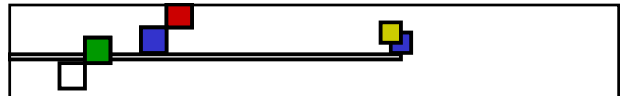


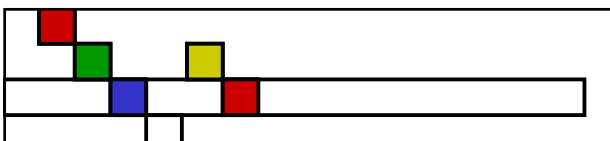
# Vestibular Rehabilitation





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- I. Anatomy and Physiology of Vestibular System*
- II. Assessment for Vestibular Disorders*
- III. Recovery Mechanism of Vestibular Disorders*
- IV. Vestibular Rehabilitation*
- V. Specific Maneuvers for Benign Paroxysmal Positional Vertigo (BPPV)*

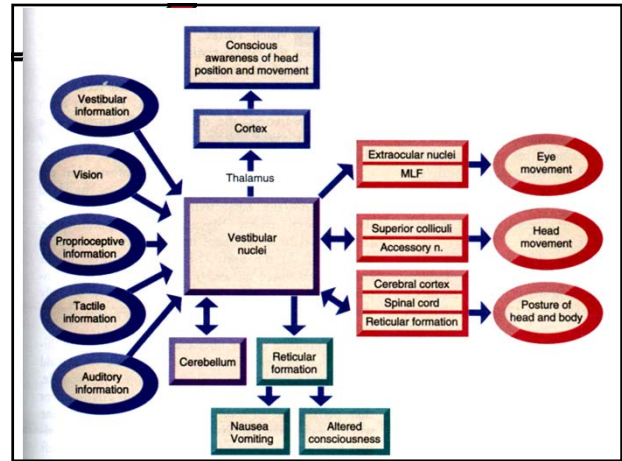
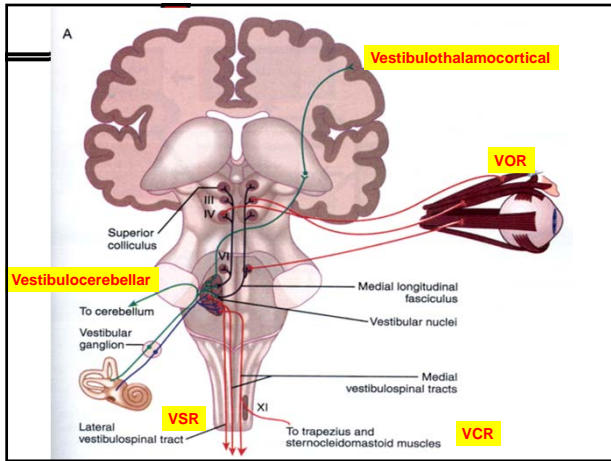


## *I. Anatomy and Physiology of Vestibular System*

## Role of Vestibular System

- Sensory information about head movement and head position relative to gravity
- Gaze stabilization  
control of eye movements when the head moves
- Postural control
- Autonomic function and consciousness



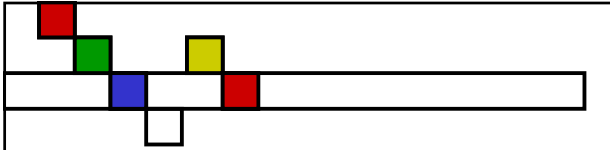
### Vestibular role in balance

- **Detect head position and movement**  
provide direction and velocity of head movement
- **Maintain head stability**  
initiate neck muscle contraction
- **Postural adjustments in upright position**  
initiate extensor muscle activation  
assist antigravity and maintain upright position
- **Control center of gravity (COG)**  
select appropriate postural strategy  
coordinate head and body movement



(Hu, MS, 1995)

### Cerebellum

- Receive inputs from vestibular nuclei complex
  - Plays an inhibitory role in modulation/calibration of VOR
  - Integrate all sorts of sensory input to control posture and coordinate movement
- **Vermis**  
– Involve VSR
- **Floculus**  
– Adjust and maintain VOR gain  
– VOR adaptation
- **Nodulus**  
– Influence duration of VOR response


