Vestibular Rehabilitation

Supervisor: 黃啟原醫師
Reporter: 丁冠中

Vestibular Rehabilitation

- An exercise-based treatment program designed to promote vestibular adaptation and substitution.

- The exercises for vestibular rehabilitation can be categorized into two types:
  - **Physical therapy for vestibular hypofunction**
  - Canalith repositioning therapy for BPPV.

History

The earliest vestibular rehabilitation therapy

- The Cawthorne-Cooksey exercises
  - Developed by Cawthorne and Cooksey
  - To treat patients with labyrinth injury resulting from surgery or head injury.
  - They found to encourage head and eye movements hastened the patient's recovery

Proc R Soc Med 1946;39:270-273.

Proc R Soc Med 1946; 39:273-278.

Cawthorne-Cooksey exercises

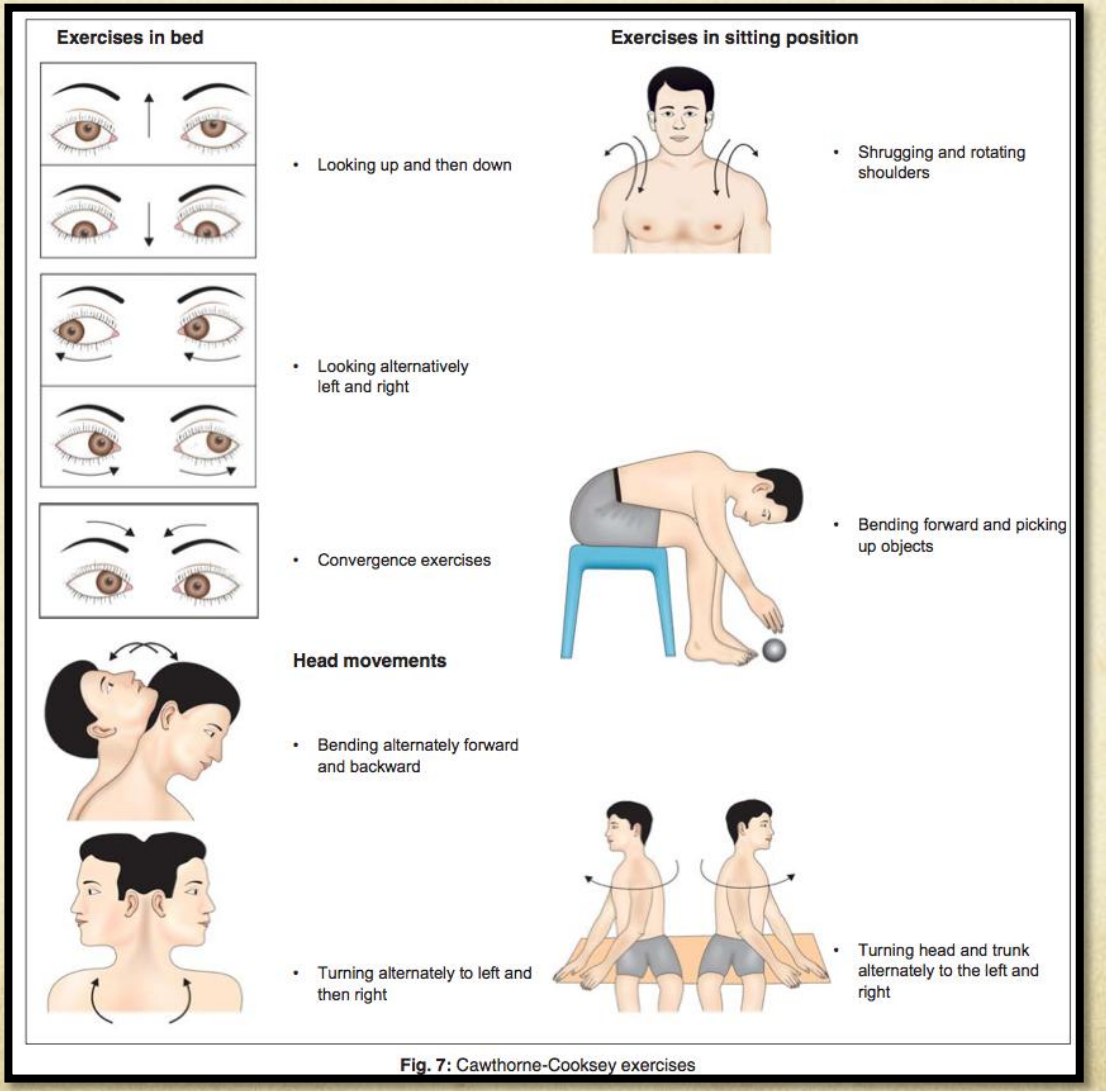


Fig. 7: Cawthorne-Cooksey exercises

Mechanisms of Recovery

- Cellular recovery
  - Suggestions: receptors or neurons that were damaged and initially stopped functioning may recover.
- Spontaneous reestablishment of the tonic-firing rate centrally
  - The disruption of tonic vestibulo-ocular and vestibulospinal responses
- **Adaptation** of residual vestibular function
- **Substitution** of allternative strategies for the loss of vestibular function
- **Habituation** of unpleasant sensations

Physiological Basis

- **Adaptation:**
  - A long-term improvement in the vestibular systems ability to adapt to head movement, achieved by the movement of an image across the retina.
    - Cawtherne Cooksey exercises
- **Substitution**
