My Ears Are Causing Me To Fall?

Understanding and Treating Vestibular Hypofunction

Tonya Fuller, MSPT

Provider Disclaimer

• Allied Health Education and the presenter of this webinar do not have any financial or other associations with the manufacturers of any products or suppliers of commercial services that may be discussed or displayed in this presentation.
• There was no commercial support for this presentation.
• The views expressed in this presentation are the views and opinions of the presenter.
• Participants must use discretion when using the information contained in this presentation.

Course Objectives

• Understand the basic anatomy and physiology of the vestibular system
• Understand the signs, symptoms, and causes of vestibular hypofunction
• Describe medical testing that can be performed to diagnose vestibular hypofunction
• Perform a basic evaluation, including clinical testing, for vestibular hypofunction
• Be able to select appropriate treatments, write goals, and perform documentation for vestibular hypofunction
INTRODUCTION

Falls

• Falls are the leading cause of fatal and non-fatal injuries in older adults
• Between 30 – 40% of community dwelling individuals age 65 and over experience falls every year

Common Causes of Falls

• Muscle / Trunk Weakness
• Decreased range of motion
• Environmental hazards
• Medications
• History of falls
• Deficits in one or more balance systems
  – Vision
  – Somatosensory
  – Vestibular
What is Balance?

• A complex biological function that relies on sensory inputs from the visual, proprioceptive, and vestibular systems that converge towards the vestibular nuclei, where they are integrated and result in the induction of oculomotor and postural stabilization synergies
• Comprised of three sensory systems
  – Visual
  – Somatosensory
  – Vestibular

System Integration for Balance

Stable Surface
• 70% SOM
• 20% VEST
• 10% VIS

Unstable Surface
• 60% VEST
• 30% VIS
• 10% SOM

Impairments

• 70 years and over
  – 1 in 6 has visual impairment
  – 75% have abnormal test for postural balance
• 80 years and over
  – Prevalence of balance problems increases by 30%
• Balance problems are 15% more likely in older persons living below poverty level
Impairments

- Dizziness is the second most common symptom up to the age of 65
- Over the age of 65, dizziness is the most common symptom
- Dizziness is present in 80% of people over the age of 75
- Up to 38% of older adults report chronic dizziness

How does the vestibular system affect dizziness and imbalance? What can I do, as a clinician, to improve these symptoms?

ANATOMY AND PHYSIOLOGY
**Vestibular System**

- Detects direction and speed of head movement
- Detects the position of the head in relation to gravity
- Stabilizes gaze while the head is moving
- Distinguishes between self motion and visual motion

**Vestibular Anatomy**

- The bony labyrinth contains a membranous labyrinth
- The membranous labyrinth contains the auditory and vestibular organs
- Supplied by CN VIII (vestibulocochlear nerve)

**Bony Labyrinth**
Membranous Labyrinth

- 3 semicircular canals (Kinetic Labyrinth)
  - anterior, posterior, and horizontal
  - Primarily sense angular acceleration
  - Aligned at right angles to one another with the horizontal canal sloping down 30°
- 2 otolithic organs (Static Labyrinth)
  - Saccule = vertical plane
  - Utricle = horizontal plane
  - Primarily sense linear acceleration and head tilt

Vestibular System

Semicircular Canals

- Perpendicular Relationships
  - R Anterior/L Posterior
  - L Anterior/R Posterior
  - Right Horizontal/Left Horizontal
- Coplanar
- Push-Pull relationship
- Sensory redundancy
- Angular velocity
Otolith Organs

- Shear forces from the otoconia
  - Translates: ‘ear rocks’
- Linear motion
  - Acceleration
  - Deceleration
- Utricle
  - Horizontal plane
- Saccule
  - Vertical plane

Vestibular Nuclei

- Superior: to eye muscles: Vestibulo-ocular Reflex (VOR)
- Lateral: to Spinal Cord: Vestibulo-spinal Reflex (VSR)
- Medial: to Spinal Cord and eye: VSR and VOR
- Inferior: Reticular Formation

