MUSC Health
Medical University of South Carolina

Introduction to Vestibular Laboratory Tests

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Disclosures

MUSC Health
Medical University of South Carolina

No financial disclosures or conflicts of interest.

No relevant non-financial relationship to disclose.

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Learning Objectives

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1. Describe vHIT, o/cVEMPs, VNG and Rotary Chair
2. Understand which portion of the system each is testing
3. Have a basic understanding of the results

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Vestibular Evaluation

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- VNG (or ENG)
- Caloric Irrigations
- Rotary Chair
- vHIT
- VEMPs

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Testing the System

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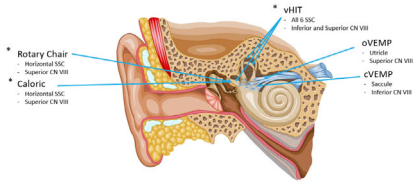
- 8th nerve (inferior and superior portions of the nerve)
- Semicircular canals
- Saccule
- Utricle



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Semicircular Canals

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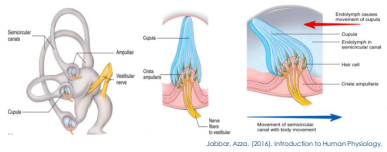
- Responsible for angular head movement
  - Lateral / Horizontal
  - Anterior
  - Posterior
- Work in three matched pairs
  - Right Lateral – Left Lateral
  - Right Anterior – Left Posterior (RALP)
  - Left Anterior – Right Anterior (LARP)



Jabbar, Azza. (2016). Introduction to Human Physiology.

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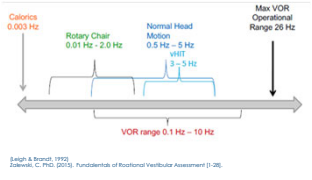
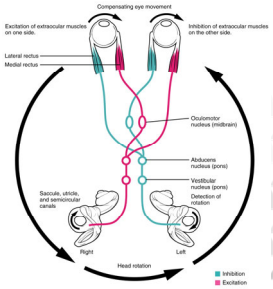
Vestibulo-Ocular Reflex

- Compensatory eye movement
- Stabilization of gaze
- Postural control



[Leigh & Brandt, 1992].
Zalewski, C. PhD. (2015). Fundalentals of Rotational Vestibular Assessment (1-28).



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Vestibular Evaluation

- **VNG (or ENG)**
- Caloric Irrigations
- Rotary Chair
- vHIT
- VEMPs

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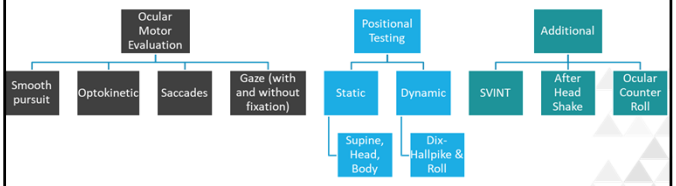
Videonystagmography (VNG)



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Vestibular Evaluation

- ~~VNG (or ENG)~~
- **Caloric Irrigations**
- Rotary Chair
- vHIT
- VEMPs

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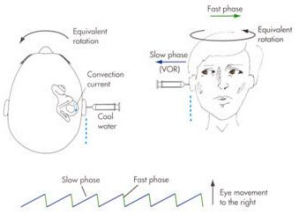
Caloric Irrigations

- Testing VOR of the horizontal SSC
- Head is at 30 degrees
- Warm and cool water (or air) presented into the ear canal
- Changes the temperature of the ear which changes the density of the endolymph in the horizontal SSC
- An absent or weak response to caloric irrigations are indicative of a peripheral lesion
- UW (unilateral weakness) or RVR (reduced vestibular response) is calculated
  - ~ 25% or greater is considered a unilateral weakness



http://www.d.umn.edu/~jfitzake/Lectures

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Calorics: The Setup

- Otoscopy prior to confirm TM is visible and intact and ear is dry and healthy
- Head at 30 degrees
- Visor over the eyes (fixation denied)
- Irrigator placed into canal
  - ANSI standards recommend warm water first then cool and to start with the right ear
- Basin/towel under ear to catch water
- Instructions are very important
- Tasking patient necessary

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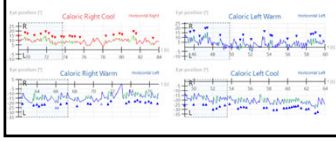
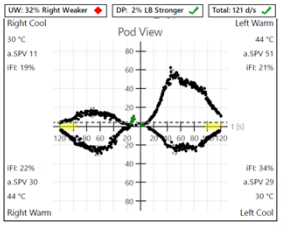
Calorics: The Results

- Nystagmus direction changes with temperature change
- "COWS"
  - Cool - opposite
  - Warm – same
- Peak nystagmus from each irrigation used for calculations





- UW or RVR: is there a weaker ear?
  - (LC+LW) -(RC+RW) / (LC+LW+RC+RW) x 100
- Direction Preponderance: was the nystagmus stronger in one direction?
- Total response RE/LE: useful to diagnose BVH
- Fixation Index: are they able to suppress the response with fixation?