  - Use of vision and somatosensory cues with vestibular cues to enhance central programming to improve gaze stability and postural stability.
- **Habituation:**
  - Reduction in symptoms and pathological responses produced by repetitive exposure to the provoking stimulus.
    - It is a central process
- Compensation: Adaptation, substitution, and habituation
  - A gradual process of functional recovery

Book: Vertigo: Its Multisensory Syndromes
Otorhinolaryngology Clinics. 2012; 4(1)

	Direction of change	Example
Adaptation	↑ ↓	Changes in gain of vestibulo-ocular reflex (VOR) (induced by convergence or inverted prisms)
Substitution	← →	Vestibular by visual or somatosensory input, ocular slow phases by saccades (defective VOR)
Habituation	↑ ↓	Motion sickness, motion perception (decrement in perceived velocity during prolonged stimulation)
Compensation	↓	Complex recovery after peripheral unilateral vestibular loss

From Brandt et al. 1997

Indication

- Any "stable" but poorly compensated vestibular lesion
  - Regardless of the patient's age, the cause, and symptom duration and intensity.
  - No evidence of a progressive process
  - Patient's natural compensation process incomplete
- Central lesions or mixed central and peripheral lesions
  - More limited than the stable peripheral injury
- Head injury
- Psychogenic vertigo
- Elderly with dizziness
  - Reduction in fall risk.
- Vertigo with uncertain etiology
- BPPV
  - Residual dizziness after successful repositioning in two-thirds of patients

Situations Where VRT is Not Indicated

- Patients has ongoing labyrinthine pathology
- Meniere's disease
- Perilymphatic fistula