Vestibulo-ocular Reflex (VOR)

- Vestibular input is used to hold images stable on the retina during head rotations
- The SCC’s signal how fast the head is rotating and the oculomotor system responds by rotating the eyes at an equal velocity in the opposite direction
Vestibulo-spinal Reflex (VSR)

• The vestibular system provides the CNS with information about the movement and position of the head with respect to gravity and inertial forces
• VSR = excitation of the extensor musculature to help stabilize our body

VESTIBULAR HYPOFUNCTION

• Infection (vestibular neuritis, labyrinthitis)
  – Vestibular neuritis is the most common cause of acute spontaneous vertigo
• Trauma
• Ototoxic drugs (i.e. IV gentamicin)
• Degeneration due to age

**List is not exclusive**
2 types of hypofunction

- Unilateral
- Bilateral

Unilateral vestibular loss (UVL)

- Loss or hypofunction of the peripheral vestibular system on one side
- Accounts for up to 40% of all dizziness
- Often caused by a viral infection of the vestibular nerve, but could be idiopathic with age
- Often confused with Benign Paroxysmal Positional Vertigo (BPPV)
  - Though 10-15% of people with vestibular neuritis will also have BPPV

Unilateral Vestibular Loss (UVL)

- Most common cause of UVL is vestibular neuritis
  - Incidence of 3.5/100,000
  - 55-100% of the time it involves the superior vestibular nerve (utricle, horizontal & anterior canals)
- Other causes
  - Inferior vestibular nerve involvement (3.7 – 15%)
  - Labyrinthitis
Signs and Symptoms of UVL

- Sensation of feeling “off” or “dizzy” but no c/o spinning or vertigo, except at initial onset
- Initial onset of severe dizziness that lasted hours but gradually got better over time
- Constant “off” feeling
  - Ambulating
  - Driving
  - Busy environments
  - Bending over

Bilateral Vestibular Loss (BVL)

- Loss or hypofunction of the peripheral vestibular system on both sides
- Commonly caused by ototoxicity (i.e. IV gentamicin) and aging, but in most cases it is idiopathic
- Drugs commonly used for vertigo almost always make symptoms worse

Bilateral Vestibular Loss (BVL)

- Prevalence of 28 /100,000 in the US (14.8%); increases at ages 75 and over to 27.7%
- 1.8 million people affected worldwide
- 88% of people with BVH report falling within a previous 5 year period
Signs and Symptoms of BVL

- Oscillopsia is primary complaint
- Sensation of falling
  - Chronic imbalance
  - Postural instability
- Rarely complaints of dizziness, but can occur in acute stages

MEDICAL TESTING FOR VESTIBULAR HYPOFUNCTION

Medical Testing

- Videonystagmography (VNG) / Electronystagmography (ENG)
  - Calorics
- Rotary Chair
- Vestibular Evoked Myogenic Potential (VEMP)
  - Cervical (cVEMP)
  - Ocular (oVEMP)
- Subjective Visual Vertical (SVV) or Horizontal (SVH)
**VNG / ENG**

- Battery of tests to identify causes of dizziness
  - Oculomotor Function
    - Smooth pursuit
    - Saccades
  - Positional Tests
    - Dix-Hallpike for BPPV
    - Calorics
- ENG uses electrodes to record eye movements
- VNG uses video-based recording to record eye movements

**Calorics**

- “Gold standard” for identifying peripheral unilateral vestibular hypofunction (UVH)
- Uses a temperature gradient to deflect the cupula of the horizontal canal and generate nystagmus by blowing cold and warm air into the ear
- Normal individuals should have nystagmus during testing
- Abnormal test is a weakness of ≥ 25%
- Only examines horizontal function, which is supplied by the superior vestibular nerve, so will not show inferior nerve involvement

**Rotary Chair**

- “Gold standard” for identifying bilateral vestibular hypofunction (BVH)
- Uses rotation at 60 and 240 deg/sec in each direction to determine gain of the vestibulo-ocular reflex (VOR)
  - Normal gain is -1 of eye velocity to head velocity
  - Compensatory eye velocity equal to the head velocity but in the opposite direction
- Normal individuals should have nystagmus during testing
- Abnormal is > 26% difference in the response to the R and L sides
- Also only examines the horizontal semicircular canals
**Rotary Chair Video**