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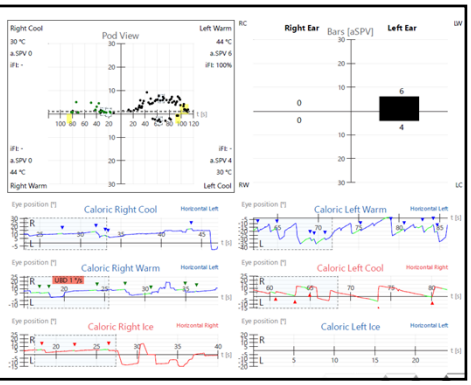
Calorics: BVH

- Total LE <12 d/s & Total RE <12 d/s = BVH (Jacobson and Newman, 1993)
- Debate about BVH criterion
- Be consistent within your clinic



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Ice Water

Ice Water Calorics:

- Used when there is no response from caloric irrigations
- Ice-water is used to determine if any residual function

The Setup:

- Use ice made with sterilized water
- Turn head for test ear up
- Inject 2 cc ice water into canal
- After 20 seconds the head is returned to center and ear is emptied onto the towel
- Can be performed two ways:
  - If no spontaneous nystagmus is visualized
    - Head is at 30 degrees to irrigate
  - If spontaneous is present
    - Supine to irrigate – if nystagmus is present patient should be rolled to prone
    - Nystagmus should disappear or change directions

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Vestibular Evaluation

- ~~VNG (or ENG)~~
- ~~Caloric Irrigations~~
- **Rotary Chair**
- vHIT
- VEMPs

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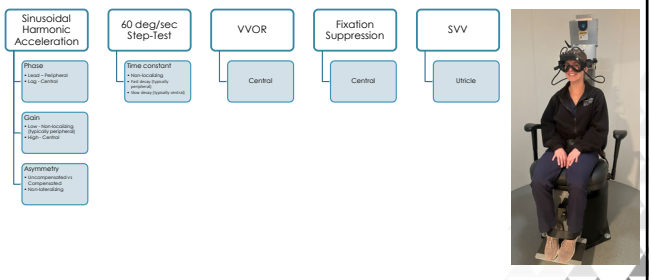
Rotary Chair



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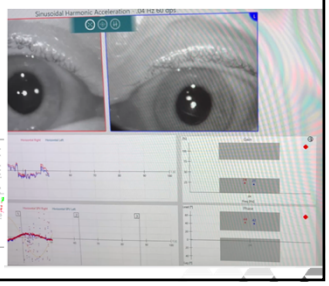
Sinusoidal Harmonic Acceleration (SHA)

- Testing VOR of horizontal SSC
- Chair rotates back and forth in the horizontal plane
- Chair rotates in one direction until peak velocity (typically 60 deg/sec) then slows and reverses
- Plotting eye velocity with chair velocity



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SHA: The Setup

- Seated upright with head pitched forward at 30 degrees to stimulate the horizontal SSC
- Seatbelt, head straps, ankle straps in place
- Vision denied (enclosure or visor)
- Tasking while testing is essential

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Sinusoidal Harmonic Acceleration (SHA)

Phase	Eye movement in comparison to the head/chair
Gain	Responsiveness of the system
Asymmetry	Ratio of nystagmus in the CW compared to CCW condition

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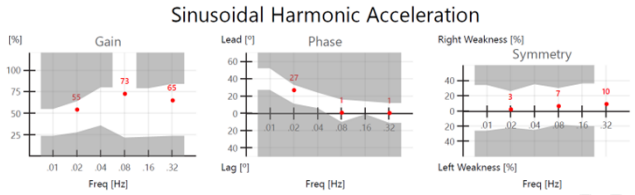
SHA: The Results



