Vestibular Rehabilitation in patients with brain stroke

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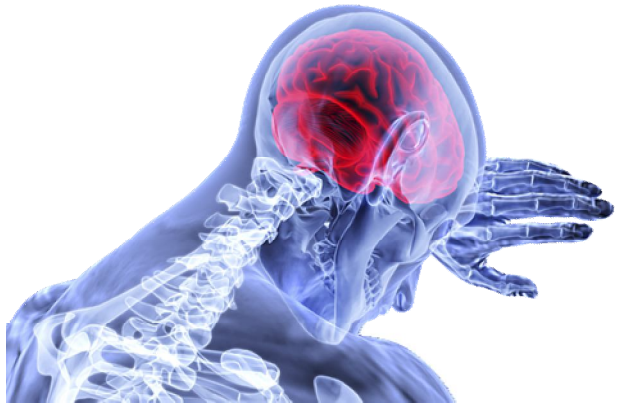
Introduction

- Vertigo and dizziness are the cognitive manifestation of a disturbance in the balance system

- There is a relation between dizziness and stroke:
  - patients who are hospitalized for vertigo are at higher risk for stroke
  - 70% of patients with first time stroke had dizziness
  - the risk of being dizzy after a stroke is higher among women than men
  - dizziness negatively affects self-perceived health
  - dizziness is a risk factor for falls
  - dizziness have a negative influence on the quality of life



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Introduction

- Research in neurological diseases reported that patient with post-stroke hemiparesis showed more risks of falling than healthy individuals
- Also, post-stroke patients lose standing postural stability more compared with healthy individuals when administered galvanic vestibular stimulation
- It is possible that post-stroke patients have a high risk of falling because of vestibular dysfunction.
- Thus, simultaneously measuring changes in the VOR function and gait performance before and after intervention with a focus on the vestibular system will provide valuable information for clinical rehabilitation

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Postural Control & Vestibular Rehabilitation

- In the postural control function, the sensory strategy consists of the visual, somatosensory, and vestibular system, and post-stroke patients tend to show an increase in postural perturbation because of under-stimulations in one of the sensory strategies.

- In particular, patients with hemiplegia cannot adequately utilize vestibular information, and instead, rely considerably on visual input for stabilizing their postures.

- Vestibular rehabilitation fosters the sensory reweight to coordinate vestibular input and as a result, patients might show improved walking performance at least up to the 3 weeks after the vestibular intervention

- In terms of time since stroke, vestibular rehabilitation research has already shown significant improvements in DGI by vestibular exercises in patients who have had an acute stroke.

- Crucial role of the vestibular rehabilitation in subacute posts-troke patients' gait performance

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Vestibular Rehabilitation

- Some studies have reported the benefit of vestibular rehabilitation to facilitate the reflex mechanism related to vestibular function.

- It is suggested that the sensory conflict might lead to neurological rearrangements, known as vestibular compensations, on which the rationale of the VOR training is based.

- The main components of vestibular rehabilitation:
  - Gaze stabilization exercises to help adapt the VOR function
  - Balance exercises, as substitution exercises, to retrain the vestibulo–spinal reflex (VSR) function

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Vestibular Rehabilitation

- Previous studies have already shown that vestibular rehabilitation improved postural stability in patients with central and peripheral vestibulopathy.

- Theoretically, patients with stroke hemiparesis could also gain improvements in both the VOR function and gait performance by **vestibular rehabilitation therapy**, similar to patients with vestibular disease.

