask if there is something wrong with your child's balance?			
Is your child's balance unpredictable?			
Does your child use a great deal of effort to keep his/her balance?			
Is your child unable to run and move as he/she likes?			
Does your child's problem make him/her feel tired?			

Example of DHI-P (8 yo with EVA)



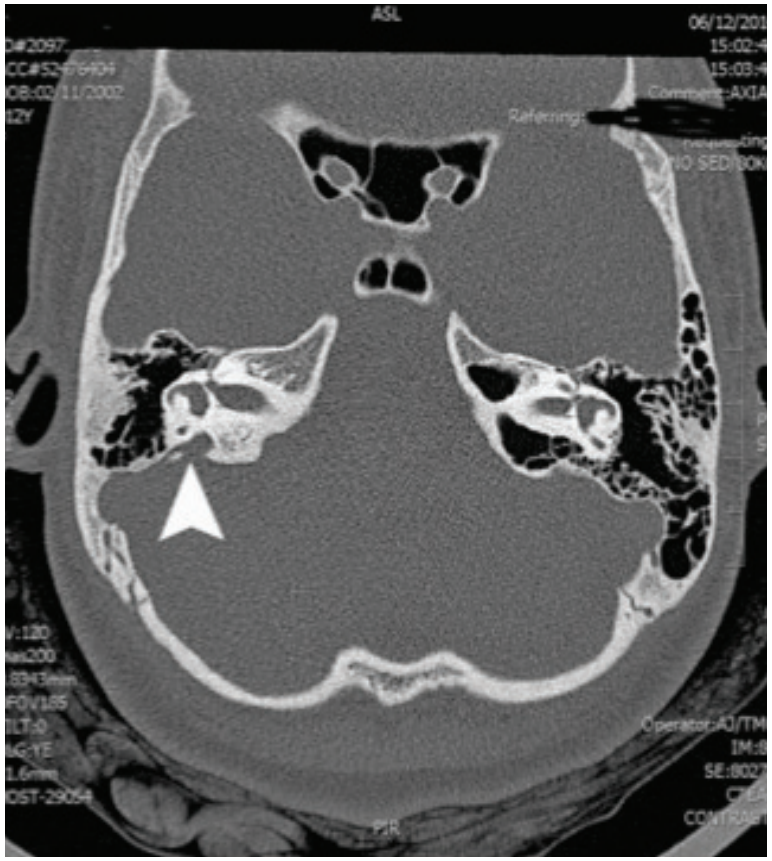
PEDIATRIC DIZZINESS HANDICAP INVENTORY (DHI)
(Age 5-12)

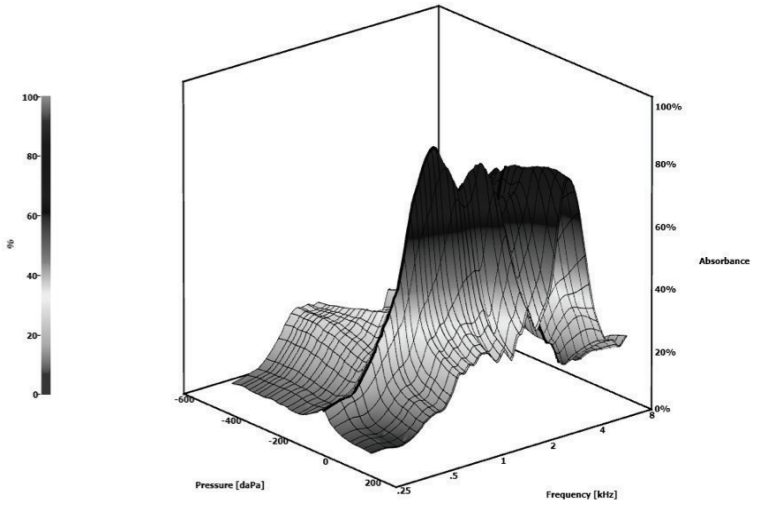
Instructions: The purpose of this questionnaire is to identify difficulties that your child may be experiencing because of his or her dizziness or unsteadiness. Please answer "yes", "no", or "sometimes" to each question.
Answer each question as it pertains to your child's dizziness problem only.

	Yes (4)	Sometimes (2)	No (0)
1. Because of your child's problem, is it difficult for him/her to walk unassisted?		X	
2. Does your child use a great deal of effort to keep his/her balance?		X	
3. Does your child's problem make him/her feel tired?			X
4. Is your child's life ruled by his/her problem?			X
5. Does your child's problem make it difficult for him/her to play?		X	
6. Because of his/her problem, does your child feel frustrated?		X	
7. Because of his/her problem, has your child been embarrassed in front of others?			X
8. Because of his/her problem, is it difficult for your child to concentrate?		X	
9. Because of his/her problem, is your child tense?		X	
10. Do other people seem irritated with your child's problem?			X
11. Do you find other people do not understand your child's problem?	X		
12. Is your child's balance unpredictable?	X		
13. Because of his/her problem, does your child worry?		X	
14. Because of his/her problem, does your child feel angry?			X
15. Because of his/her problem, does your child feel "down"?			X
16. Because of his/her problem, does your child feel unhappy?		X	
17. Because of his/her problem, does your child feel different from other children?			X
18. Does your child's problem significantly restrict his/her participation in social or educational activities, such as going to dinner, meeting with friends, field trips, or to parties?		X	
19. Because of your child's problem, is it difficult for him/her to walk around the house in the dark?		X	
20. Because of his/her problem, does your child have difficulty walking up stairs?			X
21. Because of his/her problem, does your child have difficulty walking one or two blocks?			X
22. Because of his/her problem, does your child have difficulty riding a bike or scooter?			X
23. Because of his/her problem, does your child have difficulty reading or doing schoolwork?		X	
24. Does your child's problem make it difficult to successfully do activities that others his/her age can do?		X	
25. Because of his/her problem, does your child have trouble concentrating at school?		X	
Version 2		TOTAL SCORE	

Score 34

Audio-vestibular Findings in EVA
(8 yo with EVA)





Stone & McCaslin, *ENT and Audiology News*, 2015

EVA and Dizziness

P	Age	Side of EVA	Size of EVA (mm)	DHI-P	Hearing	vHIT	oVEMP	cVEMP	Vibration	Caloric	Rotary Chair	Power Reflectance Peak
1	12	Right	R: 7.1	52	R: ✖ L: ✔	R: ✔ L: ✔	R: ✖ L: ✔	R: ✖ L: ✔	R: ✖ L: ✔	R: ✖ L: ✔ 72% UW	✔	R: ✖ L: ✔
2	8	Bilateral	R: 4.0 L: 3.2	34	R: ✖ L: ✖	R: ✔ L: ✔	R: ✔ L: ✔	R: ✔ L: ✔	R: ✔ L: ✔	R: ✔ L: ✔	✔	R: ✖ L: ✖
3	8	Left	L: 4.0	0	R: ✔ L: ✖	R: ✔ L: ✔	R: ✔ L: ✔	R: ✔ L: ✔	R: ✔ L: ✔	R: ✔ L: ✖ 30%UW	✔	R: ✔ L: ✖
4	6	Bilateral	N/A	0	R: ✖ L: ✖	R: ✖ L: ✖ Anterior canals only	R: ✖ L: ✔	R: ✔ L: ✔	R: ✔ L: ✔	R: ✔ L: ✔	✔	R: ✔ L: ✔
5	9	Left	N/A	6	R: ✔ L: ✖	R: ✔ L: ✔	R: ✖ L: ✖	R: ✔ L: ✔	N/A	R: ✔ L: ✔	✔	R: ✖ L: ✖

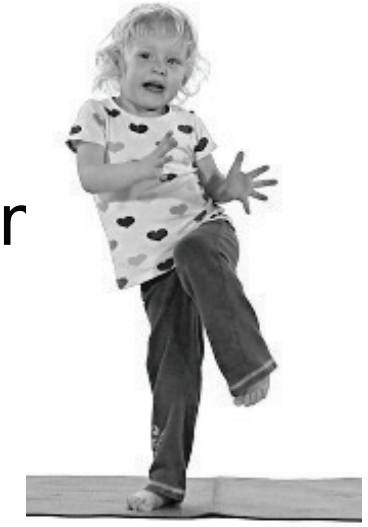
Stone and McCaslin, 2014.

