Using Functional Outcomes to Predict Vestibular Loss in Children.

Kristen Janky, AuD, PhD, CCC-A

Scientist II • Center for Hearing Research
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Disclosures

- Employee of Boys Town National Research Hospital;
- NIH Grant Recipient;
- Consultant: Natus;
- Consultant: Decibel Therapeutics;
- Consultant: Interacoustics
- Balance Function Assessment and Management Textbook, Editor
- Ear & Hearing, Section Editor

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Objectives

After this course, participants will be able to:

1. List causes of pediatric vestibular loss and dizziness
2. List consequences of vestibular loss in children
3. List outcomes that can be used to predict the presence of vestibular loss in children.

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What is the vestibular system?

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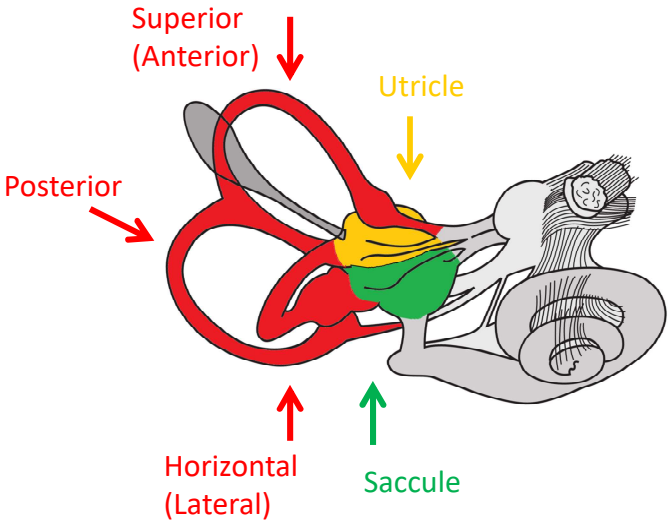
What is the vestibular system?



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

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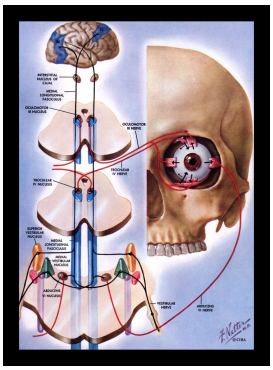
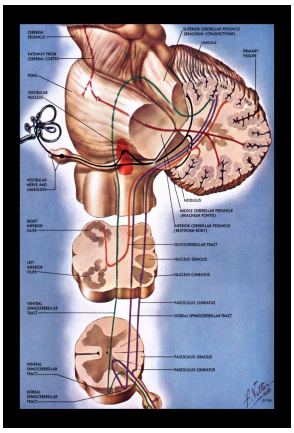
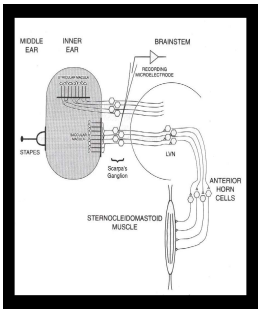
Vestibular Reflexes

Vestibulo-ocular	Vestibulospinal	Vestibulocolic
Maintain steady vision during head movements	Maintain posture	Righting reflex; stabilizes head



Jacobson & Shepard, 2008





From Halmagyi & Curthoys, In Herdman

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What happens when the vestibular system isn't functioning?

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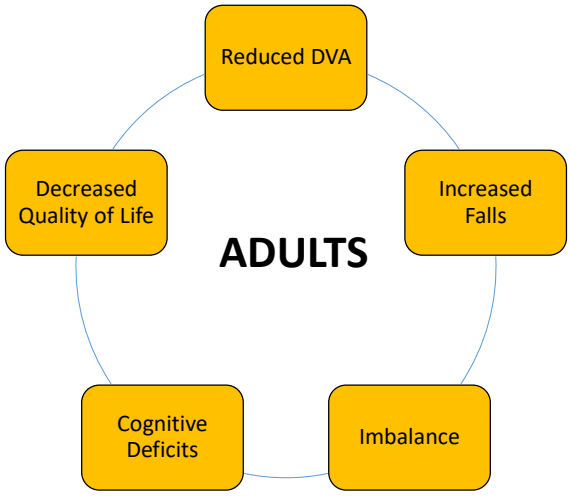
ADULTS are significantly affected by vestibular loss



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

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There are some important differences among children and adults

1)Children are not small adults

2)Most adults acquire their vestibular loss in adulthood (so can provide perspective on pre- and post- vestibular loss) whereas most children's vestibular loss is congenital or early acquired

3)Children are in a period of exponential development opposed to adults who have the added component of aging – unknown how having vestibular loss interacts with development

4)Most children with vestibular loss have co-morbid hearing loss that cannot be overlooked as a contributing factor.

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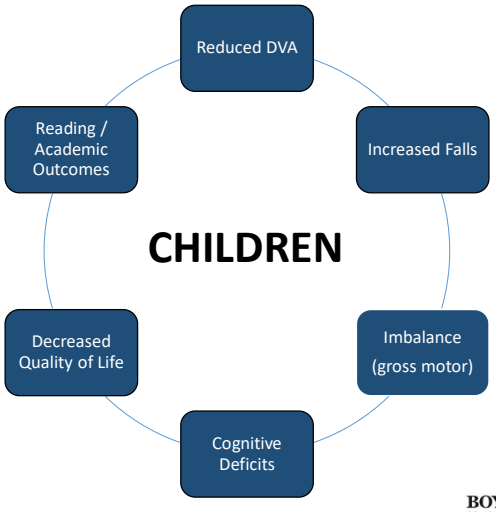
Despite these differences, preliminary evidence suggests that children suffer from the same effects of vestibular loss as adults

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



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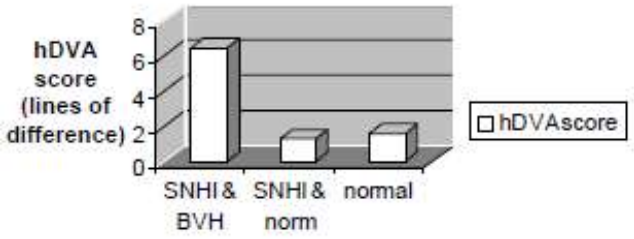
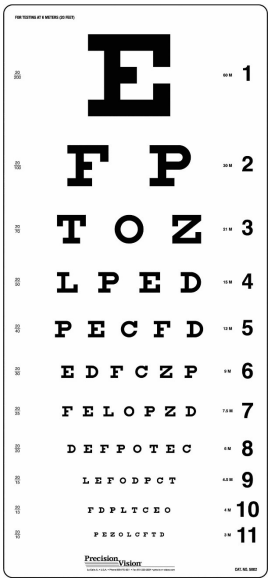
Similar to adults, children with vestibular loss have reduced dynamic visual acuity

Rine 2003; Braswell 2006; Martin 2012, Christy 2014, Janky 2015, Janky 2021, *etc*





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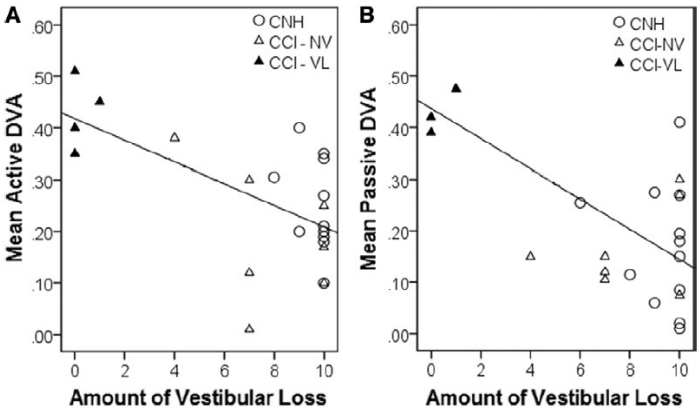
More severe vestibular loss is associated with more severe dynamic visual acuity deficits



Vestibular, Visual Acuity, and Balance Outcomes in Children With Cochlear Implants: A Preliminary Report

Kristen L. Janky[1] and Diane Givens[2]

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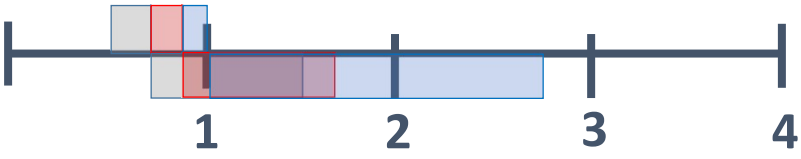
Children with vestibular loss have gross motor delay

- Children with significant vestibular loss are delayed in gaining head control, sitting, standing, and walking. (Inoue 2013; Janky 2018)
  - Typically developing children sit, stand, and walk at 6 – 8 m, 10 – 11 m, and 10 – 12 m, respectively
  - Children with vestibular loss sit, stand and walk at 8 – 18 m, 9 – 20 m and 12 – 33 m, respectively (Kaga1999).