**VEMP**

- Performed to determine pathology in the otolith organs
- cVEMP
  - Performed by placing electrodes over the sternocleidomastoid muscle, which must be contracted during the test
  - Abnormal result would be absence of muscle contraction, which would also indicate side of lesion
  - Tests the inferior vestibular nerve
  - Fair to good test – retest reliability

- oVEMP
  - Performed by placing electrodes over the inferior oblique eye muscle, and patients must be looking up to bring the muscle closer to the electrodes
  - Abnormal result would be absence of muscle contraction on the contralateral side
  - Tests the superior vestibular nerve
  - Excellent test – retest reliability
- VEMP has become a useful tool for also diagnosing superior canal dehiscence and Meniere’s disease
SVV / SVH

- Quantified behavioral tests that determine an individual's perception of vertical or horizontal
- Patients are asked to align a bar with what they perceive as vertical or horizontal
- Presumed to assess otolith function
  - cannot be used to determine utricle or saccule pathology
  - Cannot distinguish between central and peripheral pathology
- Abnormal test is alignment of the bar > 2.5 degrees off of vertical or horizontal
- Can be performed in the clinic (Bucket test)

Bucket Test

EVALUATION AND CLINICAL TESTING
Subjective

- Chief complaints
- Duration and severity of symptoms (0/10 scale)
- Functional activity limitations
- Hx of falls
- Medical testing

**Your subjective evaluation should drive your objective testing**

Objective Evaluation

- UVL testing
- BVL testing
- Balance
- Outcome Measures (vestibular specific)

UVL Testing

- Vestibulo-ocular Reflex (VOR)
- Head Thrust Test
- Head Shaking (vision blocked)
Vestibulo-ocular Reflex (VOR)

- Stabilizes the eyes in the head while the head is moving
- Tested by asking the patient to focus on a target while the head is moved horizontally and vertically
- Assesses ability of patient to stabilize gaze while head moves at 2Hz (approximately 120bpm)
- Abnormal is a speed < 2Hz or gaze moves off of target

Head Thrust Test

- Unpredictable, small-amplitude, rapid head thrust
- Patients with vestibular deficits will have to make corrective saccade to refix on the target
- Affected side is positive test in direction of the head thrust
- Caused by a low gain of the vestibular system
- Head thrust test has been shown to be a reliable (and the best) bedside test to determine hypofunction

Abnormal VOR video
Head Shaking

- Must have the ability to block vision with Frenzel lenses or infrared goggles
- Performed by shaking head 20 times from side to side quickly with vision blocked
- Used to determine vestibular hypofunction or an irritative lesion on one side
- In hypofunction, nystagmus will beat towards the intact side
- May or may not see nystagmus with a bilateral loss

Head Shaking Video

BVL Testing

- Head thrust test
  - Corrective saccades bilaterally
- Head shaking
  - Appears normal if both sides are affected equally
  - May see nystagmus beating to the stronger side
  - Should always compare results to head thrust test
Balance Testing

- Most accurate way is with computerized forceplate that can measure degrees/second of sway (Balance Master, Biodex) during SOT or mCTSIB
- Can observe with use of compliant surface, such as a cushion, with eyes closed (mCTSIB)
  - Static x 15 seconds in Romberg
  - Horizontal and vertical head turns x 10 for increased vestibular input
  - Document observable sway or loss of balance after number of seconds or head turns

Outcome Measures

- Dizziness Handicap Inventory (DHI)
- Dynamic Gait Index (DGI)
- Functional Gait Assessment (FGA)

Dizziness Handicap Inventory

- Subjective measure of 25 items
- Max score of 100 (28 points for physical, 36 points for emotional and 36 points for functional) to min score of 0.
- Answers are graded 0 (never), 2 (sometimes) and 4 (always)
- Higher score = greater the perceived handicap due to dizziness