EVA and Hearing Loss

- Pearson Correlations
  - 500 Hz ABG and fundus width (r = .105, p > 0.391)
  - 500 Hz ABG and midpoint width (r = .396**, p = .001)
  - 500 Hz ABG and porous width (r = .466**, p < .001). Strongest correlation
  - 1000 Hz ABG and fundus width (r = .035, p = .778)
  - 1000 Hz ABG and midpoint width (r = .276*, p = .022)
  - 1000 Hz ABG and porous width (r = .361**, p = .002) Strongest correlation

The Questionnaire for Dizziness, Eye, and Balance (Q-DEB) Function for Children and Adolescents

- Currently, no screening device exists to identify infants, children, and adolescents at risk for vestibular related impairments
- The purpose of this study is to develop a questionnaire to be used for screening vestibular related problems in children fror 1-21 years of age.



Christy, Rine, and McCaslin, APTA 2017

Additional Questionnaires

- The Pediatric Vestibular Symptom Questionnaire: A Validation Study (Pavlou et al., 2016).

Table I. The PVSQ

The following questions ask about how often you feel dizziness and unsteadiness. Please circle the best answer for you.
How often in the past month have you felt the following?

1. A feeling that things are spinning or moving around

3	2	3	4	?
Most of the time	Sometimes	Almost never	Never	Don't know

2. Unsteadiness so bad that you actually fall

3	2	3	4	?
Most of the time	Sometimes	Almost never	Never	Don't know

3. Feeling sick

3	2	3	4	?
Most of the time	Sometimes	Almost never	Never	Don't know

4. A light-headed or swimmy feeling in the head

3	2	3	4	?
Most of the time	Sometimes	Almost never	Never	Don't know

5. Feeling of pressure in the ear(s)

3	2	3	4	?
Most of the time	Sometimes	Almost never	Never	Don't know

6. Blurry vision, difficulty seeing things clearly, and/or spots before the eyes

3	2	3	4	?
Most of the time	Sometimes	Almost never	Never	Don't know

7. Headache or feeling of pressure in the head

3	2	3	4	?
Most of the time	Sometimes	Almost never	Never	Don't know

8. Unable to stand or walk without holding on to something or someone

3	2	3	4	?
Most of the time	Sometimes	Almost never	Never	Don't know

9. Feeling unsteady, about to lose balance

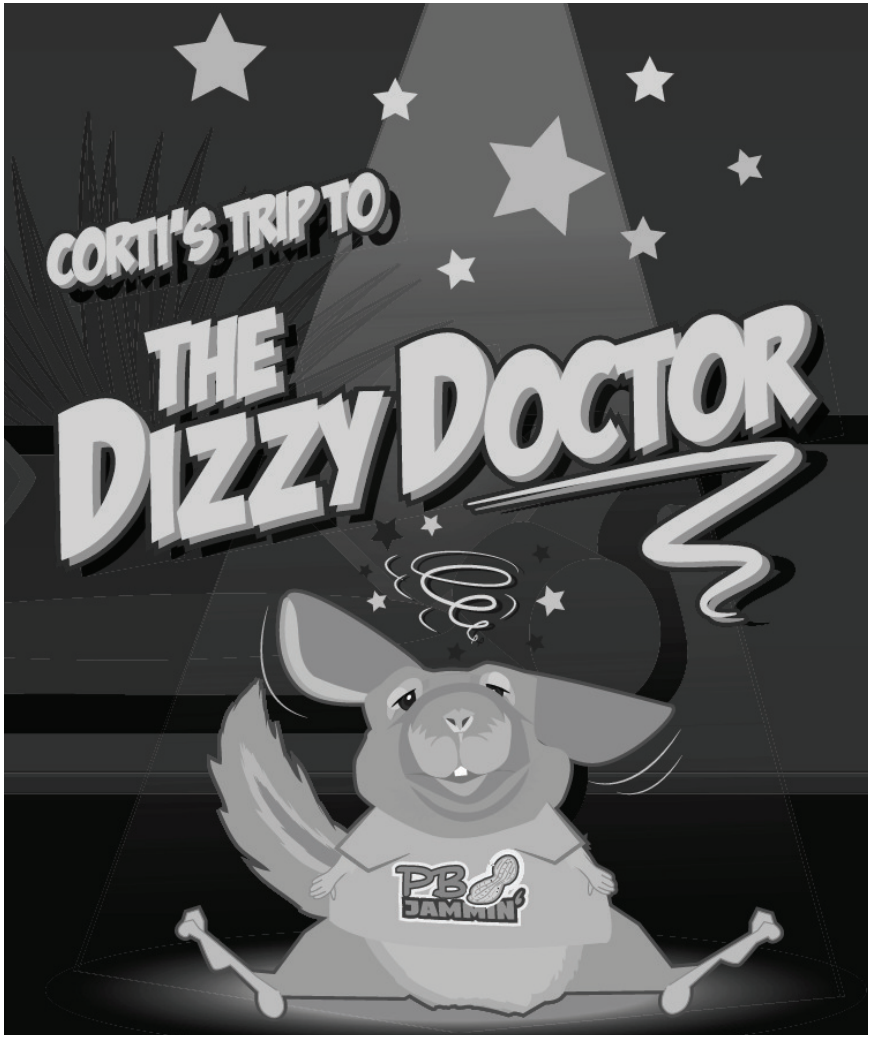
3	2	3	4	?
Most of the time	Sometimes	Almost never	Never	Don't know

10. A fuzzy or cotton wool feeling in the head

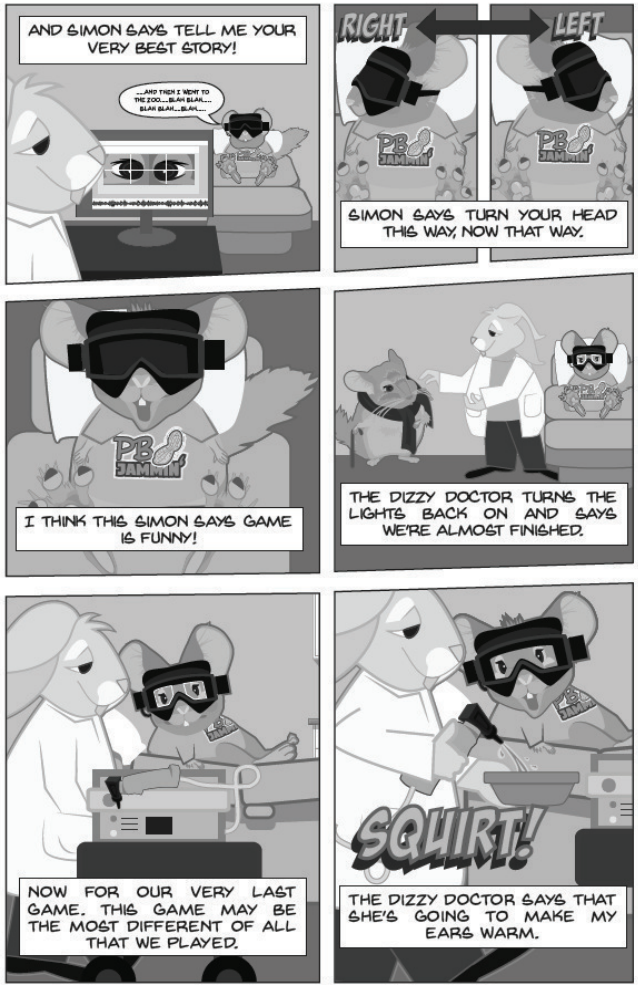
3	2	3	4	?
Most of the time	Sometimes	Almost never	Never	Don't know

