

Vestibular Rehabilitation

Current Approaches

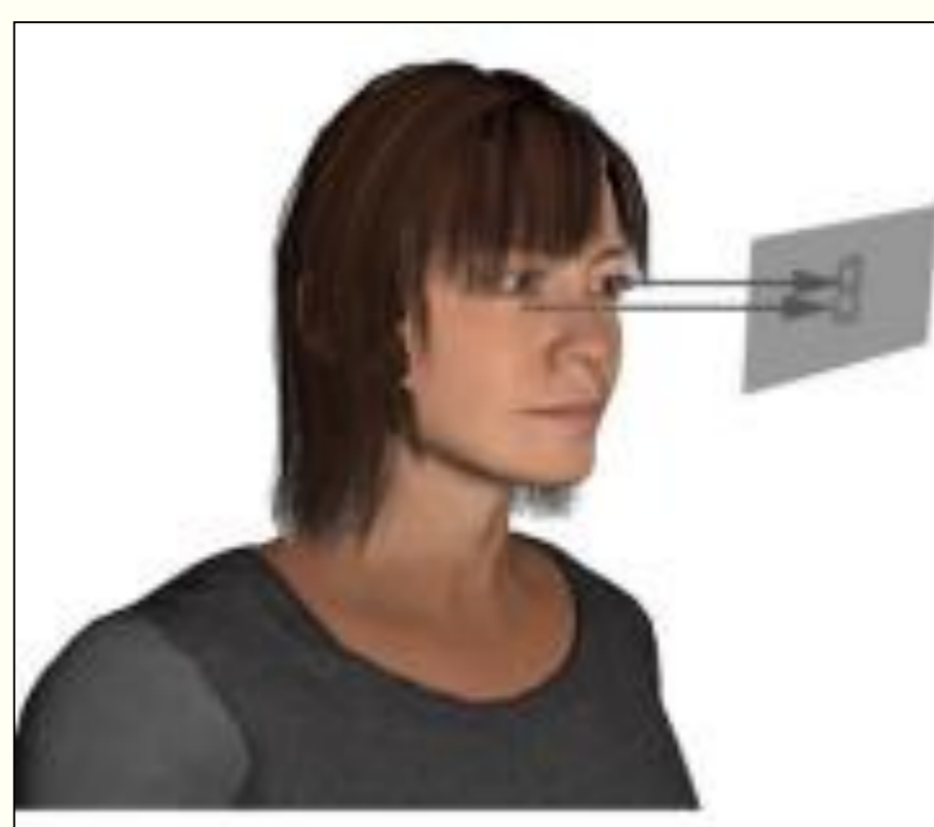
Current evidence-based practice in vestibular rehabilitation (VR) uses an exercise-package approach tailored to individuals' symptoms. It is designed to promote central compensation and functional improvement in balance through mechanisms of adaptation, habituation and substitution.

Areas for Exploration

Exercise training techniques used in other sectors may be of benefit for patients with vestibular deficits and the wider population. Emerging treatments include perturbation training, gaze-stabilization exercises using incremental increases in gain and virtual reality.

Anecdotal evidence exists that high velocity spinning exercises used in elite ice-skaters' training may be beneficial beyond the sports world.

Could spinning translate to an effective form of VR?



VR Gaze Stabilisation Exercise
With thanks to M Dawber for image



Spinner in use with coach using pulley system to lift user



Motorised Rotational Platform and Harness Setup
With permission of Sheila Thelan, Vestibular Training Services

Motorised Rotating Platform Training

Rotating Platform with Harness System: 'Spinner'

A rotating platform with supporting harness is used in elite ice skaters' training, based in America. The motorised platform can be rotated at variable speeds and the pulley system can be used to lift the user to spin in the air with inertia. There is reported benefit to the wider public for reducing dizziness and improving balance.