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Gross Motor Delay Extends into Later Childhood

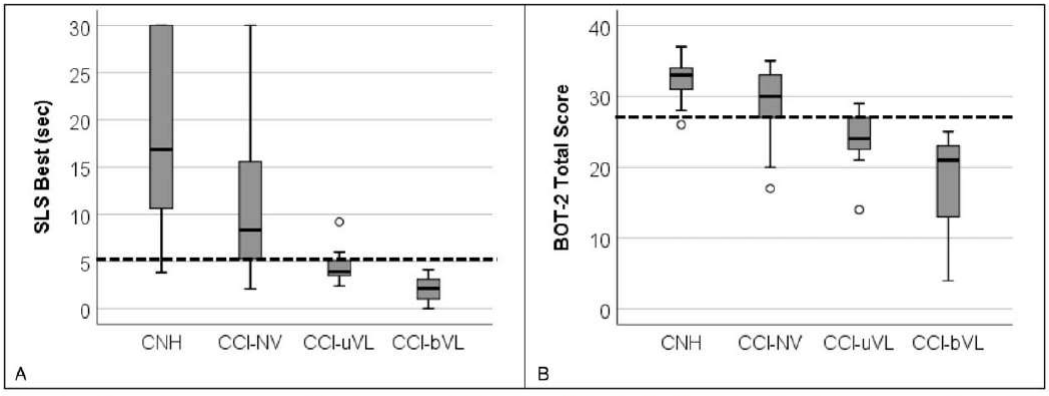

FIG. 1. *A*, Single Leg Stance (SLS) best performance across groups. Dotted line denotes 5-second cut-off criterion; *B*, BOT-2 Balance subtest, total score across groups. Dotted line denotes 27.5 cut off criterion.

Using Functional Outcomes to Predict Vestibular Loss in Children

Kristen L. Janky, Megan LA. Thomas, Jessie Patterson, and Diane Givens

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Perceptual and Motor Skills, 2000, 90, 1101-1112.

EVIDENCE OF PROGRESSIVE DELAY OF MOTOR DEVELOPMENT IN CHILDREN WITH SENSORINEURAL HEARING LOSS AND CONCURRENT VESTIBULAR DYSFUNCTION[1, 2]

- "Both gross motor and balance development scores were lower on repeated testing"

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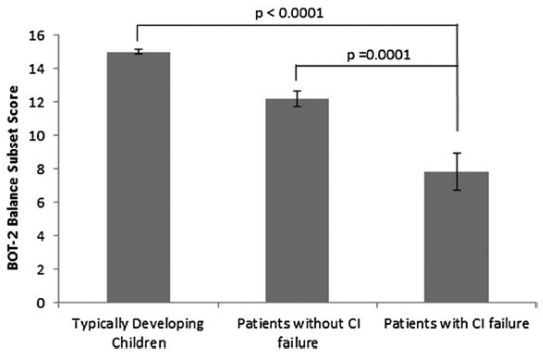
Children with Vestibular Loss have Imbalance

- Kaga 1999, Rine 2000, Inoue 2013, Maes 2014, Christy 2014, Janky 2018, Sokolov 2019, Janky 2021, etc.



Which can lead to increased falls and CI Failure

- Wolter 2015

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Cognitive Deficits and Vestibular Loss

- In adults, vestibular loss has been linked to deficits in spatial navigation, spatial memory, visuospatial, attention, executive function, and cognitive processing (e.g., Xie 2017; Kremmyda 2016; Smith 2019; Popp 2017; Bigelow 2015).
- However, the extent to which cognitive deficits exist in children with hearing and comorbid vestibular loss is unclear.

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Journal of Vestibular Research 32 (2022) 245–260
DOI: 10.3233/VES-201556
IOS Press

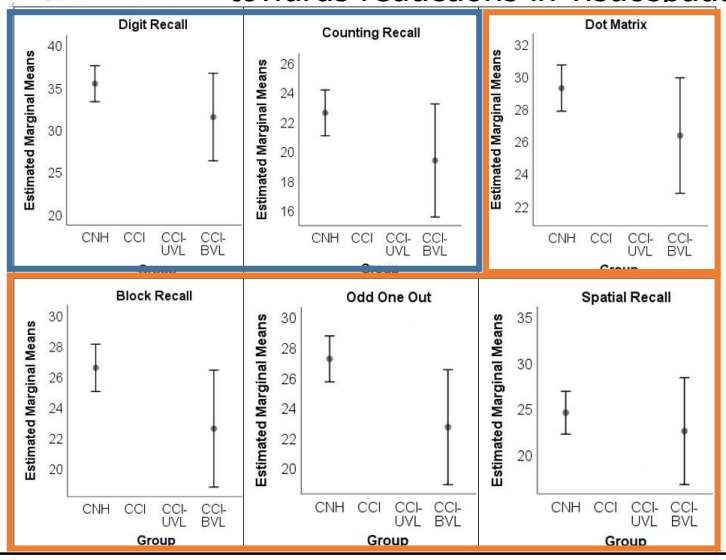
Does vestibular loss result in cognitive deficits in children with cochlear implants?

Kristen L. Janky[a,*], Megan Thomas[a], Sarah Al-Salim[b] and Sara Robinson[b]
[a]Department of Audiology, Boys Town National Research Hospital, Omaha, NE, USA
[b]Boys Town National Research Hospital, Center for Childhood Deafness, Language and Learning, Omaha,

Children with vestibular loss did NOT have *significantly* worse working memory, but trending towards reductions in visuospatial working memory

VERBAL

VISUOSPATIAL



The presence of hearing loss MATTERS!

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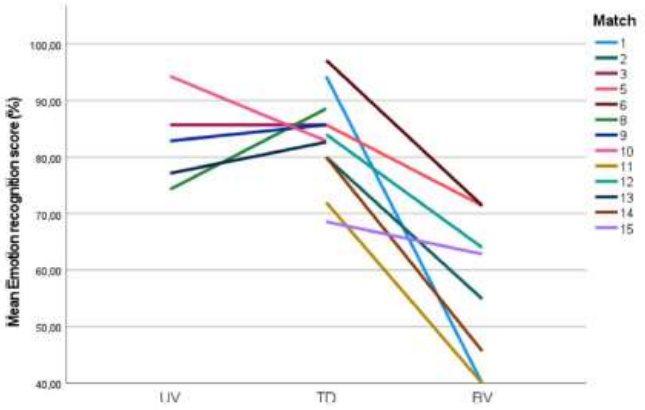
Journal of Neurology
https://doi.org/10.1007/s00415-023-11774-3

ORIGINAL COMMUNICATION

A cross-sectional study on the neurocognitive outcomes in vestibular impaired school-aged children: are they at higher risk for cognitive deficits?