11. Do any of these symptoms stop you doing what you want to do?
If yes, which ones? .....

Pediatric Materials



Pediatric Materials



Role of the Audiologist

- In pediatric patients be sure to ask the parent or caregiver about concerns with dizziness or balance.
- Questionnaires
  - pDHI
  - PVSQ
  - Q-DEB

Outline

- Background
- Review of Anatomy and Physiology
- Superior Canal Dehiscence
- Pediatrics
- Noise induced hearing loss
- Meniere's Disease

Physiological and Morphological Assessment of the Saccule in Guinea Pigs After Noise Exposure

Wei-Chung Hsu, MD, PhD; Jung-Der Wang, MD, PhD; June-Horng Lue, PhD; An-Shiou Day, MD; Yi-Ho Young, MD

- Group reported that noise exposure results in a loss of VEMPs in guinea pigs.
- Used both light and electron microscopy to confirm the loss of VEMPs after noise exposure was related to saccular impairment.

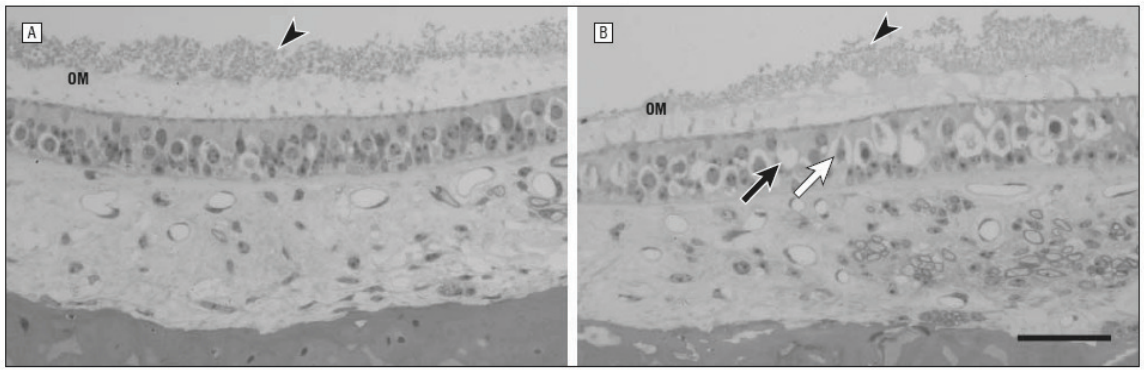
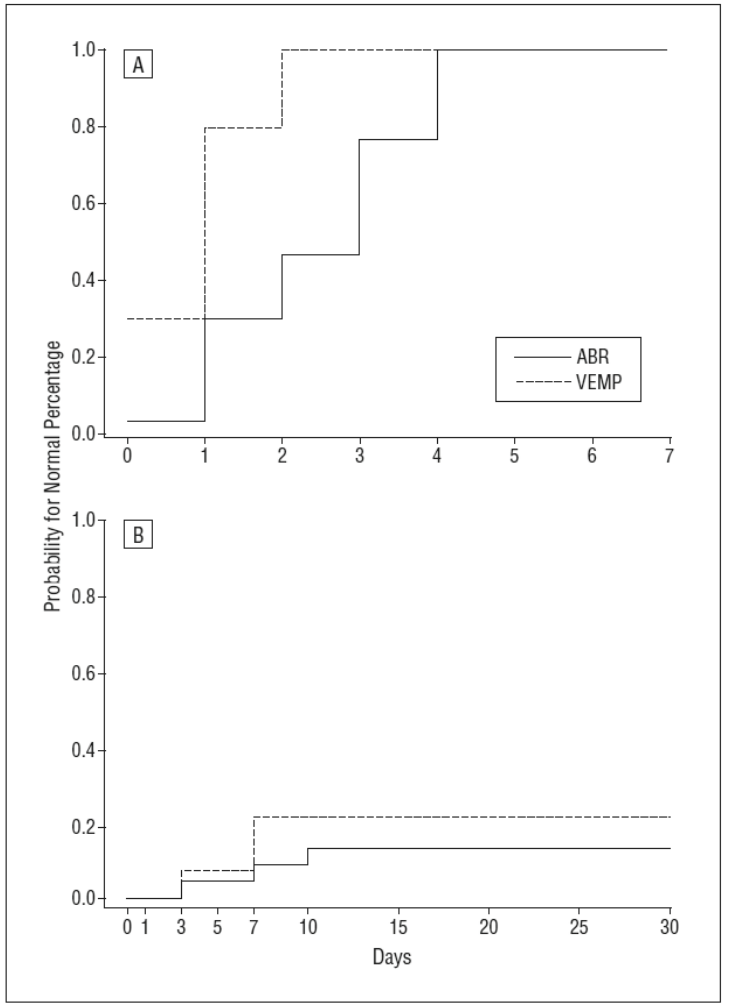


Figure 5. Light microscopic photomicrographs of the saccule. A, Guinea pig with normal vestibular-evoked myogenic potentials (VEMPs) 1 week after short-term noise exposure. B, Guinea pig with absent VEMPs 1 month after long-term noise exposure. Note that the loss (black arrow) and disruption (white arrow) of hair cells in the saccular macula are only found in panel B but not in panel A. Otoconia (arrowheads) are normal in both A and B. OM indicates otolithic membrane. (Toluidine blue stain, scale bar=200 μm.)

VEMPs and Noise Induced Hearing Loss

- Figure shows recovery curves of cVEMP responses and ABR thresholds.
  - (A) short-term
  - (B) long-term



International Journal of Audiology 2009; 48:655–660

Ten-year longitudinal study of the effect of impulse noise exposure from gunshot on inner ear function

- A longitudinal study investigating how chronic exposure to gunshot noise can reduced cochlear and saccular function.
- Twelve subjects over 10 years were tested with both audiometry and cVEMPs.

VEMPs and Noise Induced Hearing Loss

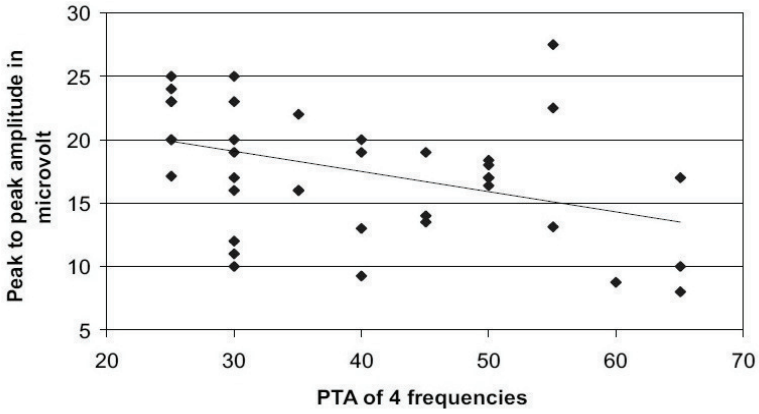
- Abnormal VEMP responses were evident in nine police officers (75%).
- The authors also concluded that a decrease in hearing may occur after long term exposure to gunfire.