Goals of Vestibular Rehabilitation

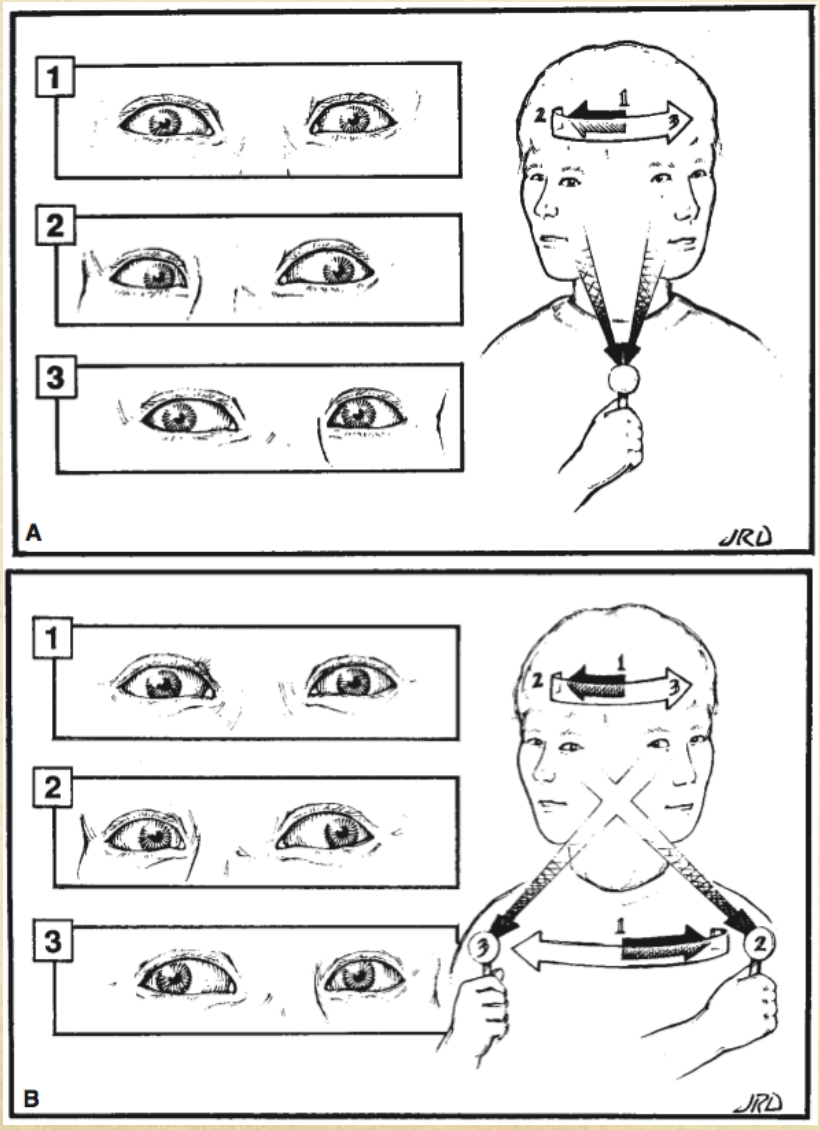
- To enhance gaze stability
- To enhance postural stability
- To improve vertigo
- To improve activities of daily living

Enhancing Gaze Stability

Vestibular **adaptation**

- Gaze instability is due to the decreased gain of the vestibular response to head movements.
  - Increasing the gain of the vestibular response with the error signal induced by retinal slip
    - Horizontal (yaw plane) and vertical (pitch plane) head movements are effective
      - ~~Roll plane~~
    - Progressively increasing retinal slip errors
      - ~~sudden, large errors.~~
    - A wide range of head movement frequencies
    - Gradually incremented of error signal
- **Four to five times daily for a total of 20-40 minutes/day, in addition to 20 minutes of balance and gait exercises**
- Good visual inputs
  - Bright room lights or with the curtains open

Exercises for Enhancing Gaze Stability



- Using a small visual target (foveal stimulus) and a large visual target (full-field stimulus) with the head moving either horizontally or vertically.

Current Therapy in Neurological Disease. 4th ed. St. Louis: Mosby Year-Book; 1993:12

Enhancing Gaze Stability

Substitution by other eye-movement systems

- Effectively cancel the vestibular deficit and protect the patient from perceiving smeared retinal images during head movements
- **Saccade modification**
  - A part of the adaptive strategy to augment the diminished slow-phase component of the VOR
    - Saccade of insufficient amplitude (under-shoot)
    - Saccade back toward the target (pre-programmed saccade)
- **Enhancing smooth-pursuit eye movement**
  - Patients with severe bilateral vestibular loss also used smooth-pursuit eye movements to maintain gaze stability during head movements while fixating on a stationary target.