Ruth Van Hecke[1] · Maya Danneels[1] · Frederik J. A. Deconinck[2] · Ingeborg Dhooge[3,4] · Laura Leyssens[1] · Emmely Van Acker[1] · Hilde Van Waelvelde[1] · Jan R. Wiersema[5] · Leen Maes[1,3]

Children with bilateral vestibular dysfunction exhibited more difficulties with **emotion recognition** compared to their typically developing peers



Springer

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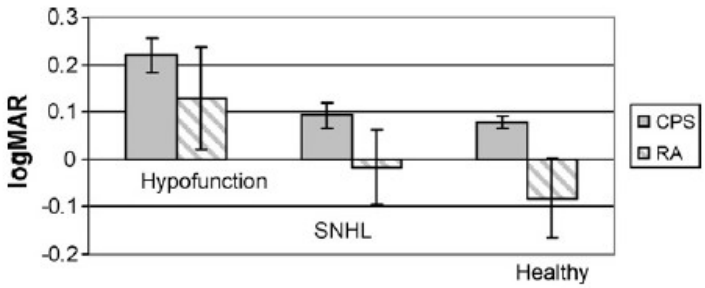
Evidence that vestibular hypofunction affects reading acuity in children

Jennifer Braswell [a,*], Rose Marie Rine [b,1]

International Journal of Pediatric Otorhinolaryngology



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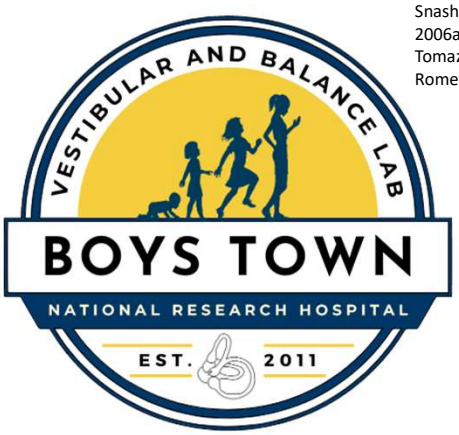
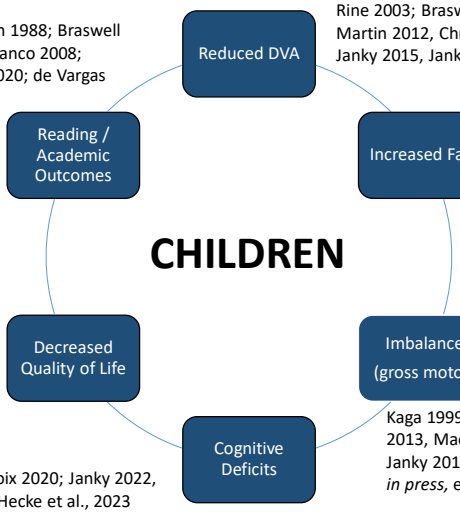
The effects of vestibular loss in CHILDREN are not well established



Snashall 1983; Levinson 1988; Braswell 2006a; Franco 2007; Franco 2008; Tomaz 2014; Caldani 2020; de Vargas Romero 2020



Rine 2003; Braswell 2006; Martin 2012, Christy 2014, Janky 2015, Janky 2021

Wolter 2015

Janky, 2023

Kaga 1999, Rine 2000, Inoue 2013, Maes 2014, Christy 2014, Janky 2018, Sokolov 2019, Janky *in press*, etc.

Lacroix 2020; Janky 2022, Van Hecke et al., 2023

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Dizziness and Imbalance Across the Lifespan: Findings of a Pediatric and Adult Vestibular Clinic

Alana L. Ferreira, BA[1]*, Alanna M. Windsor, MD[2]*, Tiffany P. Hwa, MD[1], Stephanie Y. Wang, BS[1], Erin W. Field, PA-C[3], Michael J. Ruckenstein, MD[1], and Robert C. O'Reilly, MD[1,3]

> The study of vestibular and balance disorders in children and adolescents, especially, is still developing compared with that of adults. Nonetheless, early diagnosis of these conditions in children may prompt recognition of and remediation for the known impact of vestibular disorders on gross motor development, learning, cognitive skills, and school performance.[5-11]

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Which children are at risk for vestibular involvement?

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Prevalence of Vestibular and Balance Disorders in Children

Otology & Neurotology
31:1441–1444 © 2010, Otology & Neurotology, Inc.

*Robert C. O'Reilly, †Thierry Morlet, *Brian D. Nicholas, ‡Gary Josephson, ‡Drew Horlbeck, §Larry Lundy, and ||Arnel Mercado

- Reviewed 561,151 patient encounters
  - 2,546 (0.45%) were diagnosed with a balance disorder
    - 159 (6.2%) peripheral vestibular disorders
      - Odds ratio: 43 times more likely to have SNHL
    - 109 (4.1%) central involvement was diagnosed
      - Odds ratio: 16 times more likely to have headache
    - 2,283 (90%) unspecified dizziness

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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]

(J Pediatr 2016;171:240-7).

- Parents were asked if during the past year their child was bothered by symptoms of dizziness and balance problems (10, 954)
  - Prevalence 5.3% (female: 5.7%, males 5.0%)
  - Prevalence increased with age
- Associations:
  - Hearing loss increased the risk of dizziness and balance by 4.8
  - Difficulty seeing increased the risk of dizziness and balance by 3

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Dizziness and Imbalance Across the Lifespan: Findings of a Pediatric and Adult Vestibular Clinic

Alana L. Ferreira, BA[1]*, Alanna M. Windsor, MD[2]*, Tiffany P. Hwa, MD[1], Stephanie Y. Wang, BS[1], Erin W. Field, PA-C[3], Michael J. Ruckenstein, MD[1], and Robert C. O'Reilly, MD[1,3]

- The proportion of peripheral vestibular disorders increased with age, peaking at 32% in ages 61 to 70; however, central disorders outnumber peripheral vestibular disorders

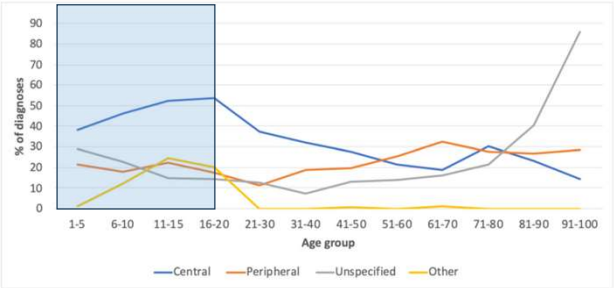

Figure 2. Distribution of diagnosis categories (central, peripheral, unspecified, or other) for each age group.

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Dizziness and Imbalance Across the Lifespan: Findings of a Pediatric and Adult Vestibular Clinic

Alana L. Ferreira, BA[1]*, Alanna M. Windsor, MD[2]*, Tiffany P. Hwa, MD[1], Stephanie Y. Wang, BS[1], Erin W. Field, PA-C[3], Michael J. Ruckenstein, MD[1], and Robert C. O'Reilly, MD[1,3]

- Vestibular migraine was the most common pathologic diagnosis in ages 6 to 20 (n = 110, 39%) and 31 and 50 (n = 69, 17%) regardless of gender, but was more prevalent in females (21% vs 14%; P < .0001)

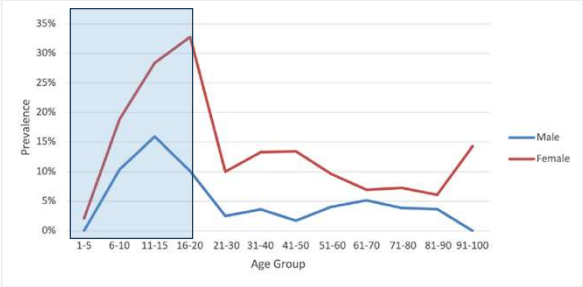

Figure 3. Prevalence of vestibular migraine by age group and gender.