Currently Used Protocol

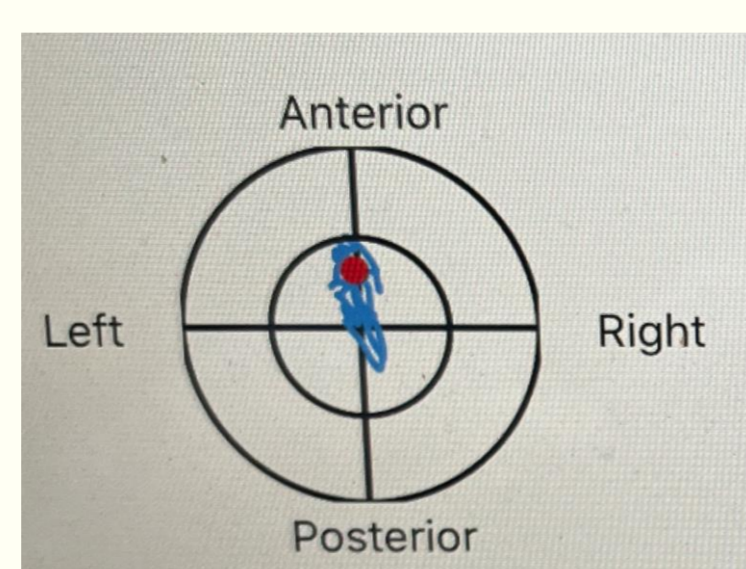
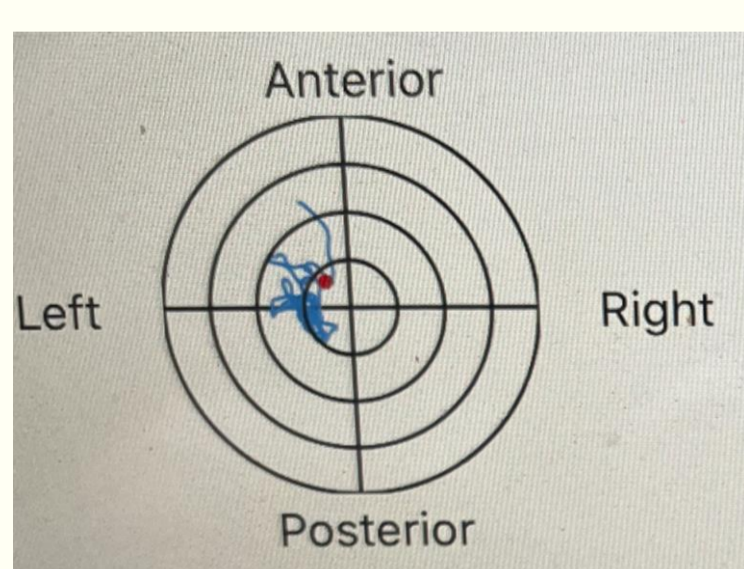
- Rotated 5 spins anticlockwise, 5 spins clockwise, 5 spins anticlockwise. Rest between rotations as desired. Speed dependent on individual
- Speed of 17 rotations per minute in non-athletes, gradually increasing speed over time according to user's preference
- Speed of 100 rotations per minute in elite athletes who have been training on the spinner 3-7 times per week over 2 years
- Performed twice per week for 6 weeks. Anecdotally reported sustained effects from 6-8 weeks

Case History

Reported typical case of a 78 year old suffering falls shows improved posturography, reported reduction in falls and subjective improvement in perception of balance.

Pre-treatment (sway area = 7.14 in²)

Post-treatment (sway area = 0.18 in²)