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The Human Vestibular Cortex

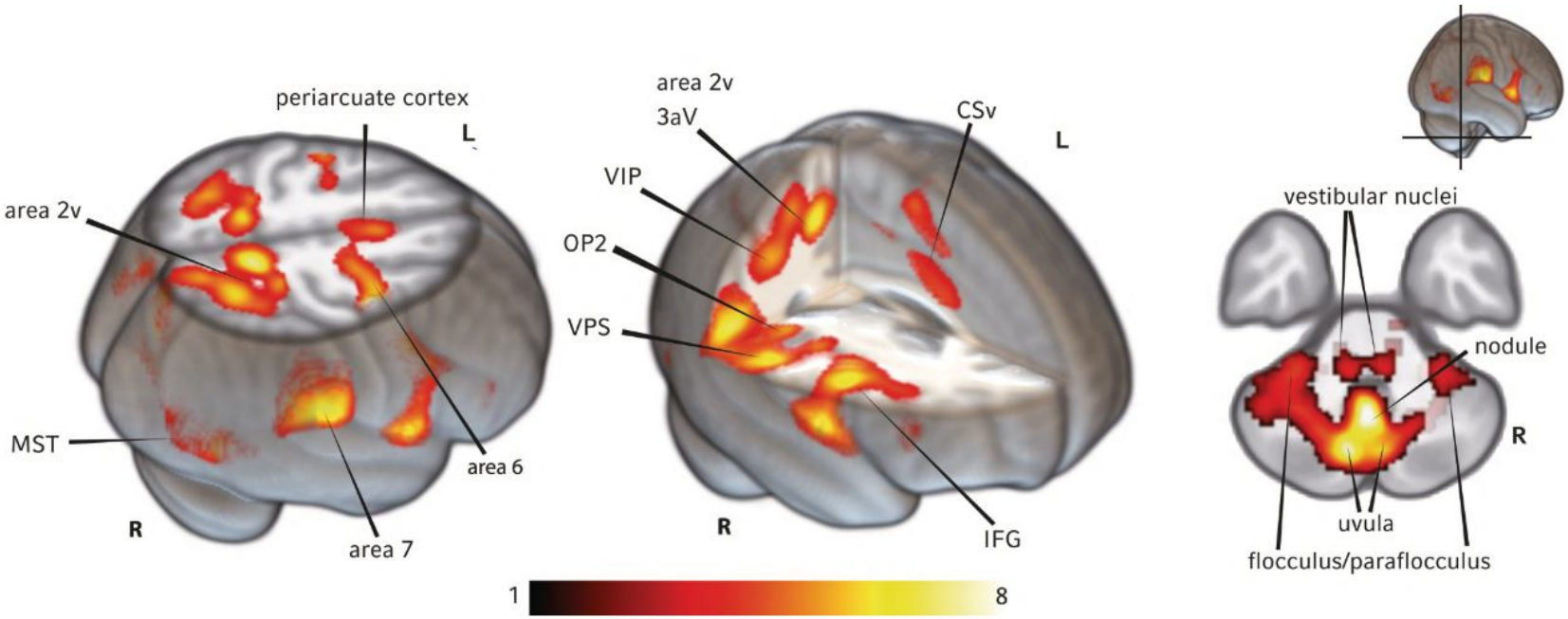

Fig.2: The entire central vestibular system after naturalistic stimulation in a large cohort (n=75). All scales represent z-scores.

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The Human Vestibular Cortex

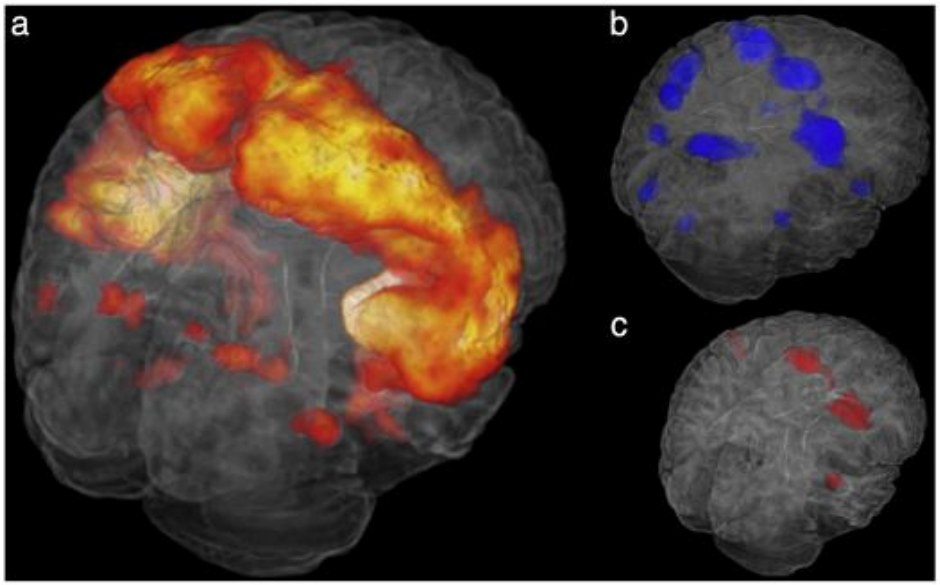

Fig. 4. a) Functional connectivity of the PIVC as indicated by significant (cluster-level $p<0.05$ corrected) correlation in resting state fMRI data. b) Significant convergence of activation reported in experiments that employed saccadic eye movements as retrieved through the *BrainMap* database. c) Conjunction between the functional connectivity of the PIVC and the meta-analysis on saccadic eye movements indicating regions that were significant in both analyses.