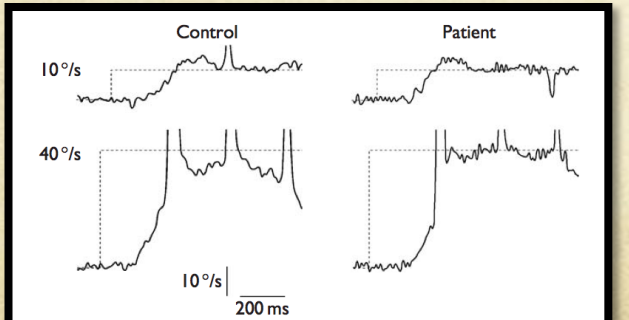


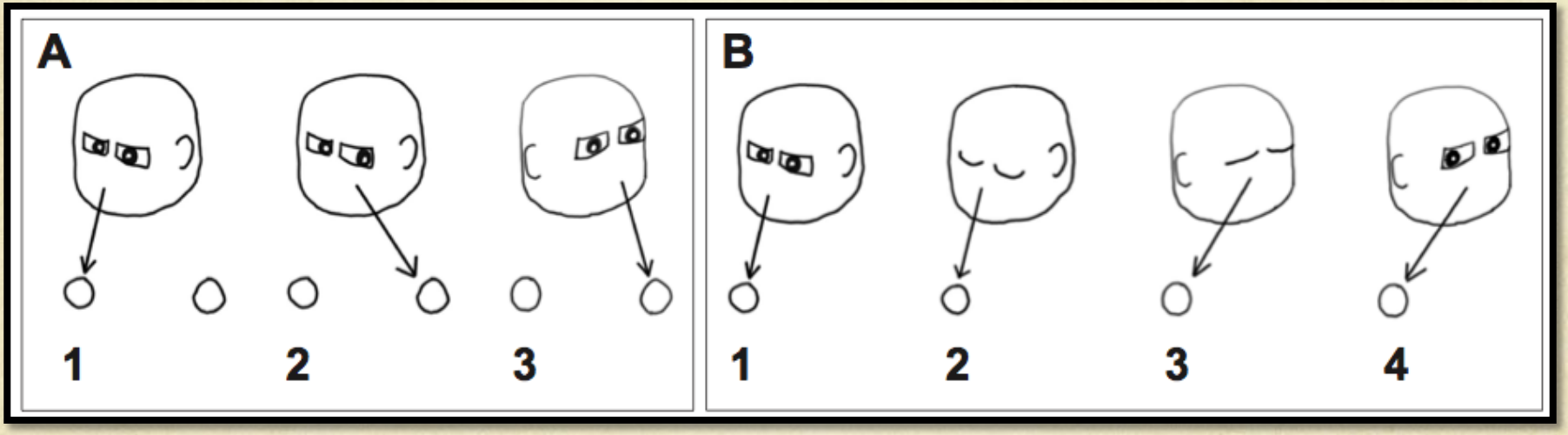
Fig. 2. Example trials show eye (solid line) and target (dotted) velocity for slow (top row) and fast (bottom row) trials with a healthy control subject (left) and a patient with a bilateral vestibular deficit (right).

Enhanced smooth pursuit eye movements in patients with bilateral vestibular deficits. *Ne-uroreport* 2004;15:2617-2620.

Enhancing Gaze Stability

Exercise for Enhancing Eye Movements

- A: Exercies for saccade and vestibulo-ocular reflex
- B: Exercise for imagery pursuit



Enhancing Postural Stability

- Postural stability recovery is slower than gaze stability recovery.
- Primary mechanisms:
  - Increasing reliance on the visual and somatosensory cues **(substitution)**
  - Improving the vestibular responses **(adaptation)**.
- Goals
  - Learn to use stable visual references and surface somatosensory information for their primary postural sensory system
  - Use the remaining vestibular function
  - Identify efficient and effective alternative postural movement strategies

Enhancing Postural Stability

1. Substitution by vision or somatosensory cues

- Patients rely on somatosensory cues from the lower extremities during the acute stage, and on **visual cues during the chronic stage.** (Unilateral)

Otolaryngol Head Neck Surg 1998;119:49-54.

- **Visual dependency:**
  - If visual cues not aligned with gravity, the patient may align the body based on visual cues and thereby destabilize him- or herself
  - Particularly when the surface reference is unstable or unavailable.

Restor Neurol Neurosci 2010;28:57-68.

- When a patient is visually dependent, a moving visual scene can be misinterpreted as a self-motion → It can cause postural instability.
  - It is not optimal to foster visual dependency

Exercises for Visual Dependency

- Exercises: balancing with **reduced or distorted visual input but good somatosensory inputs** (e.g., in bare feet).
- Maintaining balance during exposure to optokinetic stimuli
  - Moving curtains with stripes
  - Moving discs with multicolored and differently sized circles
- Patients may watch a video showing visually conflicting stimuli while performing head and body movements and while sitting, standing, and walking in the home environment
  - High-speed car chases either on a video screen
  - busy screen savers on a computer

Exercises for Somatosensory Dependency

- Somatosensory dependency may occur during vestibular recovery, especially in patients with bilateral vestibular deficits.
- In contrast to patients with unilateral vestibular deficit, patients with bilateral deficits **rely** on
  - Visual cues during the acute stage
  - **Somatosensory cues during the chronic stage**.
- Vestibular compensation would not be expected to rely solely on visual inputs in such cases (bilateral vestibular deficits).
  - The somatosensory cues are more important and could provide the requisite error signals leading to static rebalancing of the vestibular nuclei → Somatosensory dependency.