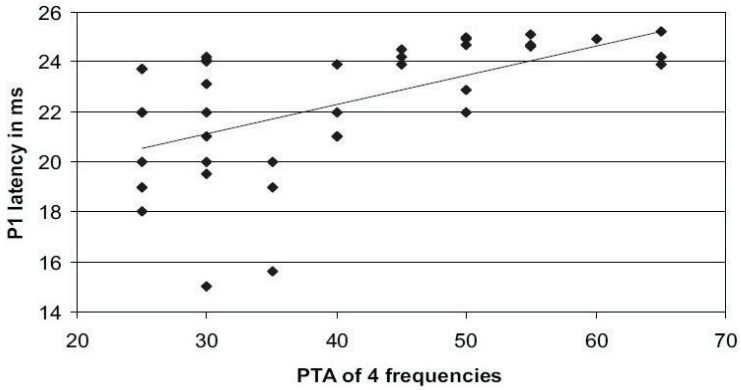
VEMPs and Noise Induced Hearing Loss

- cVEMPs were recorded in 30 subjects (55 ears) with NIHL and age range of 30-40 years.
- VEMP recordings were done at 99 dBnHL using a commercially available evoked-potential system.
- The study showed that as the average pure tone hearing threshold increased, the VEMP latencies were prolonged and peak to peak amplitude were reduced in subjects exposed to noise.

Kumar et al., 2010, *Noise & Health,* 2010

VEMPs and Noise Induced Hearing Loss



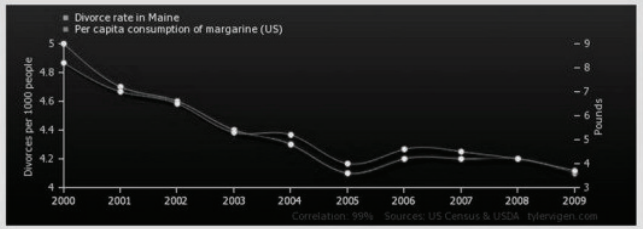


"The Pearson correlation test indicated significant correlation between pure tone average and different VEMP parameters tested (r = 0.67, P<0.01, r = 0.56, P<0.01 and r = -0.40, P<0.01, respectively for P1 latency, N1 latency and peak to peak amplitude)"

Kumar et al., 2010, *Noise & Health,* 2010

Correlations

Divorce rate in Maine
correlates with
Per capita consumption of margarine (US)

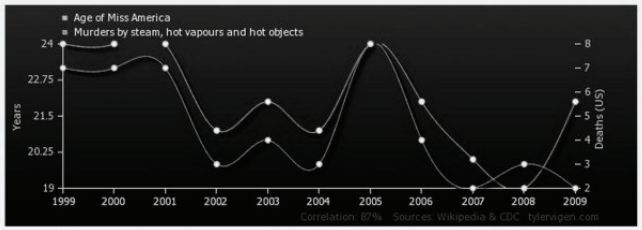


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Divorce rate in Maine *Divorces per 1000 people (US Census)*	5	4.7	4.6	4.4	4.3	4.1	4.2	4.2	4.2	4.1
Per capita consumption of margarine (US) *Pounds (USDA)*	8.2	7	6.5	5.3	5.2	4	4.6	4.5	4.2	3.7

Correlation: 0.992558

Permalink - Mark as interesting - Not interesting

Age of Miss America
correlates with
Murders by steam, hot vapours and hot objects

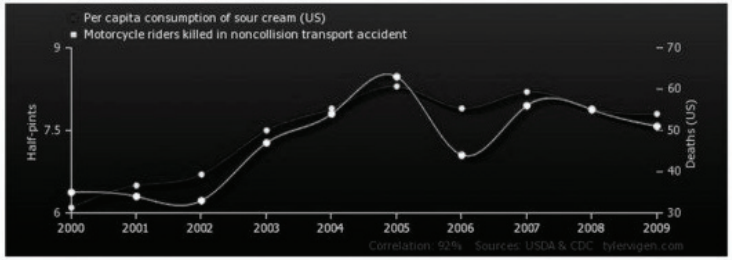


	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Age of Miss America *Years (Wikipedia)*	24	24	24	21	22	21	24	22	20	19	22
Murders by steam, hot vapours and hot objects *Deaths (US) (CDC)*	7	7	7	3	4	3	8	4	2	3	2

Correlation: 0.870127

Permalink - Mark as interesting (946) - Not interesting (355)

Per capita consumption of sour cream (US)
correlates with
Motorcycle riders killed in noncollision transport accident



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Per capita consumption of sour cream (US) *Half-pints (USDA)*	6.1	6.5	6.7	7.5	7.9	8.3	7.9	8.2	7.9	7.8
Motorcycle riders killed in noncollision transport accident *Deaths (US) (CDC)*	35	34	33	47	54	63	44	56	55	51

Correlation: 0.916391

Permalink - Mark as interesting - Not interesting

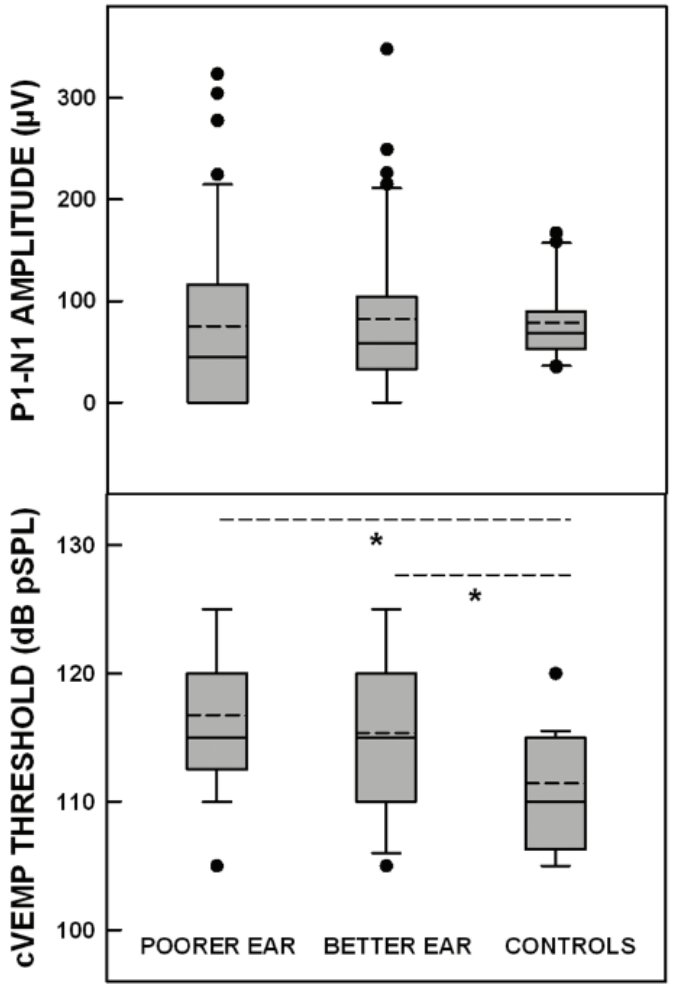
The Effect of Noise Exposure on the Cervical Vestibular Evoked Myogenic Potential

Faith W. Akin,[1,2] Owen D. Murnane,[1,2] Joanna W. Tampas,[1] Christopher Clinard,[3]
Stephanie Byrd,[1] and J. Kip Kelly[1]

- A cross-sectional observational study was employed to determine if cVEMPs in 43 individuals with a history of noise exposure greater in one ear had different responses between the two ears.
- The control group comprised 14 age-matched controls with normal-hearing sensitivity and a negative history of military or occupational noise exposure.

Noise Exposure and the Vestibular System

- 33% percent of the noise-exposed participants had abnormal cVEMPs
- cVEMPs were present and symmetrical in 100% of the age-matched controls, and cVEMP threshold was greater in the noise-exposed group than in the control group.



VEMPs and Noise Induced Hearing Loss

- The investigators evaluated twenty patients diagnosed as acute acoustic trauma.
- Relationships between hearing outcomes and level, sources of noise, caloric responses, and VEMP results were described.
- The authors determined that the VEMP test can predict the hearing outcome after acute acoustic trauma, with a sensitivity of 44% and a specificity of 100%.