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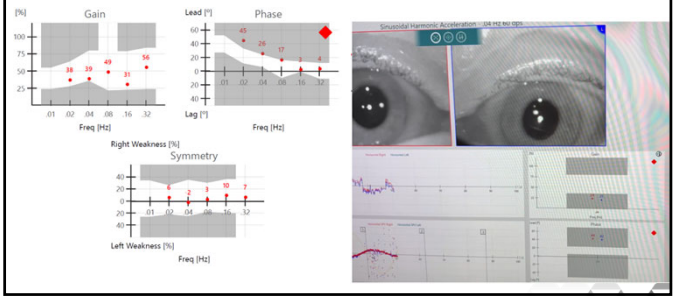
SHA: Unilateral Peripheral Weakness



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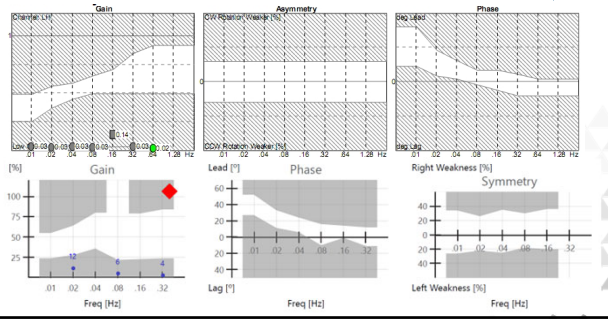
SHA: BVH



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Vestibular Evaluation

- ~~VNG (or ENG)~~
- ~~Caloric Irrigations~~
- ~~Rotary Chair~~
- **vHIT**
- VEMPs

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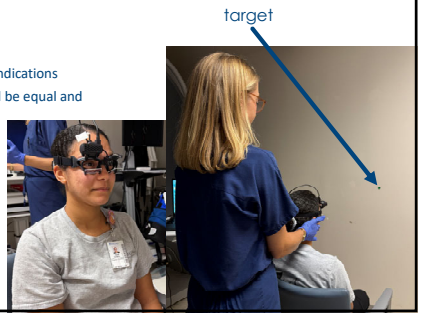
Video Head Impulse Test (vHIT)

- VOR of all 6 semicircular canals
  - Testing lateral, RALP and LARP planes
- Quick test with minimal contraindications
- Eye and head movement should be equal and opposite
- Looking for corrective eye movements



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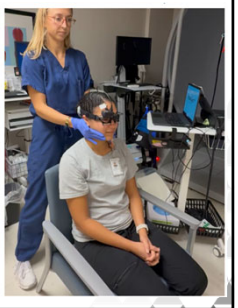
vHIT: The Setup

- Goggles with high-speed camera placed
  - Need to be tight to avoid slip
- Target is visualized
  - Earth-fixed
- Head is turned 20-30 degrees off target
  - Passive and unpredictable
  - 150 degrees/sec or greater head velocity
- Patient instructed to keep gaze on target the entire time
  - Or return to target if lost



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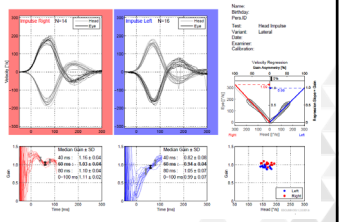
vHIT: The Results

- **Normal**:
  - Gain is ~0.75 -1.2 (clinic norms may vary)
  - No corrective saccades
- **Abnormal**:
  - Gain <0.75
  - Corrective saccades
    - Covert (during head movement)
    - Overt (after head movement)



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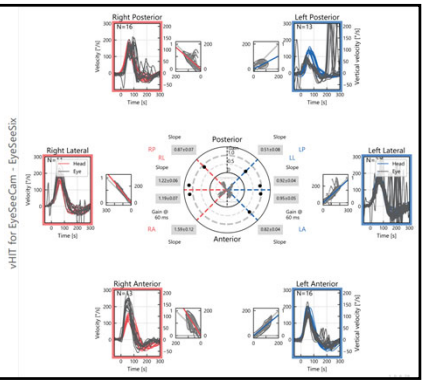
vHIT: Unilateral

- **Gain:**
  - Low gain in LP (0.51)
- **Saccades:**
  - Large overt saccades in LP
  - Large covert and overt saccades in LL



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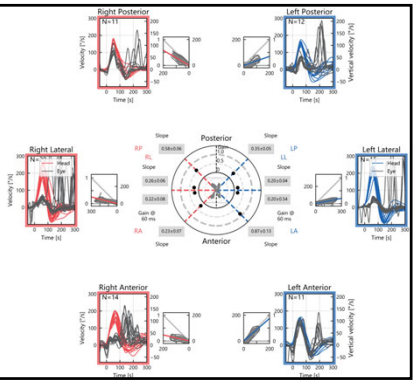
vHIT: BVH