Exercises for Somatosensory Dependency

- Patients should practice performing tasks while sitting or standing on surfaces with disrupted somatosensory cues for orientation
  - Carpets, compliant foam, and moving surfaces (e.g., a tilt board).
- An example is catching a ball while standing on a carpet.
- Lost vestibular function cannot be **fully** substituted by visual and somatosensory cues.

Enhancing Postural Stability

2. Adaptation: improving the remaining vestibular function

- If a patient is unstable when both visual and somatosensory cues are altered
  - Treatment plan should be designed to improve the remaining vestibular function.
- Ultimate goal for regaining postural stability
  - To help patients to learn to rely upon their remaining vestibular function as much as possible
  - Not to depend upon their vision and somatosensory function to substitute for the vestibular loss.

Enhancing Postural Stability

Adaptation: improving the remaining vestibular function

- Gradually reduce or alter visual and somatosensory cues
  - Maintaining a vertical position in the absence of visual or somatosensory cues with their eyes open and closed and on both firm and compliant surfaces.
  - Walking in diverse environments, such as on grass, in malls, and during the night.
- Exercises design:
  - On a cushion with the eyes closed.

Enhancing Postural Stability

3. Recovering postural strategies --Normal postural strategies

- Three main postural strategies are employed to recover balance during standing
  - Ankle, hip, and step strategies.
  - The **ankle strategy** involves standing in a **wide stance.**
    - More dependent on **somatosensory** than vestibular function
  - The **hip strategy** involves standing in a **narrow stance.**
    - More dependent on **vestibular function.**
  - The **step strategy** is a stepping movement used when stability limits are exceeded.

Enhancing Postural Stability

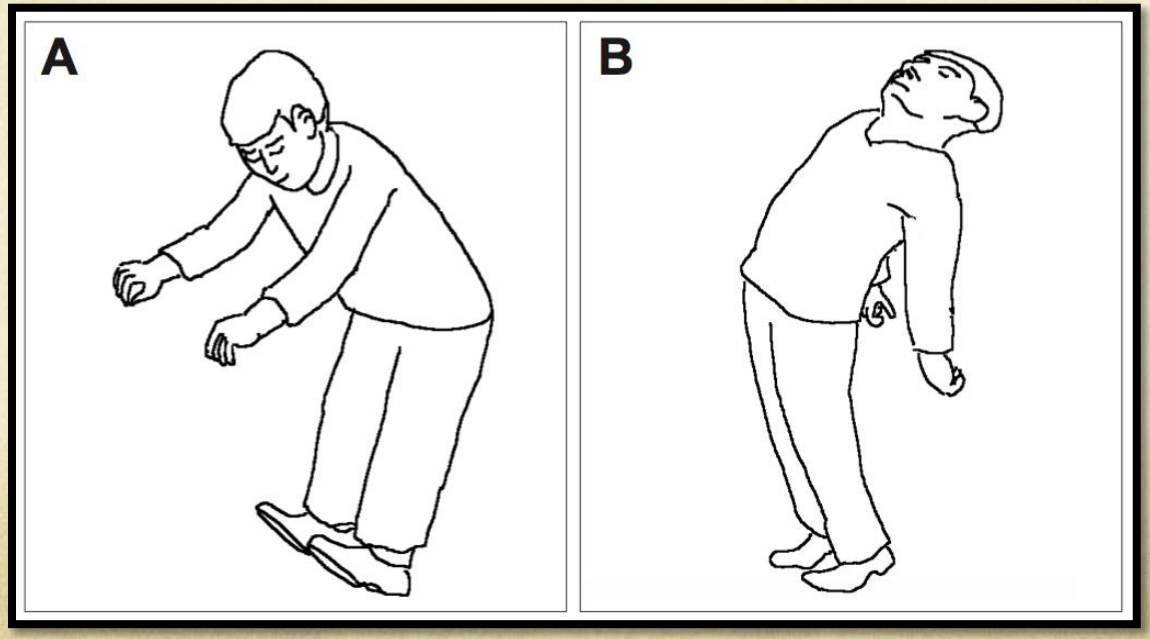
Recovering postural strategies

- Patients with vestibular loss use the ankle strategy but not the hip strategy
- Vestibular deficits may sometimes result in abnormally coordinated postural movement strategies that would give rise to **excessive hip sway**.
  - This can cause a fall when the surface is slippery.