Wang & Young 2007

VEMPs and Noise Induced Hearing Loss

- The greater the intensity of the noise, the more severe the impairment to the cochlea and saccule.
- An absent or delayed VEMPs was suggested to indicated poor prognosis for improvement in hearing

Wang & Young 2007

Outline

- Background
- Review of Anatomy and Physiology
- Superior Canal Dehiscence
- Pediatrics
- Noise induced hearing loss
- Meniere's Disease

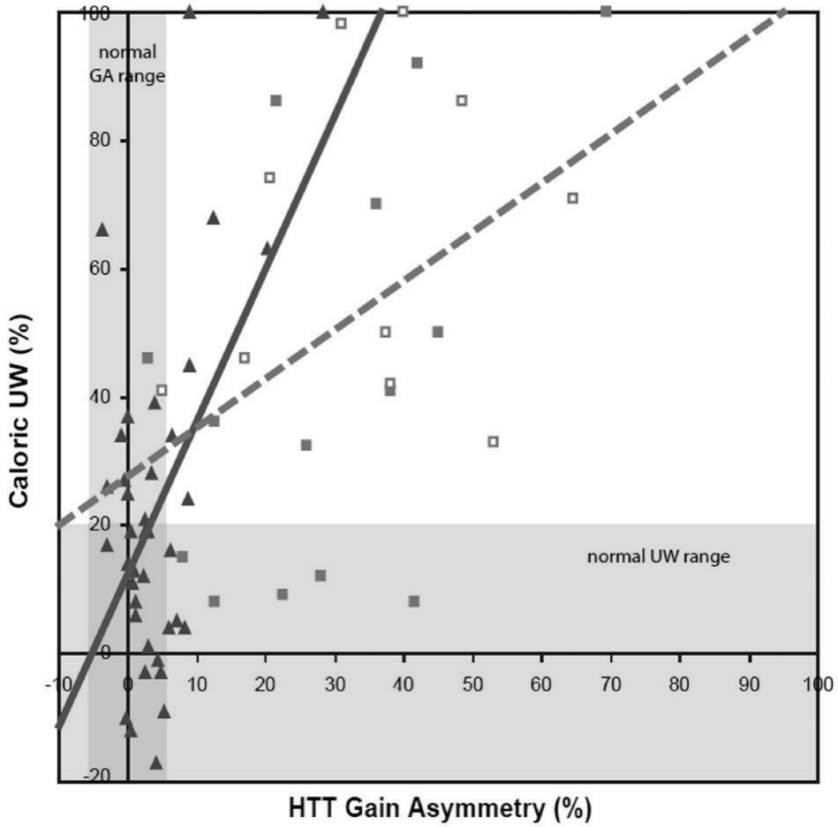
Meniere's Disease

The Dissociation of Video Head Impulse Test (vHIT) and Bithermal Caloric Test Results Provide Topological Localization of Vestibular System Impairment in Patients With "Definite" Ménière's Disease

Devin L. McCaslin,[a] Alejandro Rivas,[a] Gary P. Jacobson,[a] and Marc L. Bennett[a]