- **Gain:**
  - Low gain in LP, RP, RL, LL, and RA
- **Saccades:**
  - Large overt saccades in RP, LP, LL, LA
  - Large covert and overt saccades in RL, RA



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Vestibular Evaluation

- ~~VNG (or ENG)~~
- ~~Caloric Irrigations~~
- ~~Rotary Chair~~
- ~~vHIT~~
- **VEMPs**

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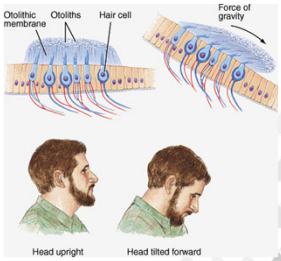
Vestibule

- **Responsible for linear movements**
  - Saccule – up/down
  - Utricle - forward/backward



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VEMPS

- **V – VESITBULAR**
  - Originates from the inner ear
- **E – EVOKED**
  - Elicit a response (by a stimulus)
- **M – MYOGENIC**
  - Measuring from the muscle
- **P – POTENTIAL**
  - Change in state (muscle activity)

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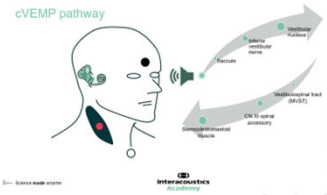
Cervical VEMP (cVEMP)

- **Testing saccule and inferior vestibular nerve**
- **Measure from the Sternocleidomastoid (SCM) muscle**
- **Ipsilateral response**



https://www.interacoustics.com/academy/evoked-potentials/vemp/vestibular-evoked-myogenic-potentials

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cVEMP: The Setup

- Normal middle ear function is needed for air conduction
  - If abnormal tympanograms or air-bone gaps on audiogram BC should be used
- Skin is cleaned and prepped for electrode placement
  - Confirm good impedances (<5kohms)
- SCM electrodes places symmetrically
  - Top 1/3rd of the muscle
- Head is turned away from stimulus and tuck chin to shoulder to contract the SCM
  - Muscle activity is monitored throughout

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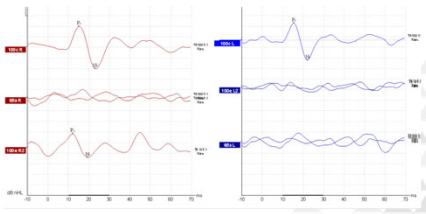
cVEMP: The Results

- **Amplitude**
  - 50 – 300 µV
- **Latencies**
  - P1 ~15 ms
  - N1 ~23 ms
- **Asymmetry**
  - calculated with the amplitude of the L/R responses at the maximum intensity
  - AR = ((larger response - smaller response) / (larger response + smaller response)) x 100
  - >36% (Young et al, 2002)



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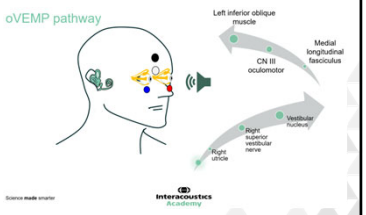
Ocular VEMP (oVEMP)

- Testing utricle and superior vestibular nerve
- Measure from the inferior oblique muscle under the eye
- Contralateral response



https://www.interacoustics.com/academy/evoked-potentials/vemp/vestibular-evoked-myogenic-potentials

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oVEMP: The Setup

- Normal middle ear function is needed for air conduction
  - If abnormal tympanograms or air bone gaps on audiogram, BC should be used
- Skin is cleaned and prepped for electrode placement
  - Confirm good impedances (<5kohms)
- Headphone placed in test ear (contralateral response)
- Gaze upward 30 degrees to contract the inferior oblique muscle

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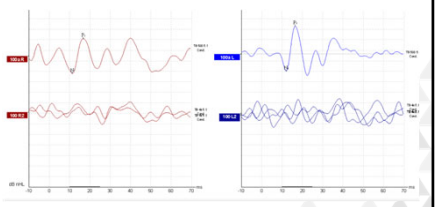
oVEMP: The Results

- **Amplitude**
  - 7 µV
- **Latencies**
  - N1 ~10 ms
  - P1 ~15 ms
- **Asymmetry**
  - Calculated with the amplitude of the L/R responses at the maximum intensity
  - AR = ((larger response - smaller response) / (larger response + smaller response)) x 100
  - >34% (Piker at al, 2011)