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Dizziness and Imbalance Across the Lifespan: Findings of a Pediatric and Adult Vestibular Clinic

Alana L. Ferreira, BA[1]*, Alanna M. Windsor, MD[2]*, Tiffany P. Hwa, MD[1], Stephanie Y. Wang, BS[1], Erin W. Field, PA-C[3], Michael J. Ruckenstein, MD[1], and Robert C. O'Reilly, MD[1,3]

- Children get the same diagnoses as adults but the prevalence of each varies

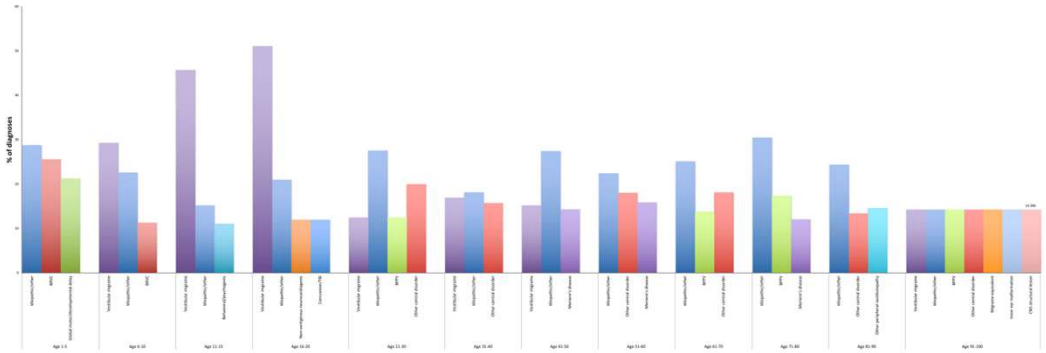

Figure 1. Graph of the top 3 diagnoses for each age group and their prevalence within each age group (% of diagnoses). BPPV, benign paroxysmal positional vertigo; BRVC, benign recurrent vertigo of childhood; TBI, traumatic brain injury.

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Ferreira et al.

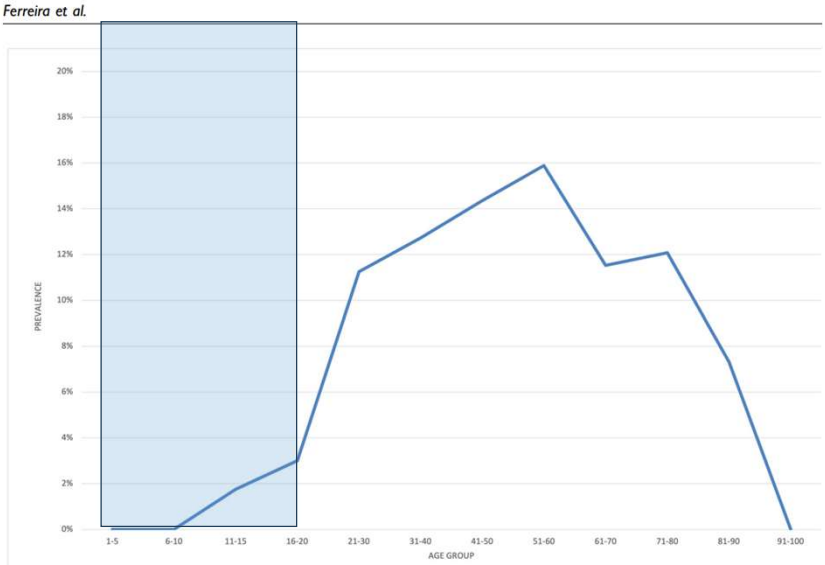

Figure 5. Prevalence of Meniere's disease by age group.

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Dizziness and Imbalance Across the Lifespan: Findings of a Pediatric and Adult Vestibular Clinic

Alana L. Ferreira, BA[1]*, Alanna M. Windsor, MD[2]*, Tiffany P. Hwa, MD[1], Stephanie Y. Wang, BS[1], Erin W. Field, PA-C[3], Michael J. Ruckenstein, MD[1], and Robert C. O'Reilly, MD[1,3]

Figure 3. Prevalence of vestibular migraine by age group and gender.

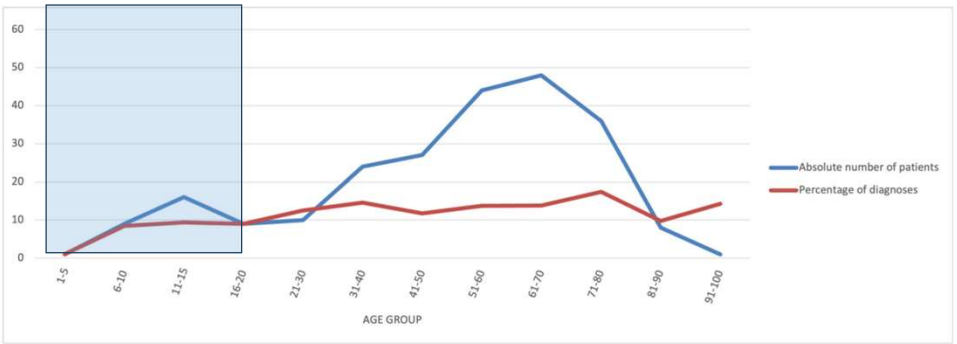

Figure 4. Diagnoses of benign paroxysmal positional vertigo within each age group in absolution number of patients and as a percentage of all diagnoses.

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Epidemiological studies tell us that there are at least 2 categories of kids at risk for vestibular loss:

Kids who complain of dizziness

- Children can develop similar etiologies of vestibular loss and thus similar symptoms as adults, including dizziness, imbalance, falls, and hearing loss
- Prevalence mix varies
- Primary: Vestibular Migraine

Kids with Hearing Loss

- Are all children with hearing loss at equal risk for vestibular loss?

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1. Complaint of Dizziness

Vestibular migraine and recurrent vertigo of childhood: Diagnostic criteria consensus document of the Classification Committee of Vestibular Disorders of the Bárány Society and the International Headache Society

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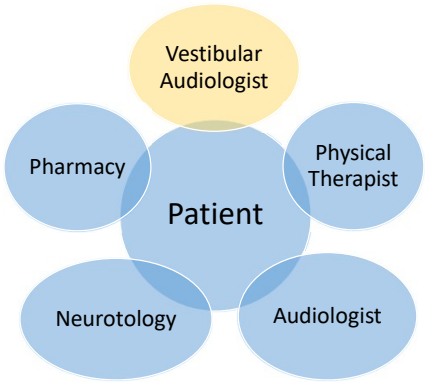
Etiologies of dizziness in children by prevalence

- Vestibular Migraine
- Vestibular Neuritis
- OME
- SNHL
  - Cochleovestibular anomaly
  - CMV
- Concussion
- Psychogenic
- 3PD
- BPPV
- Meniere's disease
- Orthostasis
- CNS [seizure, CPA tumor, autoimmune, syncope]
- SSCD



*Manuel of Pediatric Vestibular Disorders

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2. SNHL is a risk factor for vestibular loss

(Verbecque et al 2017)

- Children are more likely to have vestibular loss with:
  - Severe-to-profound sensorineural hearing loss (Janky et al., 2018; Martens et al., 2022)
  - And with specific etiologies of hearing loss:
    - Cytomegalovirus (CMV) infection (30 – 60%)
    - Auditory Neuropathy (show decline in function over time)
    - Waardenburg Syndrome (up to 70/80%)
    - Rubella (30 – 40%)
    - Pendred Syndrome
    - Malformations (depends on severity of malformation)
    - Meningitis (~100%, depends on rate sensor)
    - Ototoxicity
    - Usher Syndrome (~100%, depends on type)
    - Auditory Neuropathy Spectrum Disorder (42 – 91%)

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.