HIT and Meniere's Disease

- HIT Abnormal – 29%
- Caloric Abnormal- 42%
- Both Abnormal- 18%

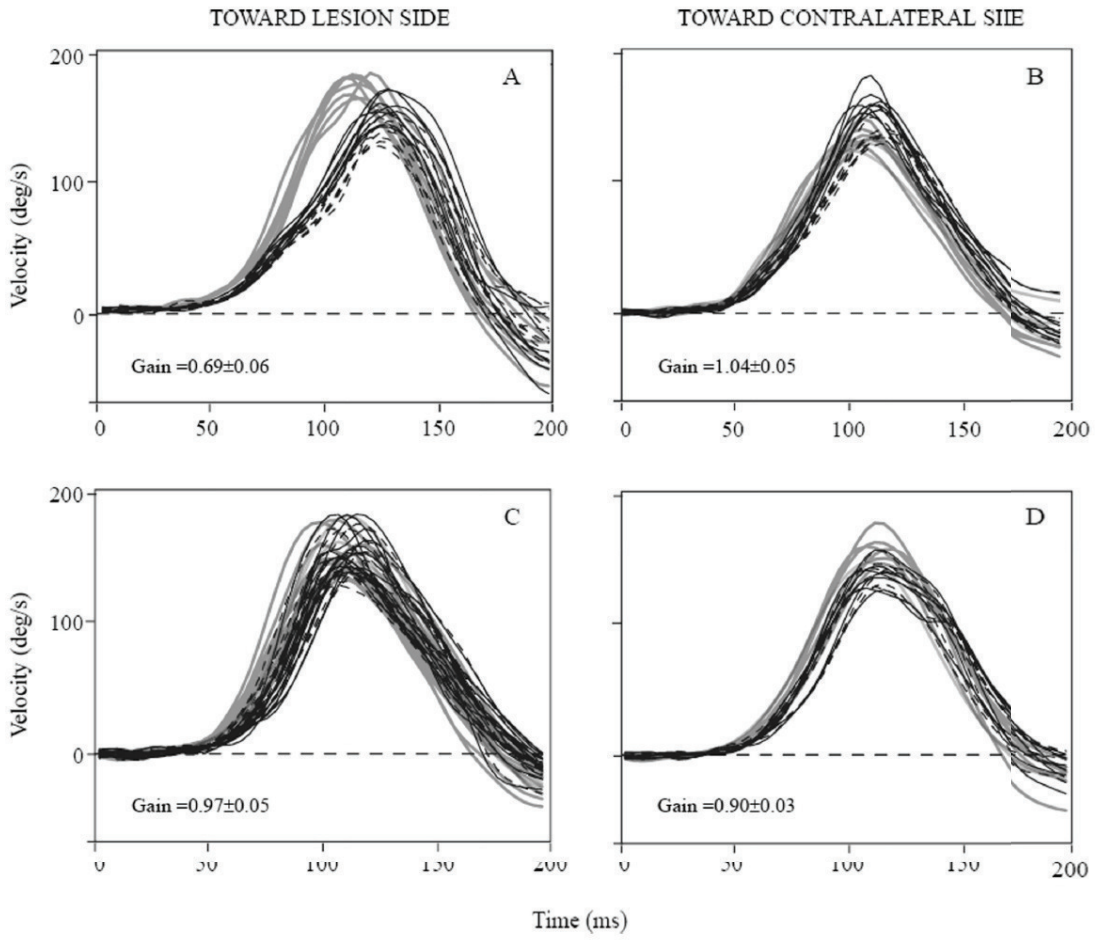


38 Patients with MD

Park et al., *Acta Oto-Laryngologica*,

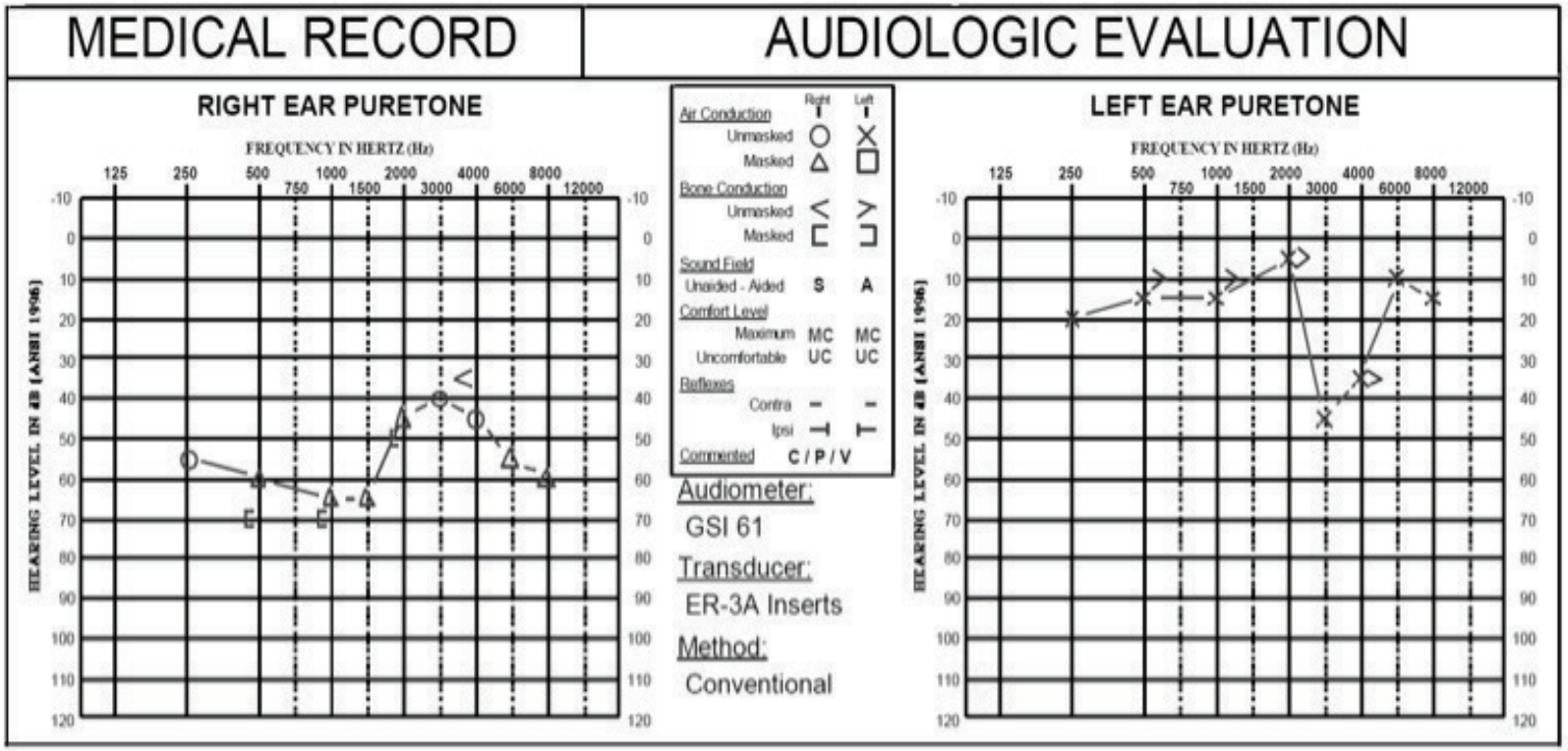
HIT and Meniere's Disease

Significant Caloric UW Normal Side

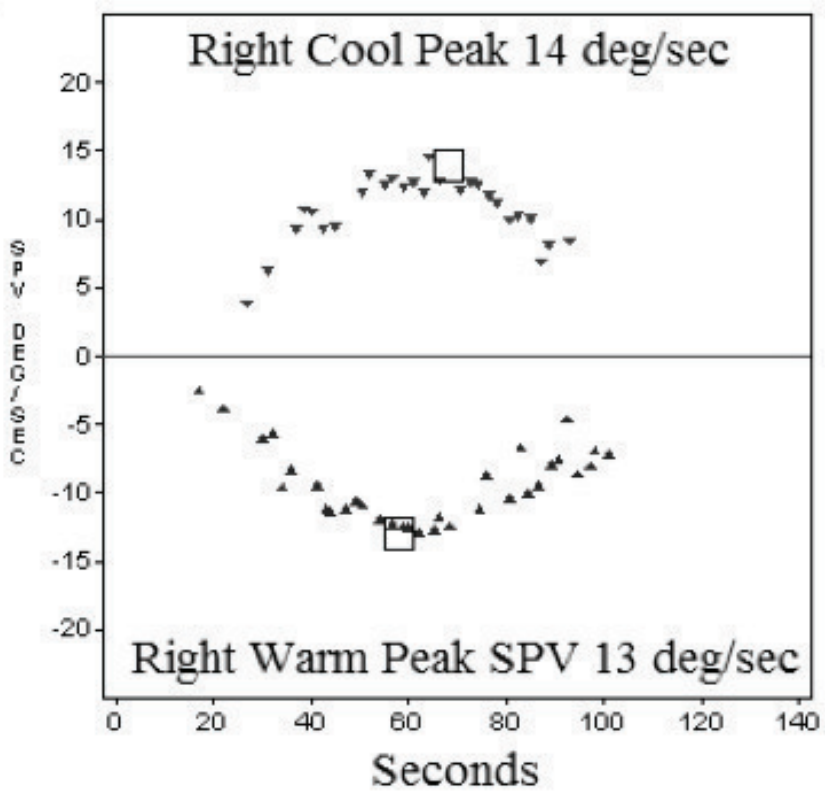


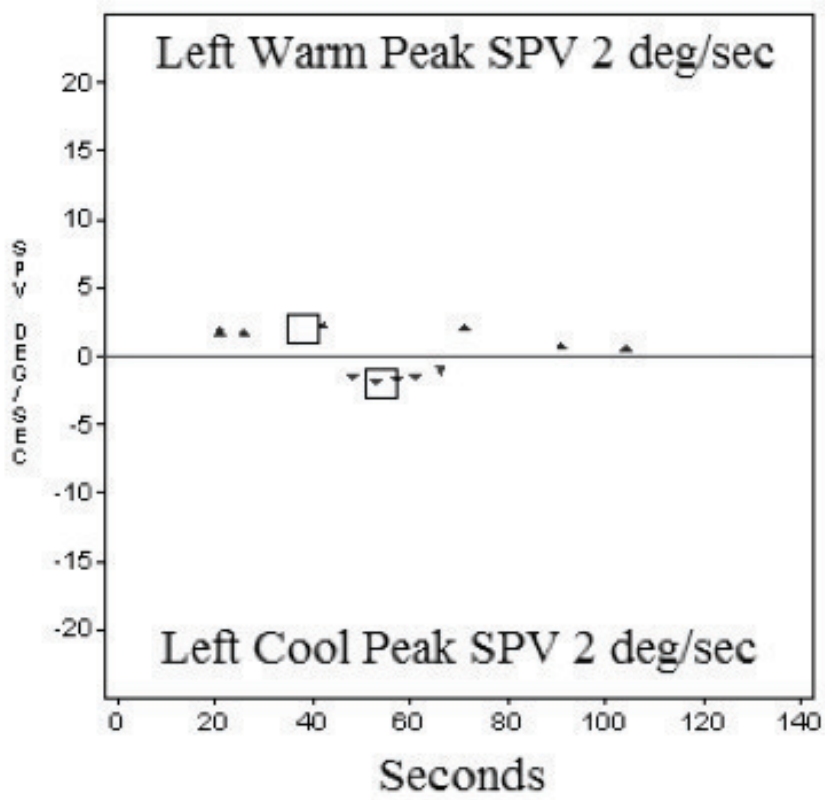
Park et al., *Acta Oto-Laryngologica*, 2005