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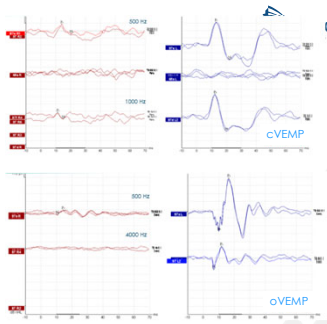
VEMP: SSCD

- **Amplitude**
  - May see larger amplitudes
- **Asymmetry**
  - Larger response from SSCD ear
- **Threshold**
  - present reduced intensity (cVEMP)
- **Frequency Tuning**
  - 4k Hz response (oVEMP)



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References

- Curthoys, I. S., Burgess, A. M., Manzari, L., & Pastras, C. J. (2022). A single-bat test for semicircular canal dehiscence—oVEMP n10 to 4000 Hz—depends on stimulus rise time. Audiology Research, 12(5), 457-466.
- Hirsch, B. (1986). Computed sinusoidal harmonic acceleration. Ear and Hearing, 7(3), 198-202
- Jabbar, Azza. (2016). Introduction to Human Physiology.
- Jha, R. N., Piker, E. G., & Romero, D. (2022). Effects of age and middle-ear on the frequency tuning of the cVEMP and oVEMP. Journal of the American Academy of Audiology, 33(03), 259-269.
- S. Kim, Y.M. Oh, J.W. Koo and J.S. Kim, Bilateral vestibulopathy: Clinical characteristics and diagnostic criteria, Otol Neurotol 32(5) (2011), 812–817.
- Kim, J. S., & Kim, H. J. (2022). Bilateral vestibulopathy: The causes, diagnosis, and treatments. Current Opinion in Neurology, 35(1), 98-104. https://doi.org/10.1097/WCO.0000000000001014
- Lee, S. U., Kim, H. J., & Kim, J. S. (2020). Bilateral Vestibular Dysfunction. Seminars in neurology, 40(1), 49–68. https://doi.org/10.1055/s-0039-3402064Kroenke, K., Hoffman, R. M., & Einstadter, D. (2004). How common are various causes of dizziness? A critical review. Southern medical journal, 93(2), 160-7.
- Piker, E. G., Jacobson, G. P., McCaslin, D. L., Hood, L. J. (2011). Normal characteristics of the ocular vestibular evoked myogenic potential. J Am Acad Audiol, 22, 222–230
- Piker, E. G., Jacobson, G. P., Burkard, R. F., McCaslin, D. L., Hood, L. J. (2013). Effects of age on the tuning of the cVEMP and oVEMP. Ear&Hear, 34, e65–e73
- Politak, L., Kushir, M., & Stryjer, R. (2006). Diagnostic value of vestibular evoked myogenic potentials in cerebellar and lower-brainstem strokes. Neurophysiologie Clinique/Clinical Neurophysiology, 36(4), 227-233.
- Ioseva, E., Morier, T., Froehlich, P., & Ferber-Viart, C. (2006). Vestibular assessment with Balance Quest: normative data for children and young adults. International journal of pediatric otorhinolaryngology, 70(8), 1457-1465.
- ElSherif, M., Reda, M. I., Saadallah, H., & Mourad, M. (2020). Eye movements and imaging in vestibular migraine. Acta otorrinolaringologica espanola, 71(1), 3–8. https://doi.org/10.1016/j.otorri.2018.10.005
- Jacobson, G. P., Shepard, N. T., Borin, K., Burkard, R. F., Janky, K., & McCaslin, D. L. (2020). Balance function assessment and management. Third edition. San Diego, CA: Plural Publishing.
- Reddy, T. M., Heinze, B., Biagio-de Jager, L., & Maes, L. (2023). Cervical and ocular vestibular evoked myogenic potentials: a comparison of narrowband chirp, broadband chirp, tone burst and click stimulation. International journal of audiology, 62(6), 575–586.
- Toh WI, Rossell SL Castle DJ. Current visual scanpath research: a review of investigations into the psychotic, anxiety, and mood disorders. Compr Psychiatry. 2011; 52: 567–579.
- Young, Y. H., Wu, C. C., & Wu, C. H. (2002). Augmentation of vestibular evoked myogenic potentials: an indication for distended saccular hydrops. The Laryngoscope, 112(3), 509-512.
- Zalewski, C.K., McCaslin, D.L., Carlson, M.L. (2019) Rotary Chair Testing. In: Babu, S., Schutt, C., Bojrab, D. (eds) Diagnosis and Treatment of Vestibular Disorders. Springer, Cham. https://doi.org/10.1007/978-3-319-97858-1_5

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