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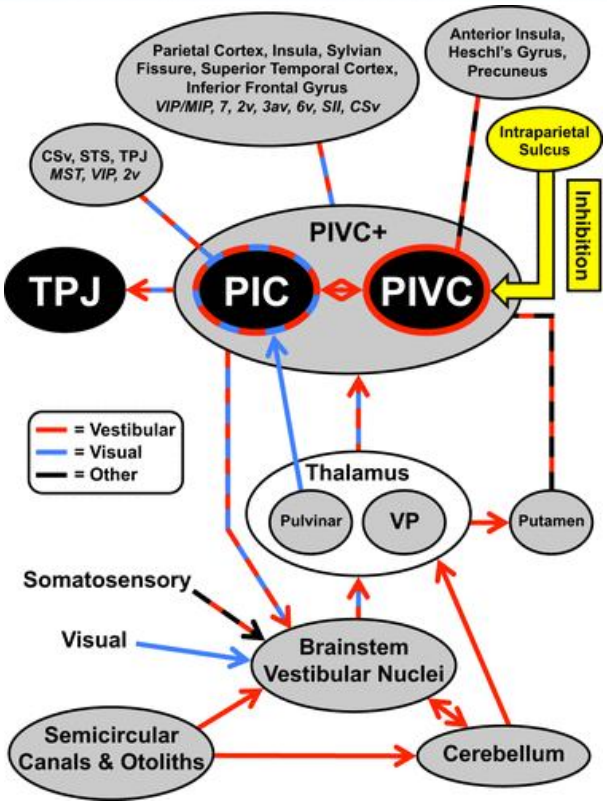
Vestibular Network



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Vestibular Network

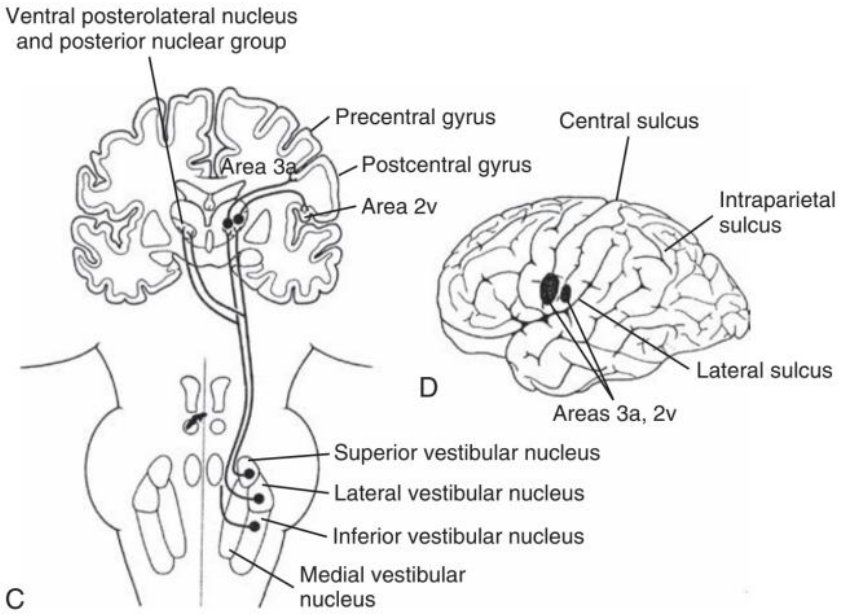

Figure 19.3, cont'd C, Vestibulo-cortical projections. **D,** Likely vestibular projection areas in the cerebral cortex. (From Dickman JD. The vestibular system. In: Haines DE, ed. *Fundamental Neuroscience for Basic and Clinical Applications*, 3rd ed. Philadelphia: Churchill Livingstone; 2006.)