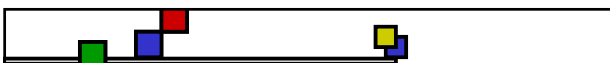


## II. Assessment for Vestibular Disorders

## Physical Examination - ENG

- **Vestibular Laboratory Evaluation**
  - Electronystagmography (ENG)
  - Pursuit, Saccade, Otokinetic nystagmus

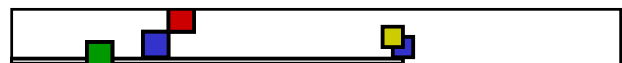
## ENG

- **Oculomotor examination (ENG)**
  - detect gaze-evoked nystagmus
  - abnormal amplitude and timing of VOR

differentiate peripheral vestibular or CNS lesion

<b>Saccade</b>	velocity	slow : CNS/cerebellar/ pontine degeneration
	accuracy	overshoot : cerebellar disease undershoot : cerebellar / basal ganglion disease
	symmetry	asymmetry : hemi-inattention
<b>Pursuit</b>	symmetry	asymmetrical disturbance : unilateral hemisphere, post. fossa lesion

(Honrubia V. 2000)



## Caloric test

- **Caloric test**
  - Nonphysiological stimulus (water, air) to induce endolymphatic flow in the semicircular canal
  - Bithermal air irrigation: warm (44° C), cold (27° C)
  - **Horizontal semicircular canal: the largest temperature gradient developed**
  - Test sequence:  
Left cold → Right cold → Left warm → Right warm
  - **“COWS”** response
    - c**old : nystagmus to the **o**pposite direction
    - w**arm : nystagmus to the **s**ame direction

## Diagnosis of vestibular disorders

- Central vestibular disorders
- Peripheral vestibular disorders  
(BPPV, Vestibular neuritis, Meniere's disease, Perilymphatic fistula)
  - Unilateral vestibular hypofunction
  - Bilateral vestibular hypofunction

## Subjective - Symptom

- Chief complaint
- Onset of symptom
  - Characteristic feature (dizziness, vertigo, lightheadedness, imbalance)
  - Sudden or gradual
  - Episodic or continuous
  - Intensity- visual analogue scale (VAS), Frequency
  - Associated symptoms of nausea / vomiting
  - Hearing loss (R't, L't)
    - Duration, progressive, fluctuation
    - Tinnitus, Fullness

## Subjective - DHI

- Dizziness Handicap Inventory (DHI)
- 3 domains : physical / emotional / functional
  - 25 items ,4-point scale , total score range 0-100
  - P13. 在床上翻身，是否會使你的頭暈更加嚴重?
  - Higher score indicates a greater level of handicap
  - The DHI is regarded as a criterion measures to document the effect of rehabilitation intervention


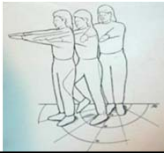
## Objective - Static Balance

- Static Balance Tests
  - Romberg test
  - Sharpened Romberg test (Tandem Romberg)  
stand in a tandem heel-to-toe position
  - Single leg stance
  - Stand on foam surface
  - Each test can be performed with eyes open and eyes closed.
  - The measured variable is the time that the patient maintain the position.



## Objective – Dynamic Balance



- **Dynamic Balance Tests**
  - **Functional reach test**
    - Reach forward or sideward
    - Generally scores of 6 inches(15.24cm) or less indicate that the patient is at high risk of falling
  - **Fukuda's stepping test**
    - The patient marches in place 50 steps (eyes open, eyes closed)
    - Abnormal- move forward >50cm, turn >30°

Vestibular Rehabilitation/Vertigo/Fukuda Stepping Test.mxd

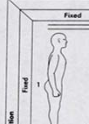
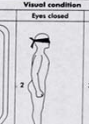