  - Mild: 0-30
  - Moderate: 31-60
  - Severe: 61-100
Dynamic Gait Index

- Objective Measure of 8 tasks
- Assesses individual’s ability to modify balance while walking in the presence of external demands
- Can be performed with or without an assistive device
- Scores are based on a 4-point scale:
  - 3 = No gait dysfunction
  - 2 = Minimal impairment
  - 1 = Moderate impairment
  - 0 = Severe impairment
- Highest possible score is 24 points.
- ≤ 19/24 are 2.58 times more likely to fall in the previous 6 months
- DGI appears more sensitive than the BBS in identifying fall risk in patients with vestibular disorders

Functional Gait Assessment

- Objective Measure of 10 tasks
  - Highly recommended for peripheral vestibular disorders
- Assesses postural stability during various walking tasks
- 10-item test that comprises 7 of the 8 items from the original DGI
- Each item is scored on a scale from 0 - 3
- May be performed with or without an assistive device
- Scores of ≤ 22/30 were found to predict falls in older adults
  - Excellent concurrent validity with:
    - Dizziness Handicap Inventory ($r = -0.64$)
    - Activities-specific Balance Confidence Scale ($r = 0.64$)
    - Number of falls in previous 4-weeks ($r = -0.66$)
    - Dynamic Gait Index ($r = 0.80$)

TREATMENT STRATEGIES
Vestibular Rehabilitation (VR)

• VR is defined as a set of exercises designed to facilitate central nervous system plasticity through adaptation or by generating substitute mechanisms in patients with balance disorders, thus improving their global stability and helping them resume their daily activities.

• VR aims at restoring spatial orientation as much as possible, stimulates visual stabilization, reduces discomfort during head movements, and leads to greater stability in body posture with static and dynamic movements.

UVL treatments

• Adaptation exercises
  – Gaze stabilization / VOR
    • x1 viewing
    • x2 viewing
    • Imaginary targets
  – Head movements

• Habituation exercises

• Postural stability / balance

UVL Adaptation Exercises

• Long term changes in the neuronal responses
• Helps system to “adapt” to decrease in VOR gain
• The system can adapt with stimulation at varying frequencies
• Stimulation can be provided in periods as low as 1 – 2 minutes
• Increase the system by providing more distraction over time
Gaze Stabilization / VOR

- Allows the image of the target to remain on the fovea during head movements
- Exercises should be performed within patient’s ability
- Target must remain in focus
- Performed horizontally and vertically

Gaze Stabilization

- **x1 Viewing**
  - Target remains stationary while the head moves
  - Eyes remain focused on target during head movements
  - 30 – 45 degrees of motion

Gaze Stabilization

- **x2 Viewing**
  - Target is moving in opposite direction of head movement
  - 30 – 45 degrees of head motion with less motion in target
Imaginary (Remembered) Targets

- Patient looks at a target in front of them and then closes eyes and turns head trying to “remember” the location of the target
- Patient then opens their eyes to see if he/she is still looking at the target
- Can be performed in the dark
- Belief is that generation of cervical inputs will help keep the eyes on the target
  - Also that mental effort will encourage improved performance

Progression

- Sitting
- Plain background
- Standing on firm surface
- Busy background
- Standing on foam surface
- Ambulating
  - Level surfaces
  - Unlevel surfaces
BVL treatments

- Adaptation exercises
  - Gaze stabilization / VOR
    - x1 viewing
    - x2 viewing
- Substitution exercises
  - Active eye-head movements
  - Saccades
- Postural stability / balance

Treatment of BVL

- Gaze stabilization is performed to adapt to differences between two sides
- Substitution exercises increase the dependence on other balance systems
- May need to use an assistive device

Substitution Exercises

- Attempt to develop alternative strategies for lost vestibular function
- Helps to minimize error by working through a pre-programmed function in the nervous system (saccades)
- Increase the response by providing more challenge over time
Active eye – head movements