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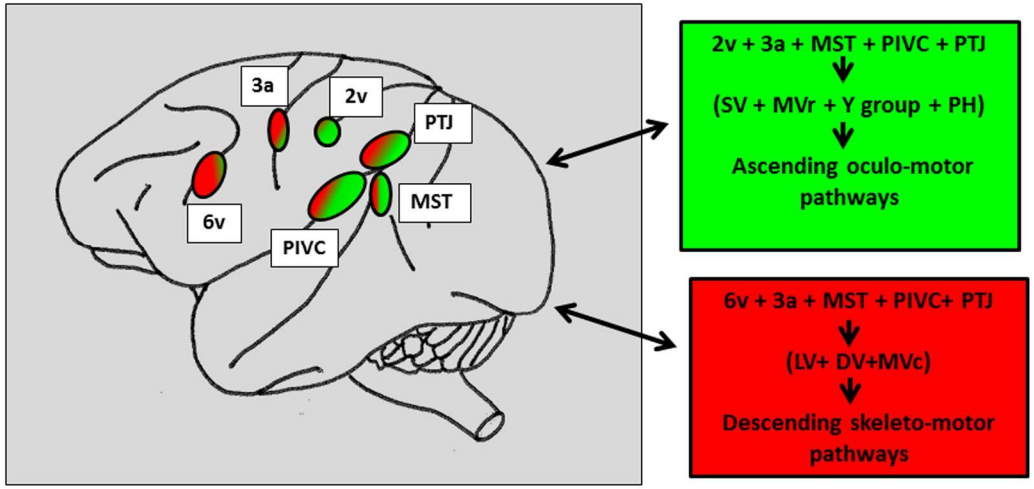
VOR & Postural Control

- The reflex mechanism related to vestibular function plays an important role in postural control. It has been suggested that the vestibulo–ocular reflex (VOR) is activated to gaze on a target during head rotation and to maintain one's posture.
- In terms of gait performance, a study has shown that the VOR function is significantly related to gait performance and evaluation of the VOR may be beneficial for identifying individuals at risk for falling.



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VR & VOR

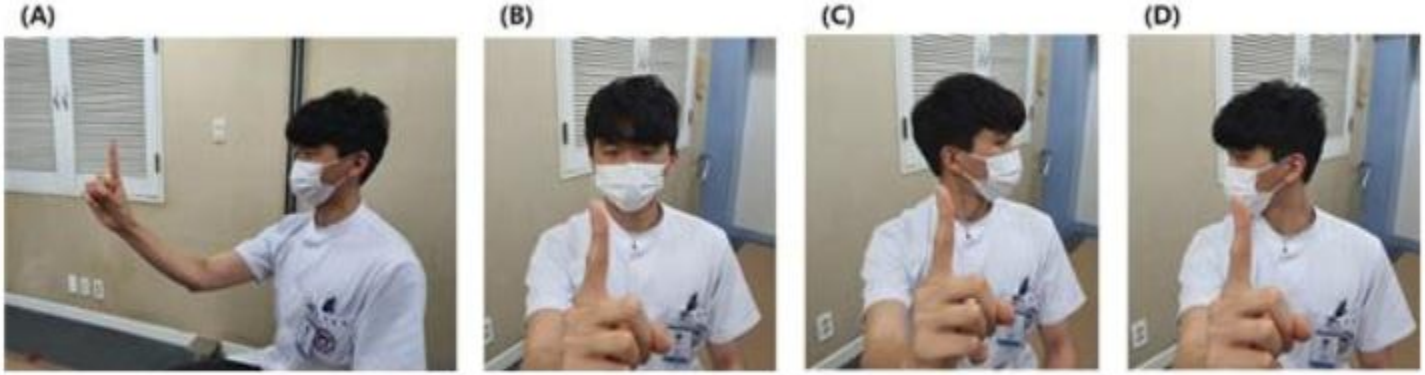

Fig. 2. Vestibular adaptation exercise (VAE). (A) Neutral position, anterolateral view of starting position. Patient is instructed to see a single fixed object like finger. (B) Anterior view of starting position of VAE. (C) Next, the patient quickly turns head to the left (right). The gaze should be fix to the object. (D) Turn head to the other side and repeat the actions.

- J Korean Med Rehabil 2020;30(4):179-186.

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VR & Balance Exercise

- Sensory integration begins with settling techniques to incorporate somatosensory and vestibular systems while decreasing visual dependence.

- Gaze stabilization for recovery of vestibular ocular reflex and visual motion challenges can be integrated at many levels.
- Balance training is achieved with appropriate changes in surface and base of support.

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Noninvasive Brain Stimulation Techniques

- There are several noninvasive brain stimulation techniques, which are used as a therapy to improve postural control.