## Objective - Posturography

- **Posturography**
  - **modified Clinical Test for Sensory Interaction in Balance (mCTSIB)**
    - Stance on firm surface (eyes open, eyes closed)
    - Stance on foam surface (eyes open, eyes closed)
    - Measured parameter- COG sway velocity (deg/min)

## Objective - Posturography

- **Sensory Organization Tests**


	Visual condition		
	Fixed	Eyes closed	Sway-referenced
Support condition			
Sway-referenced			

1. Eyes open, support surface stable, visual field stable
2. Eyes closed, support surface stable, visual field swayed
3. Eyes open, support surface stable, visual field swayed
4. Eyes open, support surface swayed, visual field stable
5. Eyes closed, support surface swayed, visual field stable
6. Eyes open, support surface swayed, visual field swayed,

Equilibrium score =  $12.5 \cdot (\theta_{max} - \theta_{min}) \times 100 / 12.5^\circ$


## Objective - Gait

- **Gait**
  - **Gait analysis**
    - At self-initiated pace, increased pace
    - Cadence- slow?
    - Step length- equal?
    - Base of support- wide-based?
    - Arm swing- decreased?
    - Head and trunk rotation- decreased?
  - **Tandem walk test (eyes open, eyes closed)**




## Objective - DGI

- **Dynamic Gait Index**
- 8 tasks (functional gait) :
  - Gait level surface, Change in gait speed, Gait with horizontal head turns, Gait with vertical head turns, Pivot turn, Step over obstacle, Step around obstacle, Stairs
- Each item 0-3 points ordinal scale, total 24 points
  - Normal-3                      Mild impairment-2
  - Moderate impairment-1    Severe impairment-0
- <19 points indicates an increased risk of falling





## Diagnosis-Driven Treatment

Diagnosis	
BPPV	Canalith repositioning maneuver (CRM) Semont Maneuver Brandt-Daroff exercise
Unilateral vestibular hypofunction	Habituation
Central vestibular disorders	Habituation
Motion sensitivity	Habituation
Bilateral vestibular hypofunction	Compensation




## *III. Recovery Mechanism of Vestibular Disorders*


## Spontaneous Recovery

- Abnormal vestibuloocular reflex (nystagmus) and vestibulospinal response (postural instability) resolve within 3-14 days following onset of unilateral vestibular deficit.
- Spontaneous recovery is probably due to the development of **denervation supersensitivity** and to **axonal sprouting**.  
(Herdman SJ, 2000)



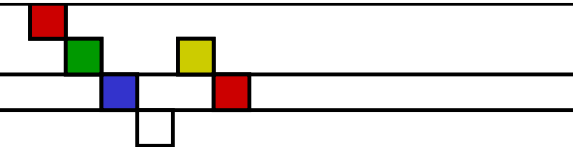
## Habituation

- Provocative stimuli repeated frequently until nervous system adapts to the stimuli. (Hu et al.1995)
- Restoring adequate motor behavior by readjusting gain, timing and direction of the VOR or VSR (Cohen,1993)
- The effect of vestibular habituation training is due to stimulation of these central adaptive mechanisms, whereas the adaptation is present for VSR. (Norr'e et al.,1987)





## Compensation

- Using alternative sensory inputs
- Use visual and/or somatosensory cues to enhance central programming and improve gaze stability and postural control
- Postural compensation is to reorganize the neural circuitry so that bilateral stimulation of the vestibular system is kept in balance. (Brandt et al., 2000)



## IV. Vestibular Rehabilitation

## Vestibular Rehabilitation

- **Indication**
  - Effective for unilateral vestibular loss or dysfunction, bilateral vestibular dysfunction, BPPV after positioning maneuver, and central vestibular disorders, traumatic brain injury
  - Ineffective for Meniere's disease, Ongoing labyrinthine pathology
- **Dosage** : 30-40 mins x 2-3 per week x 4-8 wks



## Vestibular Rehabilitation

- **Exercise program**
  - **Oculomotor exercise**  
To improve gaze stabilization
  - **Repeated head movement**  
To stimulate vestibular habituation by repeated provocative movements



## Vestibular Rehabilitation

- **Exercise program**
  - **Balance training**  
To emphasize on vestibular function during sensory organization by altering visual or proprioceptive sensory input.
  - **Functional activity**  
To facilitate vestibulospinal response, regain balance, improve physical function, and prevent fall by exercises during walking.