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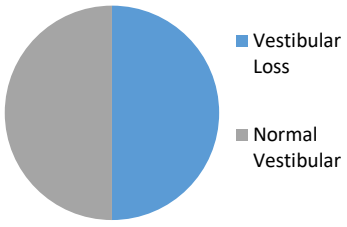
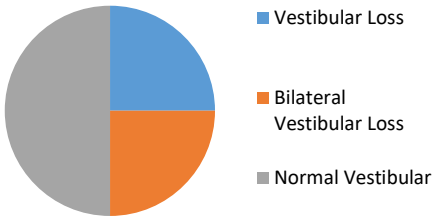
Not all children with HL have vestibular loss

- Specific to children with CI
  - 50% have some degree of vestibular loss
  - 20 – 30% have bilateral loss
    - Jacot et al. (2009), Jin et al. (2006), Cushing et al (2013), Janky et al. (2015)





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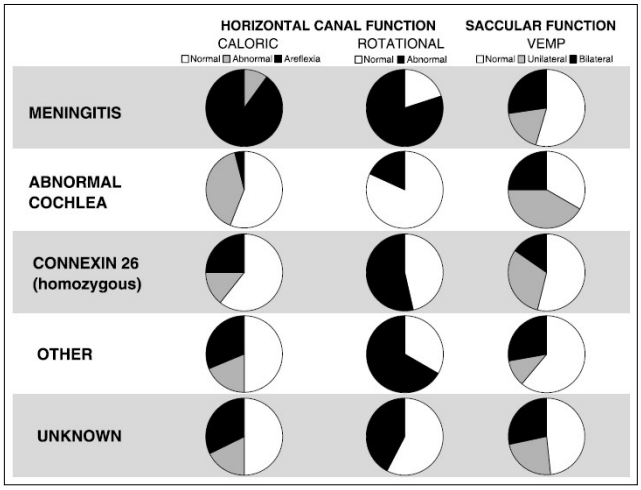
Vestibular End-Organ Dysfunction in Children With Sensorineural Hearing Loss and Cochlear Implants: An Expanded Cohort and Etiologic Assessment

Otology & Neurotology

*†Sharon L. Cushing, *†Karen A. Gordon, †‡John A. Rutka, *†Adrian L. James, and *†Blake C. Papsin



50% of children pre-CI have some degree of vestibular loss – 30 % have bilateral loss

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Children are more likely to have vestibular loss if:

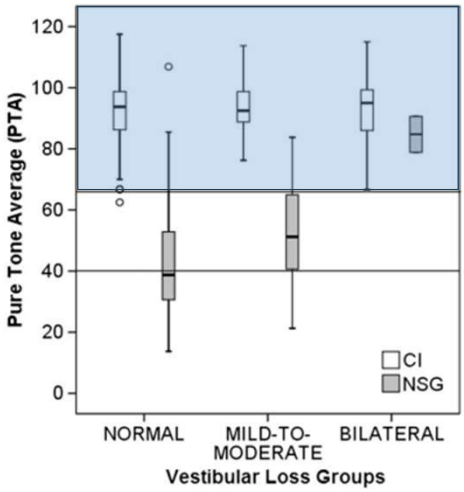
AJA

Research Article

Predictive Factors for Vestibular Loss in Children With Hearing Loss

Kristen L. Janky,[a] Megan L. A. Thomas,[a] Robin R. High,[b] Kendra K. Schmid,[b] and Oluwaseye Ayoola Ogun[c]

- Bilateral pure tone average (250, 1,000, 2,000, and 4,000 Hz) is greater than:
  - CUT-OFF SCORE: 40 dB, sensitivity = 80%, specificity = 55%
  - CUT-OFF SCORE: **66 dB**, sensitivity = 33%, specificity = 91%



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Three Years of Vestibular Infant Screening in Infants With Sensorineural Hearing Loss

To cite: Martens S, Dhooge I, Dhondt C, et al. Three Years of Vestibular Infant Screening in Infants With Sensorineural Hearing Loss. *Pediatrics*. 2022;150(1):e2021055340

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Methodological aspects of testing vestibular evoked myogenic potentials in infants at universal hearing screening program

Luca Verrecchia[1,2*], Niki Karpeta[1,2], Magnus Westin[1], Ann Johansson[1], Sonny Aldenklint[1], Krister Brantberg[1,3] & Maoli Duan[1,2]

SCIENTIFIC REPORTS
nature research

Comment > Pediatrics. 2022 Jul 1;150(1):e2022056986. doi: 10.1542/peds.2022-056986.

The Feasibility of Performing Vestibular Newborn Screening

Kristen L Janky [1], Christine Yoshinaga-Itano [2]

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Vestibular Loss Should be Suspected in:

- Children with **severe to profound sensorineural hearing loss**, which justifies testing all children prior to cochlear implantation;
- Children who pass their newborn hearing screening and **acquire hearing loss or have progressive hearing loss**; and
- Children with any degree of hearing loss and **concomitant gross motor delay** due to the known association between vestibular loss and gross motor function.

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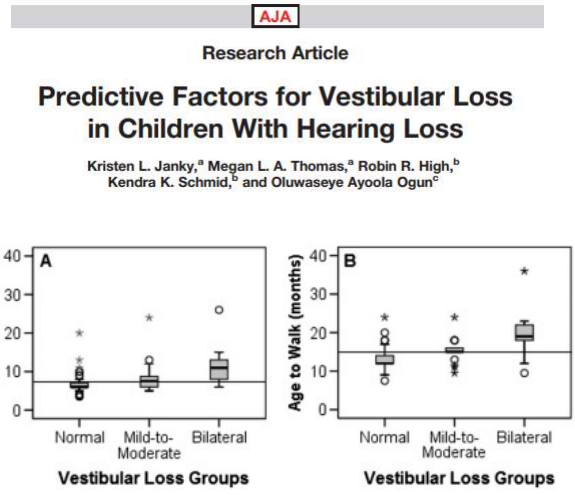
Children are more likely to have vestibular loss if:


AJA

Research Article

Predictive Factors for Vestibular Loss in Children With Hearing Loss

Kristen L. Janky,[a] Megan L. A. Thomas,[a] Robin R. High,[b] Kendra K. Schmid,[b] and Oluwaseye Ayoola Ogun[c]

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

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

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These values **do** overlap normal expectations:

- Sitting without support (3.8 to 9.2 months)
  - Age to sit > 7.25 months
- Standing with assistance (4.8 to 11.4)
- Hands and knees crawling (5.2 to13.5)
- Walking with assistance (5.9 to 13.7)
- Standing alone (6.9 to 16.9)
- Walking alone (8.2 to 17.6)
  - Age to walk > 14.5 months

WHO Multicentre Growth Reference Study

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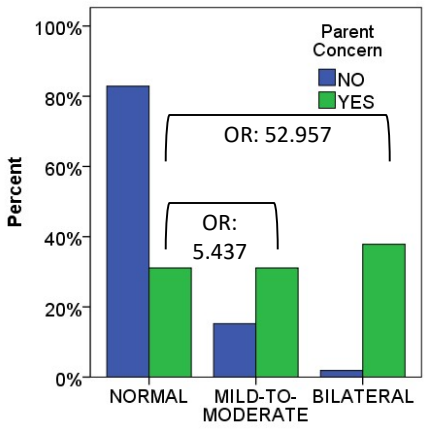
Research Article

Predictive Factors for Vestibular Loss in Children With Hearing Loss

Kristen L. Janky,[a] Megan L. A. Thomas,[a] Robin R. High,[b] Kendra K. Schmid,[b] and Oluwaseye Ayoola Ogun[c]

"Are you concerned about your child's gross motor skill acquisition?"

A significantly higher proportion of parents reporting concern for gross motor skills as severity of vestibular loss increased.