Audiometry

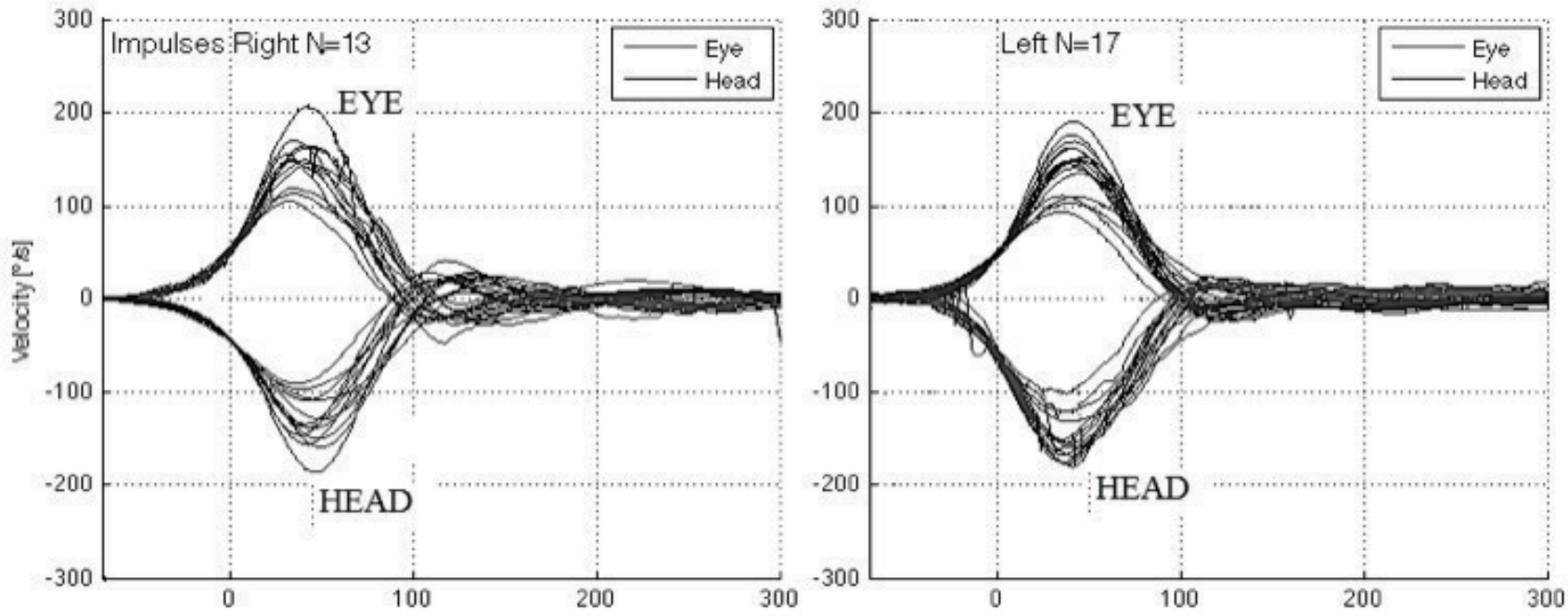

MEDICAL RECORD
AUDIOLOGIC EVALUATION
RIGHT EAR PURETONE
LEFT EAR PURETONE
FREQUENCY IN HERTZ (Hz)
125 250 500 750 1000 1500 2000 3000 4000 6000 8000 12000
HEARING LEVEL IN dB (ANSI 1996)
-10 0 10 20 30 40 50 60 70 80 90 100 110 120
Right
Left
Air Conduction
Unmasked
Masked
Bone Conduction
Unmasked
Masked
Sound Field
Unaided - Aided S A
Comfort Level
Maximum MC MC
Uncomfortable UC UC
Reflexes
Contra
Ipsi
Comments C / P / V
Audiometer:
GSI 61
Transducer:
ER-3A Inserts
Method:
Conventional

Abnormal Caloric Response





vHIT


Impulses Right N=13
Eye
Head
EYE
HEAD
Velocity [°/s]
300
200
100
0
-100
-200
-300
0
100
200
300
Left N=17
Eye
Head
EYE
HEAD

Mechanisms

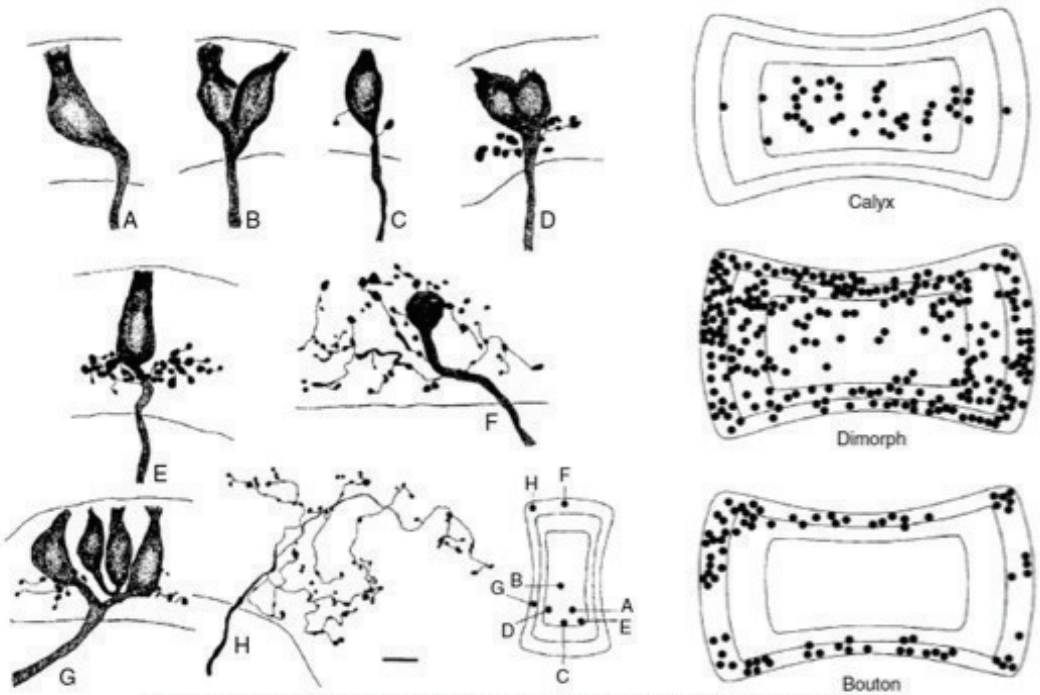
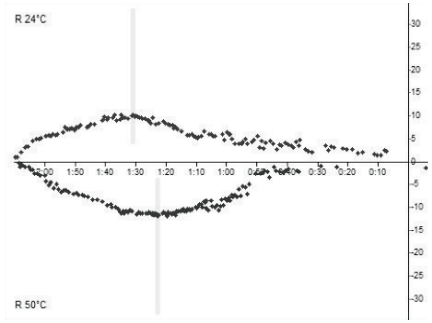
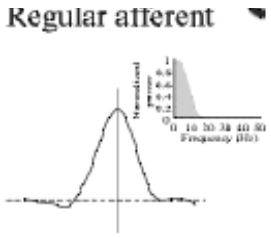
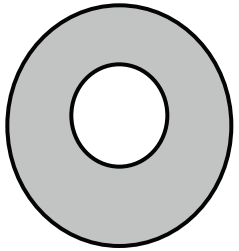


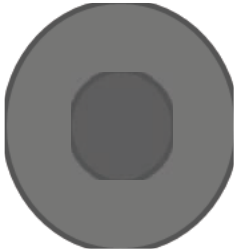
Figure 139-11. Morphology of mammalian vestibular afferents as revealed by horseradish peroxidase labeling of individual units in the chinchilla. **A,** Calyx fiber innervating a single type I hair cell. **B,** Calyx fiber innervating two Type I hair cells. **C** through **G,** Dimorphic fibers innervate both Type I and II hair cells. H, Bouton fiber. Inset: Locations of these afferents are placed on a standard map of the crista. *Right,* Three standard maps of the cristae divided into concentrically arranged central, intermediate, and peripheral zones of equal areas. Shown are the locations of calyx, dimorphic, and bouton fibers with each symbol (•) representing a single dye-filled fiber. Dimorphic units make up 70% of the population, bouton units 20%, and calyx units 10%. From Fernandez, Baird, and Goldberg.[38]