## Principles of treatment progression

- Eyes open → Eyes closed
- Firm surface → Uneven surface
- Comfortable speed → Increasing/Altering speed
- Straight direction → S-shape/circular route
- Wide base of support (BOS) → Narrowing BOS



## Principles of treatment progression

- Patients may complain of increased vertigo or imbalance, neither is a reason to stop the exercises.
- Vomiting or significant nausea are reasons for terminating or modifying the exercise

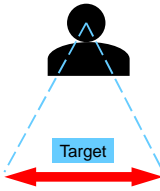
(Herdman, 2000; Whitney, 2000)



**Oculomotor Exercise**

■ **Visual tracking**

- Set a target in front of patient's eye level
- Move the target in the horizontal, vertical, and diagonal direction.
- Keep patient's head still and follow with patient's eyes.
- Gradually move the target at faster and faster speeds.
- Repeat 15-20 times in each direction.




The diagram shows a silhouette of a person's head and shoulders. A blue dashed line extends from the eyes to a blue box labeled 'Target' positioned in front of the eye level. A red double-headed arrow is placed below the target, indicating horizontal movement.

**Oculomotor Exercise**

■ **Gaze stabilization**

- Set a target in front of patient's eye level
- Patient turn head from side to side and gaze stabilize at the target.
- Gradually increase the speed of the head turns.
- Repeat 15-20 times

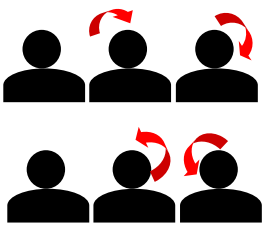


The diagram shows a silhouette of a person's head and shoulders. A blue dashed line extends from the eyes to a blue box labeled 'Target' positioned in front of the eye level. A red curved arrow above the head indicates the direction of head turning.

**Repeated head movement**

■ **Head circles**

- Patient move head in a clockwise direction with eyes open.
- Patient move head in a counterclockwise direction with eyes open.
- Repeat the motion with eyes closed.
- Repeat 15-20 times.

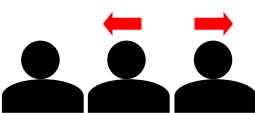


The diagram shows two rows of three silhouettes of people. The top row has red curved arrows above each head pointing clockwise. The bottom row has red curved arrows above each head pointing counter-clockwise.

**Repeated head movement**

■ **Horizontal head movement**

- Keep trunk erect.
- Patient quickly turn head from side to side with eyes followed in the same direction.
- Focus eyes on the target in front of patient's eye level when turning head.
- Repeat 15-20 times.

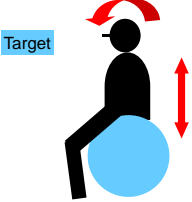


The diagram shows three silhouettes of people. Red double-headed arrows are placed above the middle and right silhouettes, pointing left and right respectively, indicating horizontal head movement.

**Balance training**

■ **Balance ball & eyes gaze**

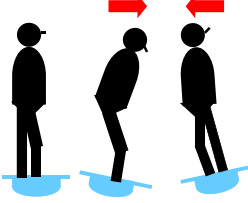
- Patient sit on the ball and the feet touch the floor.
- Patient slowly bounce on the ball and eyes focus on the target in front of eye level.
- Increase task difficulty:  
Turn head horizontally or vertically when eyes focus on the target.



**Balance training**

■ **Tilting board exercise**

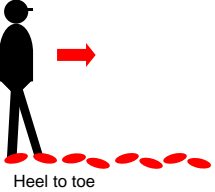
- Patient keep trunk erect and gradually lean forward or backward.
- Patient keep trunk erect and tilt the board from side to side.
- Increase task difficulty:  
Perform the task with eyes closed.