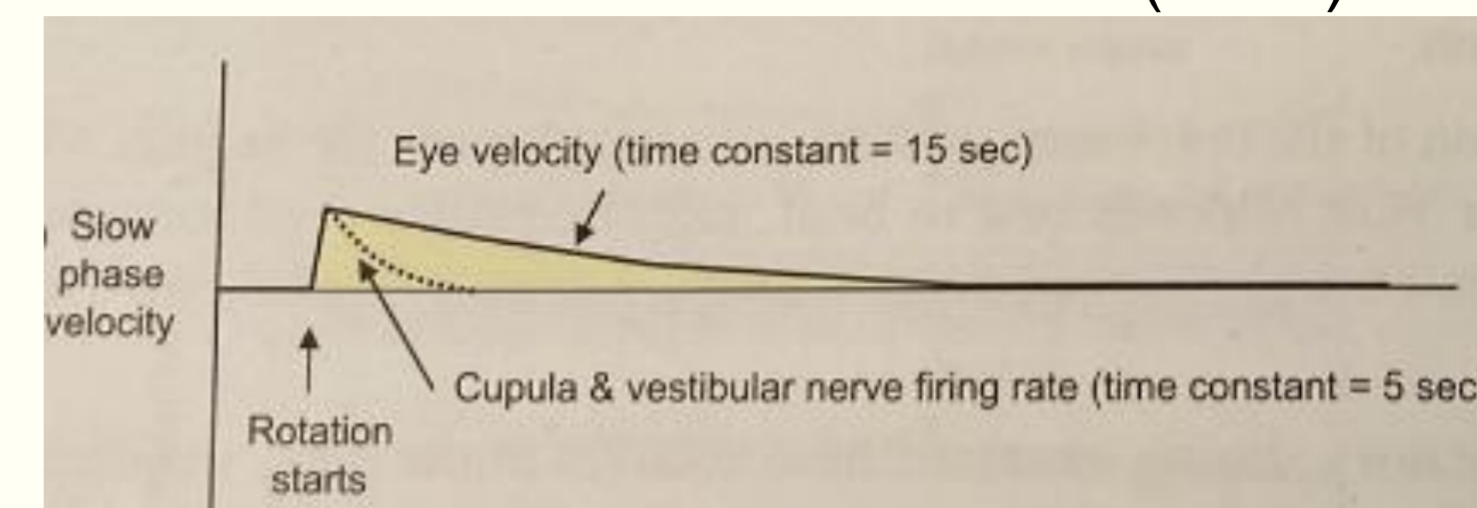
Areas for Exploration

Robust investigation in normals and patients with dizziness could explore the true effects of the spinner for use in VR.