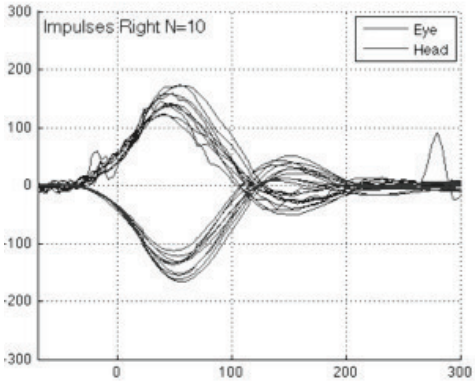
vHIT in Meniere's Syndrome

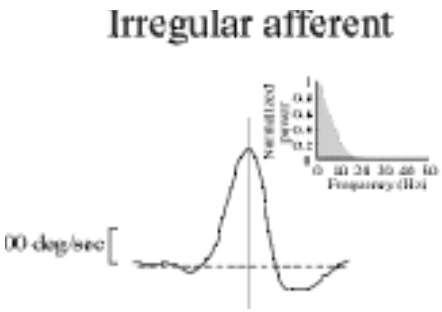


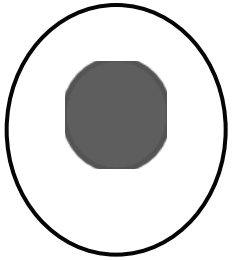










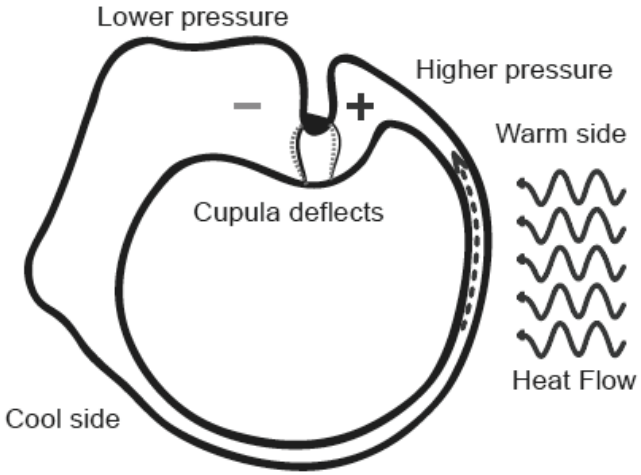


ANNALS OF THE NEW YORK ACADEMY OF SCIENCES
Issue: *Dizziness and Balance Disorders*

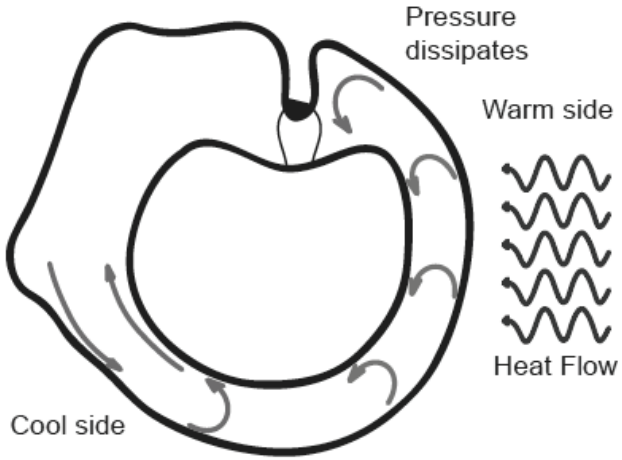
What does the head impulse test versus caloric dissociation reveal about vestibular dysfunction in Ménière's disease?

Leigh A. McGarvie,[1] Ian S. Curthoys,[2] Hamish G. MacDougall,[2] and G. Michael Halmagyi[1]

[1]Institute of Clinical Neurosciences, Royal Prince Alfred Hospital, Camperdown, NSW, Australia. [2]Vestibular Research Laboratory, School of Psychology, University of Sydney, NSW, Australia

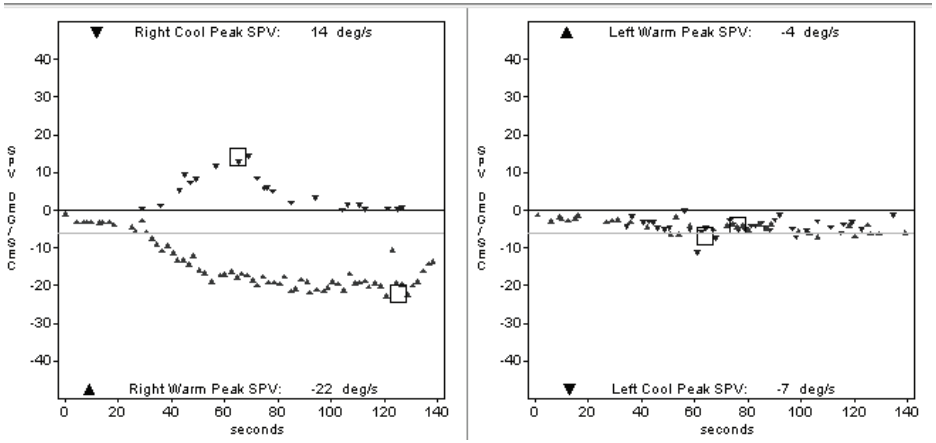


Normal Duct: No local flow, hydrostatic pressure drive retained and Cupula bent.



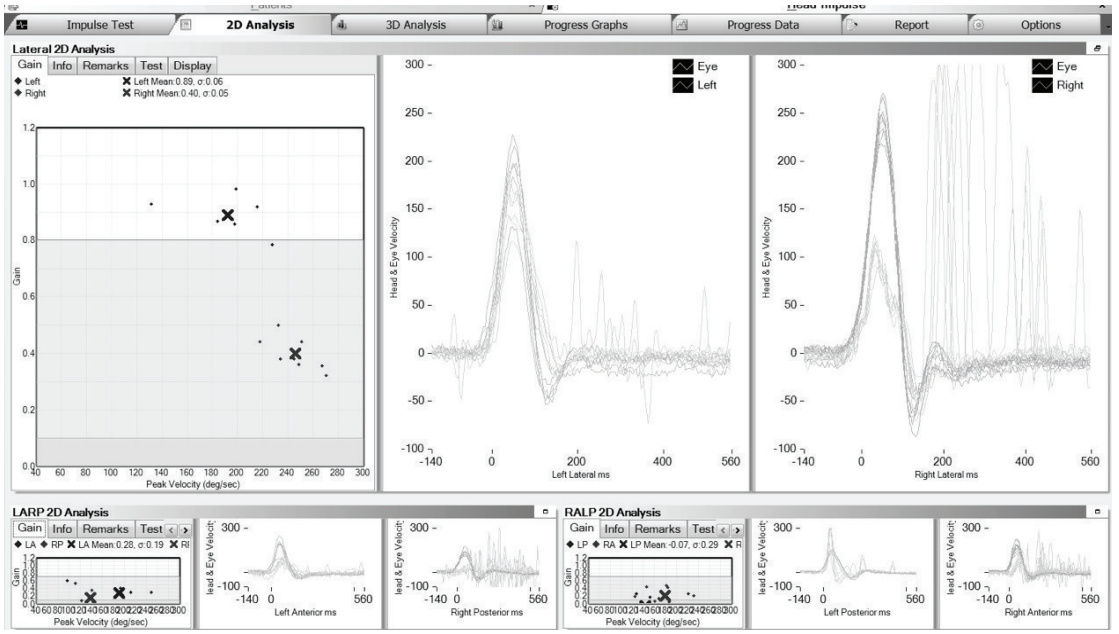
Hydropic Expansion of Duct: Local convective flow dissipates hydrostatic pressure across Cupula.

vHIT Meniere's Patient-Expected



Caloric examination

vHIT examination



Summary

- Wang and

Questions & Discussion