Enhancing Postural Stability

Recovering normal postural strategies

- Swaying back and forth
  - A: Bend forward and move the center of your body backward with your toes up.
  - B: Bend backward and move the center of your body forward with your heels up. Repeat several times.

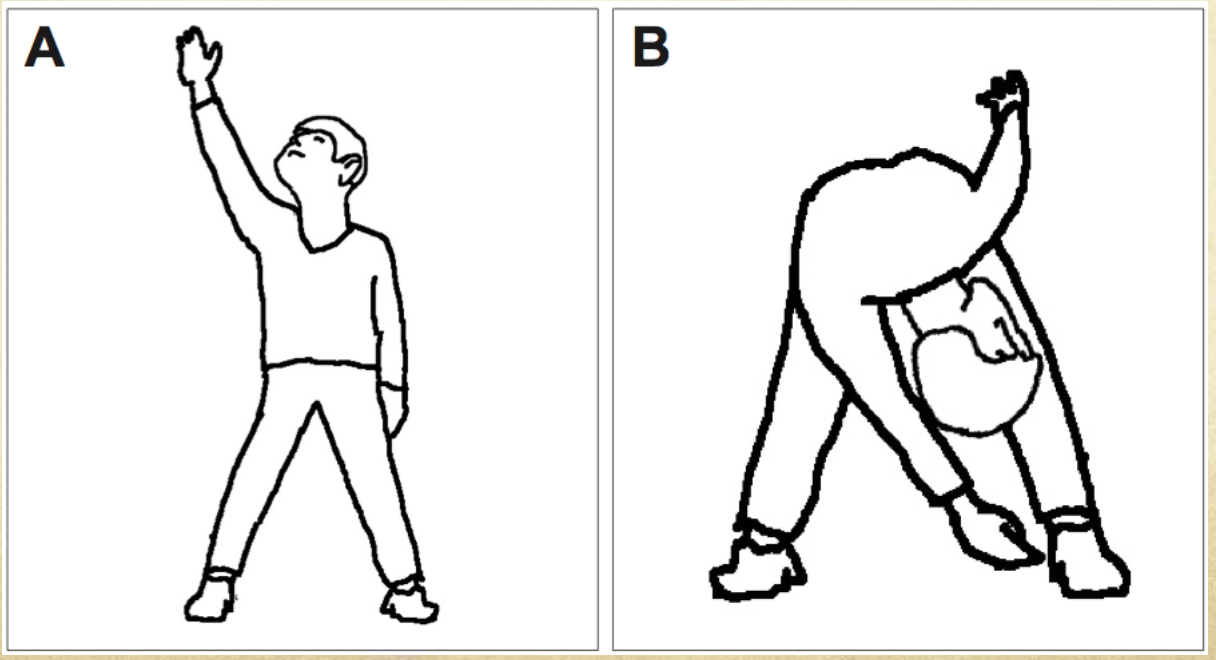


Improving Vertigo

- For most patients with provoked positioning vertigo without a definite diagnosis but with a benign etiology.
- **Habituation** of abnormal vestibular responses to rapid movements.
  - **Inappropriate** for patients with bilateral vestibular loss
    - They are designed to decrease unwanted responses to vestibular signals rather than to improve gaze or postural stability.
- Provoked vertigo disappears when the central compensation stimulated by the exercise has developed sufficiently.

Exercises for Improving Vertigo

- A: Stand with one arm elevated over the head, with the eyes looking at the elevated hand.
- B: Bend over and lower the arm diagonally with the eyes continuously looking at the hand until the hand arrives at the opposite foot.
- Repeat with the other arm.