**Balance training**

■ **Tandem walk**

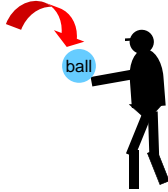
- Patient walk heel to toe on firm surface at a comfortable speed.
- Increase task difficulty:  
Walk on the foam surface.  
Perform the task with eyes closed.



**Functional activity**

■ **Ball toss**

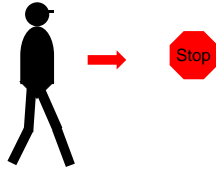
- PT gently toss a ball and patient attempt to catch the ball.
- Increase task difficulty:  
Toss the ball to different positions so that patient must take additional action such as stepping side to side.



**Functional activity**

■ **Walk – stop**

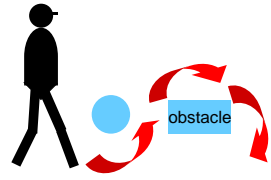
- Patient begin walking and then **stop abruptly** at PT’s command.
- Increase task difficulty:  
Increase walking **speed**  
Walk with altering speed at PT’s command before stopping.



**Functional activity**

■ **Obstacle course**

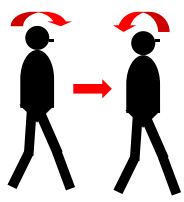
- Patient is instructed to walk the obstacle course in a specific route.
- Increase task difficulty:  
**Toss a ball** for the patient to catch while walking.



**Functional activity**

■ **Walk with head movement**

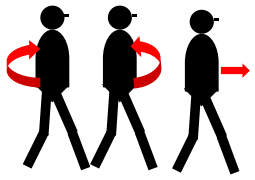
- Set a target in front of patient’s eye level
- Begin walking at normal speed.
- Patient **turn head and walk** straight ahead.
- Increase task difficulty:  
Patient **look at the target** when turning head.  
Patient walk in **S-shape route** or on the foam surface.




**Functional activity**

■ **Roll body and reversion**

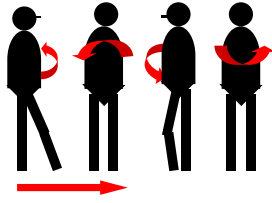

- Patient roll body in the **clockwise direction**.
- Then patient roll body in the **counterclockwise direction**.
- Patient regain balance and walk straight ahead.
- Increase task difficulty:  
Increase the rolling circles.





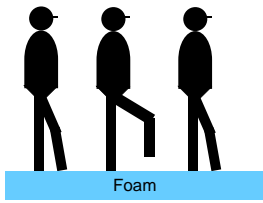
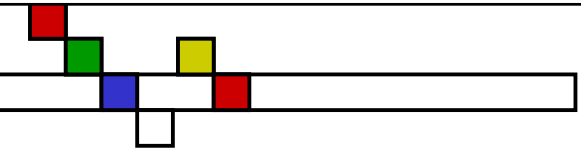
### Functional activity

- **Roll body against wall**
- Patient walk with body rolling against wall.
- At the end, patient stabilize their body.
- Increase task difficulty: Gradually **increase speed or distance**. Perform the task with **eyes closed**.






### Functional activity

- **Walk on foam/trampoline**
- Patient's eyes focus on the target located at eye level.
- Begin walking with small step.
- Increase task difficulty: Perform the task with **eyes closed**. **Turn head** horizontally or vertically when walking on the foam/ trampoline.





### V. Specific Maneuvers for Benign Paroxysmal Positional Vertigo (BPPV)

### Diagnostic Test

- **Hallpike-Dix test**  
Moving the patient rapidly from sitting to supine position with head turn 45° and 30°-45° below horizontal will stimulate the posterior canal.
- (+)  
vertigo, nystagmus  
latency of onset 2~20 sec  
lasted <60 sec



[Vestibular Rehabilitation/vertigo/The Dix-Hallpike test for BPPV.mp4](#)

## Diagnostic Test

### ■ Roll test for horizontal canal BPPV

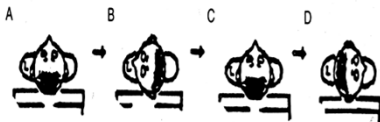


FIGURE 19-4. Roll Test for horizontal canal BPPV. (A) The patient is laid supine with the head flexed 20°. (B) The head is quickly rolled to one side, and nystagmus is looked for and the patient is asked to report any vertigo. (C) The head is then slowly rolled back to a supine position. (D) The head is then quickly rolled to the other side, and nystagmus is looked for and the patient is asked to report any vertigo. (Modified from Tusa, RJ, and Herdman, SJ: Canalith repositioning for benign positional vertigo. Education Program Syllabus 3BS.002, Am Acad Neurol, Minnesota, 1998, p 8, with permission.)