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Single Leg Stance

- Stand on dominate leg with nondominant leg raised, knee bent to 90 degrees, hands on hips, and eyes closed for a maximum of 10 s. Timing is stopped if eyes open, foot is put down, or standing leg is moved
  - CUT-OFF: < 4 seconds, sensitivity = 90%, specificity = 100%
  - (Janky et al. 2022; Oyewumi et al., 2016)

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Single Leg Stance

Age	Duration in Seconds (Eyes Open/Closed)
30–36 months	1–2
4 years	5
5 years	10/<5
7 years	15/5
9 years	30/15
11 years	30+/30
Modified with permission from Cushing et al.[38]	

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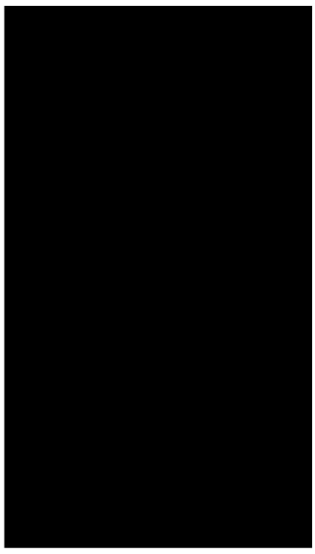
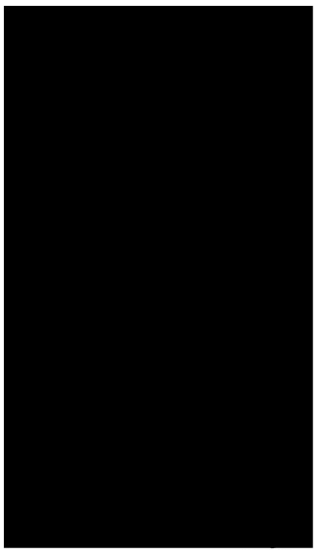
Bedside Head Impulse Test

- The head is tilted 30 degrees downward and high acceleration, unpredictable head thrusts are delivered in the plane of each horizontal canal
  - CUT-OFF: corrective saccade, sensitivity = 75%, specificity = 91%
  - (Christy et al., 2014)





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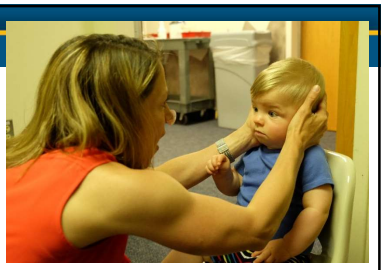
Bedside Head Impulse Test

Positive for most caloric weaknesses > 40-50%



Caloric vs Head Thrust (Horizontal)
Perez N & Rama-Lopez J
Otology & Neurotology 24, 2003:913-917

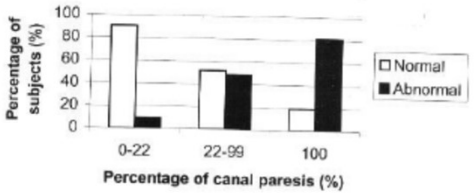


FIG. 1. Percentage of subjects in each group of canal paresis in which a normal (*white bar*) or abnormal (*black bar*) head-impulse test was obtained.

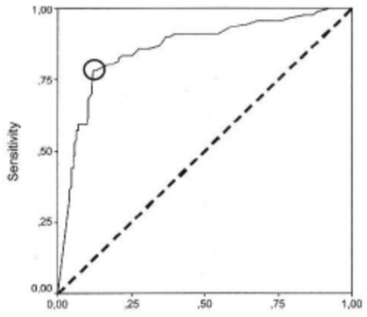


FIG. 3. Receiver-operating (ROC) curve for the canal paresis in the caloric test versus head-impulse result. The best cut-off point is 42.5 percent.

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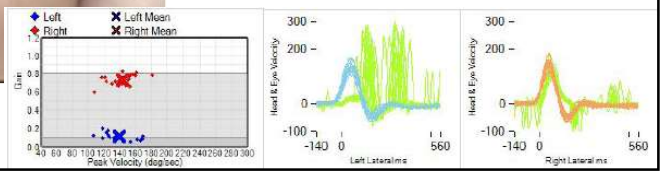
Bedside Head Impulse Test

Positive for most caloric weaknesses > 40-50%



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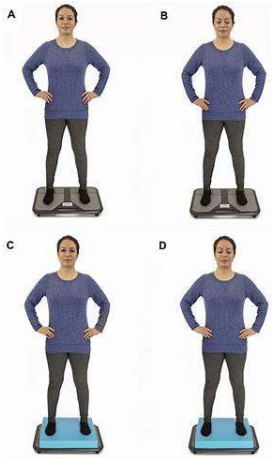
Modified Clinical Test of Sensory Integration on Balance

- Maintain balance with arms crossed against chest for 30 s while
  - (1) standing, eyes open;
  - (2) standing, eyes closed;
  - (3) standing on foam, eyes open;
  - (4) standing on foam, eyes closed.

  - Maximum score is 120 s
  - CUT-OFF: 100 s
  - Sensitivity = 88%, specificity = 85%
  - (Christy et al., 2014)



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Modified Emory Clinical Vestibular Chair Test (m-ECVCT)

- Patients sit in a rotating office chair with the head centered and slightly flexed and eyes closed.
- Rotate chair right for 30 seconds at 0.5 Hz, using a metronome.
- After 30 seconds of rotation, stop the chair, place frenzels over the eyes and time the duration of eye movements
- Rest for 2 minutes or double the duration of nystagmus to dampen the effect of the first rotation.
- Repeat to the left.
- Nystagmus duration < 29.2 seconds (total) = possible vestibular loss

Reliability and Diagnostic Accuracy of Clinical Tests of Vestibular Function for Children

Jennifer B. Christy, PT, PhD; JoAnne Payne, MA, CCC-A; Andres Azuero, PhD, MBA; Craig Formby, PhD

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Dynamic Visual Acuity (DVA)

- Comparison between static (head still) and dynamic (head moving) visual acuity
- Instructions:
  - Patient reads down eye chart until they miss one letter. One line above = static visual acuity.
  - Repeat while physically moving patient's head back and forth
- Interpretation:
  - > 2 lines suggests oscillopsia
  - 5-6 lines is normal for true bilaterals

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Reliability and Diagnostic Accuracy of Clinical Tests of Vestibular Function for Children

Quantitative Vestibular Function Testing in the Pediatric Population

Kristen L. Janky, Au.D., Ph.D.[1] and Amanda I. Rodriguez, Au.D., Ph.D.[1]

ABSTRACT

Quantitative tests of vestibular function include the caloric test, cervical and ocular vestibular evoked myogenic potential (VEMP), rotary chair, and head impulse test, either at the bedside or utilizing video head impulse test (vHIT). The purpose of this article is to provide an overview of how to perform these tests in children, including which tests are recommended based on the child's age and any modifications or considerations that can be made. A variety of clinical measures have been recommended as screening measures for vestibular loss, which will be reviewed. Symptom questionnaires designed to assess the functional impact of dizziness and vestibular loss in children will also be discussed. If a child complains of dizziness or if vestibular loss is suspected (either by case history or positive screening measure), vestibular function testing is warranted. For vestibular function testing, children aged 0 to 2 years typically receive rotary chair, cervical VEMP, and vHIT if a remote system is available. For children aged 3 to 7 years, vHIT, cervical VEMP, and ocular VEMP are completed, and for children aged 8+ years, vHIT, caloric testing if vHIT is normal, and cervical and ocular VEMP are completed. For all children, modifications to testing can be made, as needed.

KEYWORDS: Vestibular, pediatric, VEMP, vHIT, rotary chair, caloric

Learning Outcomes: As a result of this activity, the participant will be able to (1) list which tests of vestibular function are appropriate for children based on their age; (2) describe modifications that can be made to each test of vestibular function to accommodate children.

[1]Department of Audiology, Boys Town National Research Hospital, Omaha, Nebraska.
Address for correspondence: Kristen L. Janky, Au.D., Ph.D., Department of Audiology, Boys Town National Research Hospital, 555 N. 30th St. Omaha, NE 68131 (e-mail: kristen.janky@boystown.org).