Improving Activities of Daily Living

- Ultimate goal of vestibular recovery
  - To enable the patient to return to all of his or her normal activities of daily living.
- Exercise: normal activities such as **walking**
  - Avoid with sitting or standing quietly.
- General exercise program that is suited to age, health, and interests.
  - Jogging, walking on a treadmill, doing aerobic exercises, or bicycling.
  - Activities that involve coordinated eye, head, and body movements such as golf, bowling, handball, or racquet sports may be appropriate.

Table 1. The key exercises for VRT based on the goals are described

1. Exercises for enhancing gaze stability
   1) Head turns: Rotates the head side to side horizontally with gaze fixed on a stationary target. Do the same exercise with vertical head turns (Fig. 1A).[15,17,52]
   2) Head-trunk turns: Rotates the head and trunk together (en block) horizontally with gaze fixed on the thumb while the arm moving together with the trunk [modified from Zee's exercise (Fig. 1B)[60]].
   3) Head turns while walking: While walking in a straight line, the patient rotates the head horizontally to the left and right with gaze fixed on a stationary target. Do the same exercise with vertical head turns.[60]
2. Exercises for enhancing eye movements.
   1) Saccade: Keeps the head still and moves only the eyes. Imagine horizontally placed two targets close enough together that while looking directly at one. Look at one target and quickly looks at the other target, without moving the head. These movements are repeated several times (one of the Cawthorne-Cooksey exercise[60]).
   2) Pursuit: Keep the head still and moves only the eyes. Extends one arm forward and make the thumb (target) up, and turn the arm side to side while focusing on the thumb (modified from one of the Cawthorne-Cooksey exercise[60]).
   3) Saccade and vestibulo-ocular reflex: Horizontally placed two targets are imagined. For example, two arms are extended forward with two thumbs (target) up. Look at a target, being sure that the head is lined up with the target. Then, look at the other target and turn the head slowly to the target. Repeat in the opposite direction. Repeat both directions several times (Fig. 2A).[52]
   4) Imagery pursuit (remembered target exercise). Look directly at a target, being sure that the head is lined up with the target. Close the eyes, and the head is slowly turned away from the target while imagining that one is still looking at the target. Then, open the eyes and whether the target is kept in focus is checked. If not, adjust the gaze on the target. Repeat in the opposite direction. It should be as accurate as possible. Repeat both directions several times (Fig. 2B).[52]
3. Exercises for enhancing postural stability.
   1) Stand on one leg. Stay for 15 seconds. Switch to the other leg (one of the Cawthorne-Cooksey exercise[60]).
   2) Standing with the feet heel-to-toe with both arms extended. Stay for 15 seconds. Switch to the other leg.[15,17]
   3) Sway back and forth. Locate the patient behind a chair and before a wall. This prevents the patient from falling. The patient starts with bending low and move the center of body backward with the toes up. Next is bending backward and move the center of body forward with the heels up. Repeat 10 times (one of the authors' exercise)(Fig. 3).
   4) March in place.[17]
4. Exercises for decreasing vertigo

   Stand with one arm elevated over the head, with the eyes looking at the elevated hand. Bend over and low the arm diagonally with the eyes continuously looking at the hand until the hand arrives at the opposite foot. Repeat 10 times (one of the authors' exercise)(Fig. 4).
5. Exercises for improving activities of daily living
   1) Gait with sharp or wide turns to the right and left.[17]
   2) Go from a seated to a standing position, then return to sitting (One of the Cawthorne-Cooksey exercise[60]).

VRT: vestibular rehabilitation therapy.

Vestibular rehabilitation for unilateral peripheral vestibular dysfunction (Review)

McDonnell MN, Hillier SL

39 studies, 2441 participants with unilateral peripheral vestibular disorders

Cochrane Database of Systematic Reviews 2015 Jan, Issue 1.

Evidences in Summary

- Moderate to strong evidence that vestibular rehabilitation (movement, exercise-based) is a safe and effective approach for **unilateral peripheral vestibular disorders**.
  - Symptom reduction (dizziness), gait, activities of daily living, visual impairments, balance and quality of life
- Moderate evidence that there is maintenance of improvements over the following months post-intervention.
- The evidence for the dosage (frequency, intensity, timing) and specifics of vestibular rehabilitation (e.g. compensatory, adaptation, substitution, task-specific) is still limited
  - Due to the largely heterogeneous studies.