Spinning in the Literature

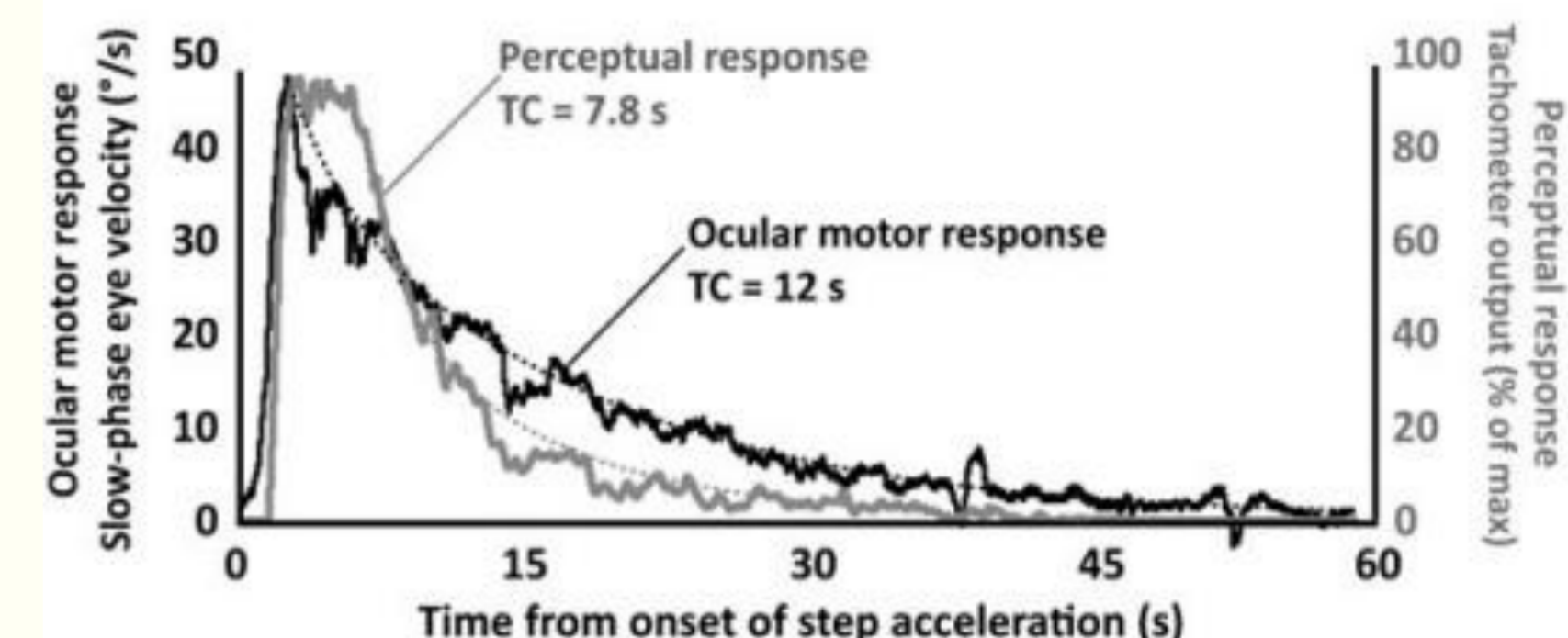
Vestibular System in Motion

When rotating, the cupulae of the semicircular canals respond to the angular acceleration. At constant velocity of spinning, it is thought that neural firing continues beyond the cupula time constant due to the velocity storage mechanism; this extends the vestibular ocular reflex (VOR).



Velocity Storage Mechanism to sustained constant velocity in the dark
From Wong

Studies have investigated the time constant of the VOR (VOR time constant) and its relationship with time constant of rotation perception (perception time constant)



VOR time constant and perception time constant: relationship in response to rotation
From Nigmatullina et al.

Research So Far: The Effects of Rotation on Ocular Motor and Perceptual Responses

Clement and Tilikete¹ rotated normal subjects in the dark, twice daily over five days to assess the effects on VOR and perception and to assess the retention of habituation. Findings included:

- VOR time constant reduced over time
- Perception time constant reduced over time in both directions, even if stimulation was unidirectional
- Effects were bigger using alternate clockwise and anticlockwise rotations than unidirectionally
- Habituation persisted; it took one month to recover to 63% but near complete recovery would take over 8 months

Nigmatullina et al² compared dancers with long-term rotational training to rowers (controls). Findings included:

- Dancers had reduced time constants for both vestibular reflex and perceptual responses
- Dancers' VOR and perceptual responses were uncoupled
- Cerebellar-gating of perceptual signals mediating training-related attenuation of perception and uncoupled VOR is postulated with potential benefits for VR

Wrisley and Stephens 2011³ compared VR and training with ramp rotations (exact methodology unclear) at different velocities in healthy subjects and patients with vestibular dysfunction. They measured postural stability and validated self-perceived disability questionnaires. Findings included:

- Patients with vestibular dysfunction improved in postural stability and self-perceived disability at mid-frequency ramp rotations; frequency of rotations affected level of benefit

It is noted in the literature that velocity storage time constants are elevated in those with motion sickness, vestibular migraine and mal de debarquement syndrome^{4, 5}

Conclusions and Ideas for Research

There is emerging evidence^{1, 2} in normals that rotational training may: - Reduce VOR time constants and perception time constants - Uncouple the perception and VOR reflexes

There is limited evidence on the effects of rotational training in people with vestibular deficits but it is postulated that a similar reflex uncoupling and decrease in perception time constant (and thus symptoms of dizziness) could occur.

Suggestions:

- Normative data collection (VOR time constants, perception time constants and balance) pre- and post- rotation training with a robust spinning protocol and validated questionnaires.
- Similar data collection in patients with vestibular migraine (known increased time constants).

References

- ¹Clement G, Tilikete C, Courjon JH. Retention of habituation of vestibulo-ocular reflex and sensation of rotation in humans. *Exp Brain Res*. 2008 Sep;190(3):307-15
- ²Nigmatullina Y, Hellyer PJ, Nachev P, Sharp DJ, Seemungal BM. The neuroanatomical correlates of training-related perceptuo-reflex uncoupling in dancers. *Cereb Cortex*. 2015 Feb;25(2):554-62.
- ³Wrisley, D. and Stephens, M. The effects of Rotational Platform Training on Balance and ADLs, Conference Proceedings, IEEE Engineering in Medicine and Biology Society. Conference August 2011
- ⁴Huang, T., Wang, S. and Kheradmand, A. Vestibular Migraine: An update on current understanding and future directions. *Cephalalgia*, 2020, 40 (1) 107-121.
- ⁵Dai, M, Cohen, B., Smouha, E., Cho, C. Readaptation of the vestibulo-ocular reflex relieves the mal de debarquement syndrome. *Frontiers in Neurology* 2014 (5)124