Contemporary Concepts in Pediatric Vestibular Assessment and Management; Guest Editors, David L. McCaslin, Ph.D. and Jennifer B. Christy, PT, Ph.D.
Semin Hear 2018;39:257–274. Copyright © 2018 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662.
DOI: https://doi.org/10.1055/s-0038-1666837.
ISSN 0734-0451.

Table 2 Screening Measures for Vestibular Loss in Children

Measure	Description	Cutoff score	Sensitivity	Specificity
mCTSIB[a]	Children maintain balance with arms crossed against chest for 30 s while (1) standing, eyes open; (2) standing, eyes closed; (3) standing on foam, eyes open; (4) standing on foam, eyes closed. Maximum score is 120 s	110 s	88%	85%
HTT[a]	The head is tilted 30 degrees downward and high acceleration, unpredictable head thrusts are delivered in the plane of each horizontal canal	Corrective saccade	75%	91%
ECVCT[a]	Children are rotated in an office chair with eyes closed for 30 s at 0.5 Hz. After 30 s, Frenzel lenses are placed over the child's eyes and nystagmus is timed	< 29.2 s	75%	100%
DVA[a]	Children read letters/symbols from an eye chart with the head still and again with head in motion (2 Hz or 120 degrees/s). The number of missed letters/symbols is recorded	10 optotypes	88%	69%
Single-leg stance[b]	Children stand on their dominate leg with their nondominant leg raised, knee bent to 90 degrees, hands on hips, and eyes closed for a maximum of 10 s. Timing is stopped if eyes open, foot is put down, or standing leg is moved	< 4 s	90%	100%
Tandem standing[b]	Children stand with one foot placed in front of the other, hands on hips, eyes closed. Timing is stopped if they take a step, move hands from hips or open eyes	< 8 s	95%	69%
Age to sit[c]	During case history, parents report age child sat independently	> 7.25 mo	62%	81%
Age to walk[c]	During case history, parents report age child walked independently	> 14.5 mo	78%	77%
Hearing loss[c]	Compute the bilateral pure tone average for 250, 1,000, 2,000, and 4,000 Hz	> 40 dB HL > 66 dB HL	80% 33%	55% 91%

Abbreviations: DVA, dynamic visual acuity; ECVCT, Emory clinical vestibular chair test; HTT, head thrust test; mCTSIB, modified clinical test of sensory integration on balance.
[a]Christy et al.[75]
[b]Oyewumi et al.[76]
[c]Janky et al.[61]

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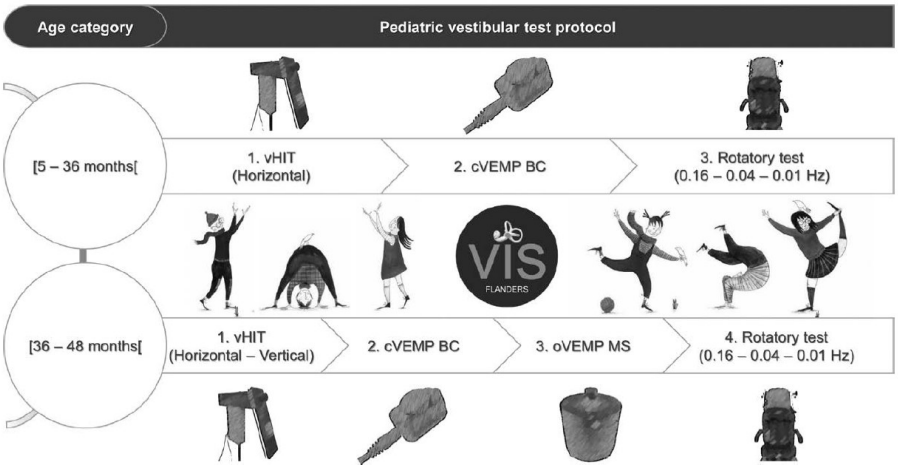
Pediatric Vestibular Assessment: Clinical Framework

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



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Illustrative Patient Cases

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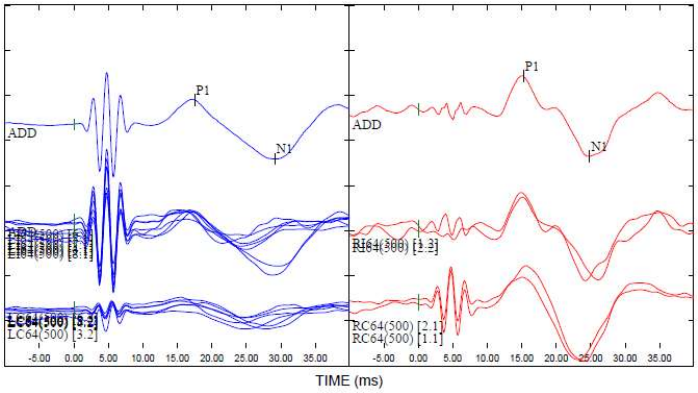
Case 1: 20-month-old male with bilateral, mild hearing loss and **gross motor delay**

- Medical history is significant for Cornelia de Lange syndrome, born at 33 weeks, 20-day stay in the neonatal intensive care unit (NICU) due to intra uterine growth restriction, hypospadias, plagiocephaly, and torticollis.

Cervical VEMP: age 11 months



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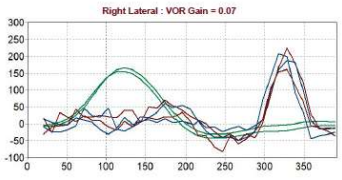
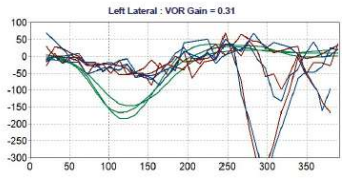
Case 1: 20-month-old male with bilateral, mild hearing loss and **gross motor delay**

- Due to significant gross motor delay additional testing was recommended
- Rotary chair demonstrated normal gain with abnormal phase



Impulses			VOR		
Canal		n	Mean gain	σ	Asymmetry
Ant.	R	0			
	L	0			
Lat.	R	2	0.07	0.12	64 %
	L	3	0.31	0.02	
Post.	R	0			
	L	0			



- This is a unique finding given the patient's mild hearing loss.

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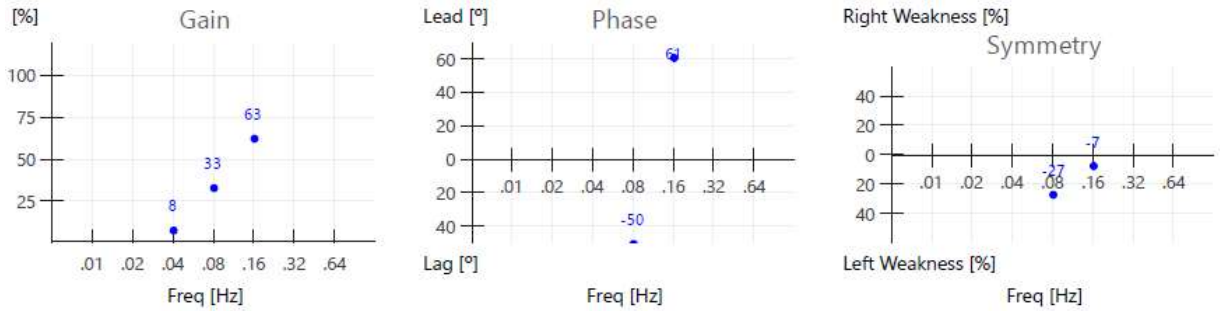
Case 2: 8-month-old female with **bilateral, profound, SNHL**. Imaging showed **cochlear aplasia, cochlear nerve deficiency, vestibular dysplasia with enlarged vestibule, and poor development of semicircular canals**