Evidences in Summary

- For BPPV, physical (repositioning) maneuvers are more effective in the short term than exercise-based vestibular rehabilitation;
  - Combination of the two is effective for longer-term functional recovery
- Moderate evidence that vestibular rehabilitation is effective in improving function in
  - **Post-surgical patients**
  - **Patients with vestibular neuritis**
  - **Patients with acute unilateral peripheral vestibular dysfunction.**

Journal of Vestibular Research 22 (2012) 283–298
DOI 10.3233/VES-120464
IOS Press

The effect of vestibular rehabilitation on adults with bilateral vestibular hypofunction: A systematic review

Franchino Porciuncula[a,b,*], Connie C. Johnson[a] and Leslie B. Glickman[a]
[a]*Department of Physical Therapy and Rehabilitation Science, University of Maryland School of Medicine, Baltimore, MD, USA*
[b]*Department of Biobehavioral Sciences, Teachers College, Columbia University, New York, NY, USA*

Population: adults with BVH of peripheral origin;
Interventions: vestibular exercises, balance training, education, or sensory prosthetics;
Comparison: single interventions or compared to another psychophysical intervention, placebo, or healthy population;
Outcomes: International Classification of Functioning, Disability and Health Body Functions and Structure, Activity, and Participation;

14 studies, 5 Level II, 9 Level III studies

Evidences in Summary

- Moderate evidence that adults with bilateral vestibular hypofunction improved their **gaze and postural stability** following exercise-based vestibular rehabilitation.
- There was a lack of evidence on outcomes relating to participation and activity.

Reference

REVIEW
J Clin Neurol 2011;7:184-196

Print ISSN 1738-6586 / On-line ISSN 2005-5013
http://dx.doi.org/10.3988/jcn.2011.7.4.184

Open Access

Vestibular Rehabilitation Therapy: Review of Indications, Mechanisms, and Key Exercises

Byung In Han,[a] Hyun Seok Song,[b] Ji Soo Kim[c]

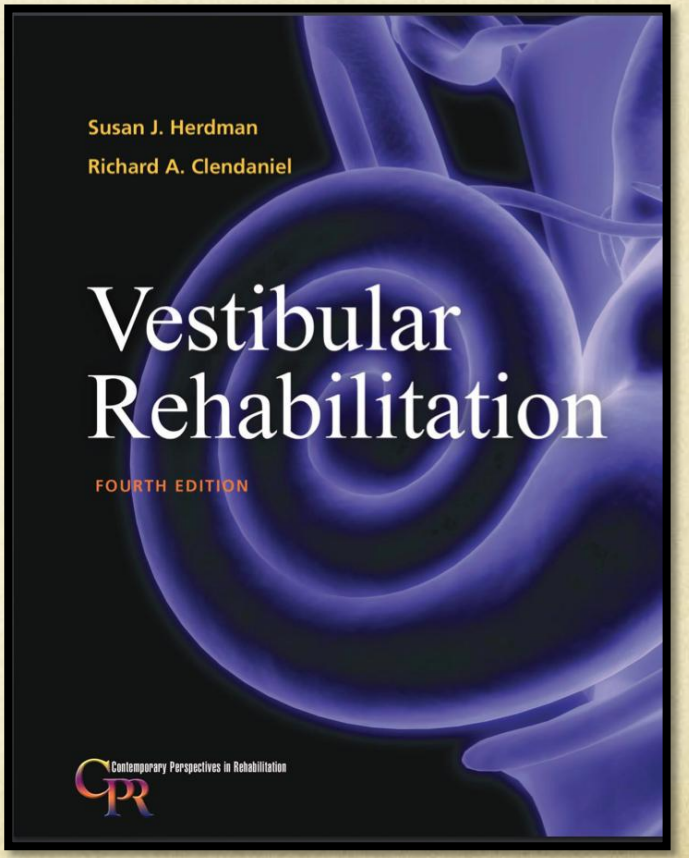
[a]Do Neurology Clinic, Daegu, Korea
[b]Department of Neurology, School of Medicine, Kyungpook National University, Deagu, Korea
[c]Department of Neurology, School of Medicine, Seoul National University, Seoul, Korea

10.5005/jp-journals-10003-1088

REVIEW ARTICLE

Vestibular Rehabilitation: An Overview

HS Writer, RD Arora



Thank You