  - Transcranial direct current stimulation (tDCS)

  - Galvanic Vestibular Stimulation (GVS)

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tDCS & Postural Control

- Transcranial direct current stimulation (tDCS) is one such technique, which can be easily applied using a simple generator of the direct current.

- According to ‘‘somatic doctrine’’, anodal tDCS (a-tDCS) induces inward current flow under the anode, leading to somatic depolarization and therefore enhances corticospinal excitability.

- On the other hand, cathodal tDCS (c-tDCS) induces an outward current leading to somatic hyperpolarization, which may lead to a decrease in corticospinal excitability.

- It should be noted that the effect of the tDCS montage depends on several factors including target area, spatial orientation of neurons with respect to stimulation and modifying factors such as different pathologies and drugs

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GVS

- Galvanic vestibular stimulation (GVS) is a technique that can stimulate the vestibular nerves associated with both semicircular canals and otolith organs.
- By applying a small current through a surface electrode over the mastoid process behind the ear, the firing rate of all vestibular afferents can be changed.

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GVS & Vestibular Cortex

- The vestibular afferent excitation induced by GVS using direct current passes through the vestibular nucleus of the brainstem and the vestibular thalamus, and finally activates the area related to multisensory input (area 2, area 3a/b, area 7, and the parieto-insular vestibular cortex)

- alternating current GVS activates the areas (supramarginal gyrus, posterolateral thalamus, cerebellar vermis, posterior insula, and hippocampus) involved in the processing of vestibular information for head and body orientation in space.

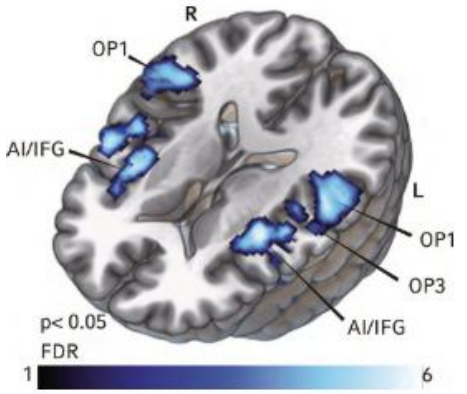

Fig.3: Conjunction analysis of a mastoidal sham stimulation and GVS shows significant activations in somatosensory area OP1, adjacent area PFcm, OP3, the rolandic operculum (RO) and the anterior and middle insula as part of the salience network (IN).

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GVS & Postural control

- The activation of cortical areas involved in multisensory input, including vestibular information, may be involved in the reduction of postural sway during nGVS.

- GVS can stimulate the vestibular nerve associated with the semicircular canal and otolith organs. The input to the otolith organs is projected through the lateral vestibular spinal tract to the motor neurons of the lower limb extensor muscle, which is an antigravity muscle.

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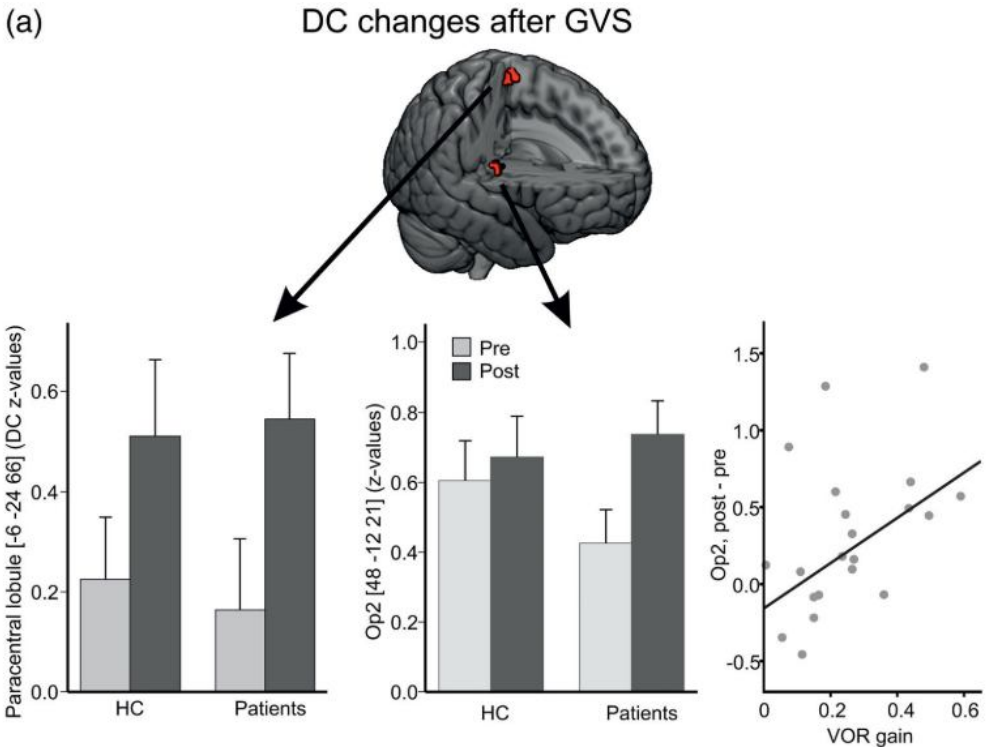
GVS & Cortex