• Patient has 2 targets (within peripheral vision) and stands centered between them
• Patient moves his/her eyes to a target first followed by head movement
• Eyes are then moved to other target followed by head movement
• Exercise is performed to both sides for 1 – 3 minutes
• Should be performed at varying speeds as long as target remains in focus
• Progression is the same as in UVL treatments

Active eye-head movements

Saccades

• Patient has 2 targets (within peripheral vision) and stands centered between them
• Patient moves eyes ONLY between the 2 targets
• Targets should be clear each movement
• Gradually increase speed to improve ability
Habituation Exercises

- Reduction of symptoms to movement as a result of repetitive exposure
- Central Process
- Exercises
  - Perform up to 4 movements that increase dizziness 2-3x, twice daily
  - Move fast enough to provoke symptoms
- Motion Sensitivity Quotient
- May take 4 weeks to 2 months to show improvement

Postural Stability / Balance Exercises

- Firm surface
  - Eyes closed static
  - Eyes closed dynamic (horizontal and vertical head turns)
  - Variable foot positions
    - Feet apart
    - Feet together
    - Semi tandem stance
    - Tandem stance

- Foam surface
  - Eyes closed static
  - Eyes closed dynamic (horizontal and vertical head turns)
  - Variable foot positions
    - Feet apart
    - Feet together
    - Semi tandem stance

Postural Stability / Balance Exercises
Postural Stability /Balance
Exercises

• One foot up on step
  – Static
  – Dynamic
• Touch back onto step
• Improve proprioception
• Mirror for visual cues

Gaming

• Home based gaming using head rotation and increased balance challenges results in improvements in standing balance, gaze performance, and walking performance
• Wii Fit
• Sony EyeToy

Outcomes

• Group exercise has been shown to improvements over individual exercise
• 75 – 88% improvement in outcome measures with VR
• In BVL, there is moderate evidence for exercise based VR, but posturography correlates less well with measures of balance and dynamic gait performance
Medications

- Vestibular suppressants should generally be used only for the first 24 hours
- After 24 hours, patients should be weaned off of medications due to their suppressive effect, which can prolong recovery
- Remember, medications for BVL typically make symptoms worse due to suppression of intact vestibular function

Common medications for dizziness
- Valium / Diazepam
- Antivert / Dramamine / Meclizine
- Klonopin / Clonazepam

Decompensation

- May occur months or years after injury
- The brain has “forgotten” the fine-tuning procedure it performed during VR, so symptoms return
- Can be provoked by cold/flu, surgery, vacations, extreme fatigue, change in meds, period of inactivity
- Recovery quicker than initial episode and symptoms are generally less intense
RECOVERY AND GOALS

Treatment Goals
• Decrease the patient’s sense of imbalance and visual blurring / oscillopsia
• Improve the patient’s functional balance, especially during ambulation
• Improve the patient’s ability to see clearly during head motion
• Improve the patient’s overall general physical condition
• Enable the patient to return to more normal level of activity and participation
• Reduce the patient’s social isolation

Example of Treatment Goals
• To optimize compensation for peripheral/central deficits
• To help force habituation of abnormal vestibular responses
• To teach substitution techniques to help manage symptoms and functional deficits
• To reduce risk of falls by improving balance and postural control
• To improve functional balance with gait
• To increase ability to see clearly with head movement
• To increase overall conditioning/activity tolerance
• To decrease overall social isolation
Documentation

• Medical Diagnosis
• Therapy Diagnosis
• Goals need to relate to function
• Clear objective documented in the evaluation and treatment notes

Billing & Coding

• Vestibular rehab / balance rehab
  — Therapeutic Activities
    • Functional activities
    • CPT code = 97530
  — Gait Training
    • Training of biomechanical & kinesiological components of walking including balance
    • CPT code = 97116
  — Neuromuscular Re-education
    • Balance, coordination, kinesthetic sense, posture, proprioception
    • CPT code = 97112

Billing & Coding

• ICD-10 codes
  — Peripheral vertigo
    • H81.39x
  — Dizziness and giddiness
    • R42
  — Abnormality of Gait
    • R26.89
Questions?

Email: tonyafullerpt@yahoo.com