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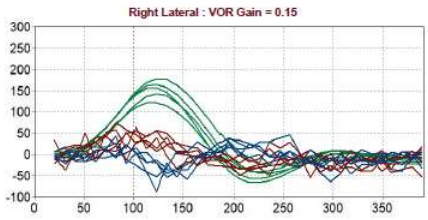
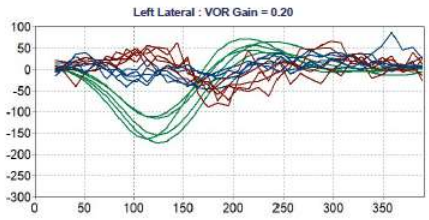


Impulses			VOR		
Canal		n	Mean gain	σ	Asymmetry
Ant.	R	0			
	L	0			
Lat.	R	5	0.15	0.19	15 %
	L	5	0.20	0.21	
Post.	R	0			
	L	0			



No corrective saccades. Opthalmology diagnosed bilateral Duane's retraction syndrome

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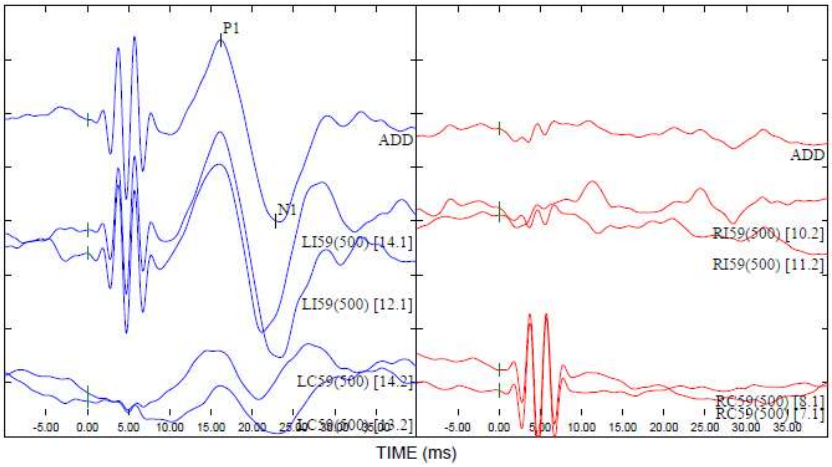
Case 3: 23-month-old female with **profound SNHL in the right ear** and normal hearing sensitivity in the left ear. **She sat independently at 8 months, stood at 12 months, and walked at 16 months**.

Absent cVEMP in the right ear



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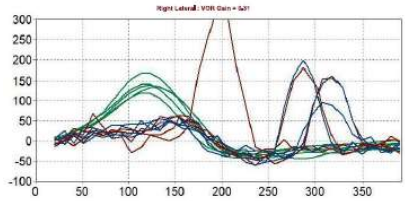
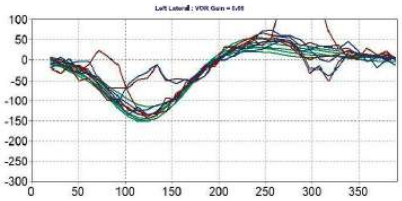
Case 3: 23-month-old female with profound SNHL in the right ear and normal hearing sensitivity in the left ear. She sat independently at 8 months, stood at 12 months, and walked at 16 months.



Impulses			VOR		
Canal		n	Mean gain	σ	Asymmetry
Ant.	R	0			
	L	0			
Lat.	R	5	**0,31**	0,11	36 %
	L	5	**0,66**	0,38	
Post.	R	0			
	L	0			



Right vestibular loss confirmed with vHIT

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Objectives, Revisited

After this course, participants will be able to:

1. List causes of pediatric vestibular loss and dizziness
   - Similar etiologies seen in adults with large proportion of vestibular migraine; different prevalence mix compared to adults, strong association with SNHL
2. List consequences of vestibular loss in children
   - Reduced DVA, reading acuity, cognitive outcomes, gross motor skills, and increased falls
3. List outcomes that can be used to predict the presence of vestibular loss in children.

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Objectives, Revisited

- Dizzy
  - YES? **AT RISK**
- Hearing Loss
  - PTA > 66 dB? **AT RISK**
  - Acquired/progressive? **AT RISK**
- Are parents concerned for their child's gross motor function?
  - YES? **AT RISK**
- What age did your child sit independently?
  - > 7.25 months? **AT RISK**
- What age did your child walk independently?
  - > 14.5 months? **AT RISK**
- Single Leg Stance
  - < 4 s? **AT RISK**
- Head Impulse test
  - Corrective Saccades present? **AT RISK**

Other confirmatory tests like the mCTSIB, DVA, or m-ECVCT

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More info….

American Academy of Audiology Clinical Consensus Statement: Assessment of Vestibular Function in the Pediatric Population

Violette Lavender[Q2], AuD (Chair)[1] Katheryn Bachmann, PhD[1] Melissa Caine, AuD[2]
Micheal Castiglione, AuD[1] Kristen Janky, AuD, PhD[3] Guang Wei Zhou, ScD[4]

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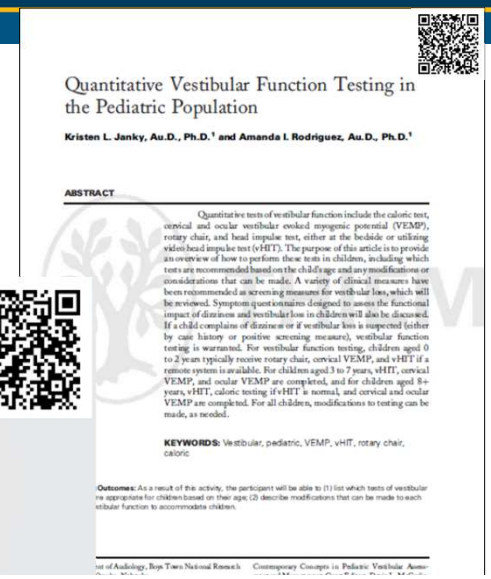
How to Complete VEMP Testing in Children less than 5 years old



Quantitative Vestibular Function Testing in the Pediatric Population

Kristen L. Janky, Au.D., Ph.D.[1] and Amanda I. Rodriguez, Au.D., Ph.D.[1]

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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]

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Reading (& Cognition & QOL) Outcomes in Children with Vestibular Loss

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https://redcap.link/boystown-ci-research

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Pediatric Audiology Translational Research CONFERENCE

COLLABORATING TO ADVANCE CLINICAL OUTCOMES

SAVE THE DATE **MAY 30-31, 2025**
Boys Town National Research Hospital, Omaha NE

KEYNOTE Susan Scollie, Ph.D.
Professor and Director of the National Centre for Audiology, Western University

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- Liz Marler
- Nicole Greenwalt
- Kyli Schulz
- Gabby Merchant
- Katie Gordon
- Kayla Samuelson
- Sarah Al Salim
- Sophie Ambrose
- Casey Vandervelde
- Manuel Vicente

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Questions?

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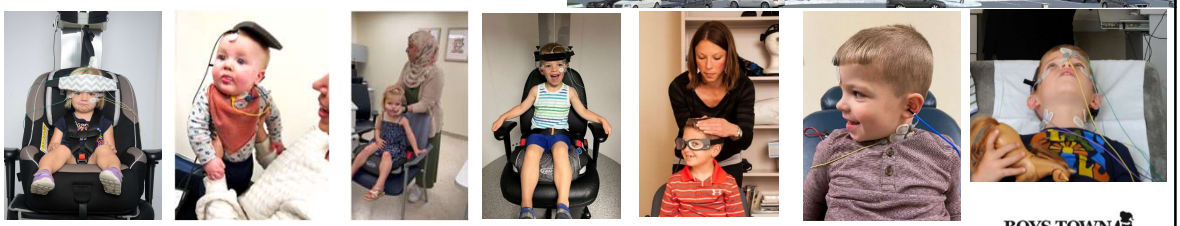

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