## Specific Maneuvers for BPPV

BPPV	Specific maneuver	
Posterior canal	Epley	Canalolithiasis
	Semont	Cupulolithiasis
	Brandt-Daroff Exercise	Cupulolithiasis
Horizontal canal	Barbecue rotation	

## Clinical Evidence

- Brown et al. 2001  
Many patients with **bilateral vestibular loss** benefit from a vestibular exercise program based on improved **physical function and reduced levels of handicap** (DHI).
- Kammerlind A-S C. 2001  
Balance training in elderly people with **nonperipheral** vertigo and unsteadiness seem to improve both **vertigo and balance** (SOT 3,4,6).
- Cohen HS. 2003  
For many patients a simple home program of vestibular habituation head movement exercises is related to reduction in **symptoms** and increasing **independence in activities of daily living** (Vestibular Disorders Activities of Daily Living Scale).

## Clinical Evidence

- Hall CD. 2004  
Vestibular rehabilitation is effective in significantly **reducing fall risk** (DGI score) in individuals with **unilateral vestibular deficit**.
- Badke MB. 2005  
Outcome measures of vestibular rehabilitation protocols confirmed objective and subjective improvement of **balance** (vestibular SOT, composite SOT) and **dizziness handicap** (functional DHI) in patients with **peripheral and central vestibular disorders**.

## Clinical Evidence

- Chang WC. 2008

Additional exercise training, which emphasizes vestibular stimulation, can improve **balance ability and functional gait performance** (DGI) among patients with **benign paroxysmal positional vertigo** who had already undergone the canalith repositioning manoeuvre.

**Table 2** Static and dynamic balance tests for subjects in the experimental group and control group at baseline, 2-week, and 4-week assessments

Outcome variable	Experimental group (n = 13)			Control group (n = 13)		
	Baseline	2-week	4-week	Baseline	2-week	4-week
<b>Static balance (sway velocity)</b>						
Mean (SD)						
Stance on foam surface (degrees/sec)	EO 0.57 (0.25)	0.48 (0.16)	0.44 (0.15)	0.56 (0.25)	0.49 (0.28)	0.44 (0.17)
	EC 2.43 (1.62)	1.52 (0.49)**	1.22 (0.36)**	2.32 (1.09)	1.76 (0.73)**	1.94 (0.77)
Single leg stance (degrees/sec)	EO 0.68 (0.28)	0.61 (0.17)	0.52 (0.16)*	0.75 (0.38)	0.70 (0.41)	0.58 (0.16)
	EC 10.16 (2.67)	5.45 (4.47)**	5.59 (4.58)**	10.72 (2.59)	10.42 (3.09)	9.43 (3.49)*
<b>Dynamic balance (sway velocity)</b>						
Tandem walk (degrees/sec)	4.58 (1.75)	3.67 (1.43)	3.56 (0.73)	5.13 (1.54)	3.91 (1.52)	3.90 (1.39)
DGI (points)	19.2 (2.3)	22.5 (1.5)**	23.5 (0.7)**	19.8 (2.8)	21.9 (1.60)**	22.5 (1.40)**

## Clinical Evidence

McDonnel MN, Sillier SL. (2015) Vestibular rehabilitation for unilateral peripheral vestibular dysfunction. Cochrane Database Syst Rev, 1: CD005397.

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McDonnel MN, Sillier SL. (2015) Vestibular rehabilitation for unilateral peripheral vestibular dysfunction. Cochrane Database Syst Rev, 1: CD005397.