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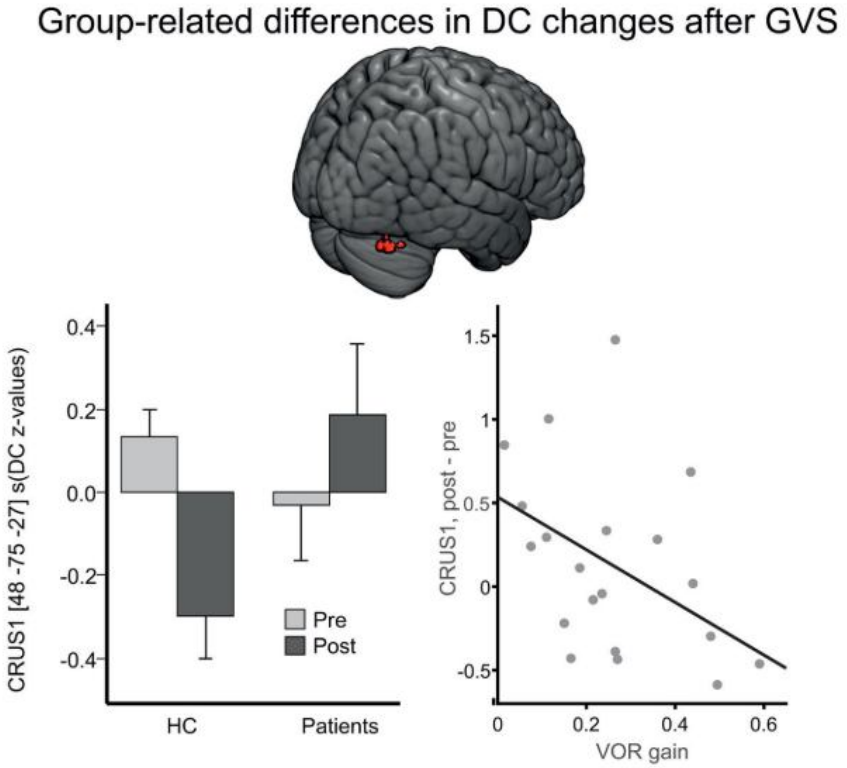
GVS & Cerebellum



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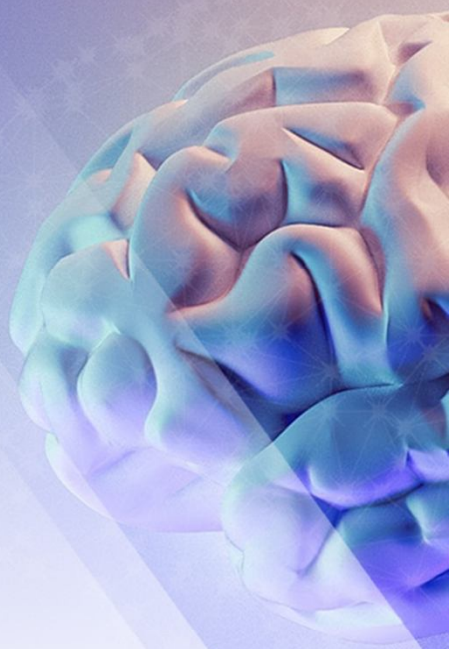
Conclusion

- Vestibular rehabilitation might improve the VOR & VSR functions in post-stroke patients especially at acute strokes.

- VR programs are safe and could easily be implemented with standard neurorehabilitation protocols in patients affected by neurologic disorders.



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