Sensorimotor function: What should we be treating?

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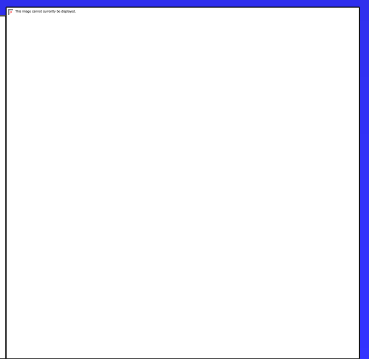


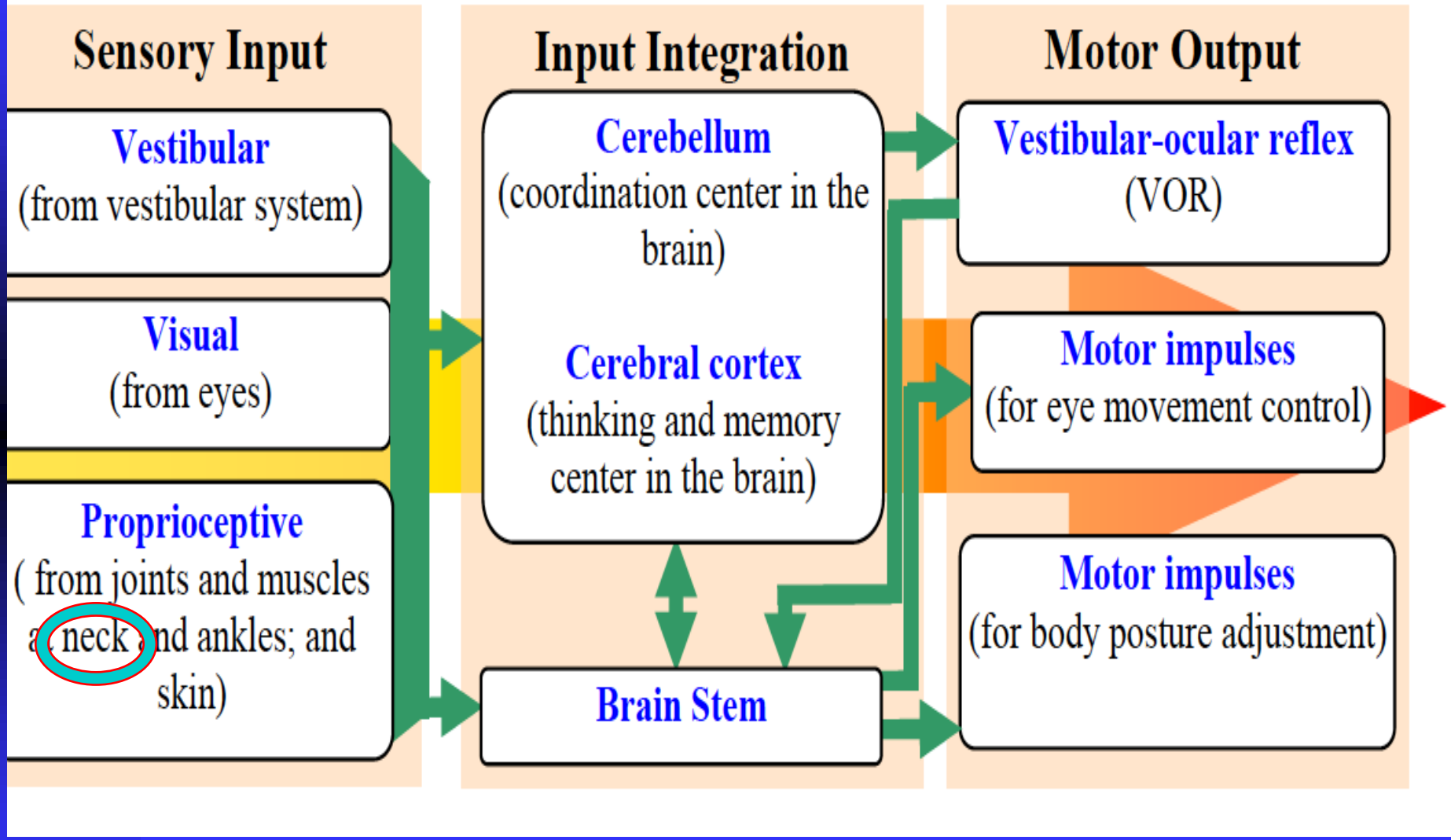
What should we treat ?

Need to understand what might need to treat and why

Importance assessment and differential diagnosis

Directed tailored management.

Sensorimotor control



Whiplash common complaints

1. Dizziness and unsteadiness are common symptoms 70%
Treleaven et al 2003

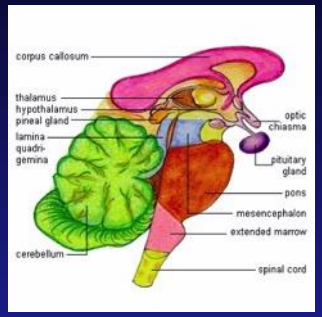
2. Loss of balance 20% Treleaven et al 2003

3 . Reports of visual disturbances are not uncommon 50-70%
Treleaven and Takasaki 2014

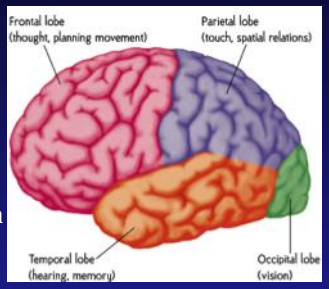
- Need to concentrate to focus
- Visual fatigue
- Sensitivity to light

Potential damage to sensorimotor control structures

Central Vestibular- Oculomotor, Vestibulospinal pathways



Cerebellum
Brain Stem



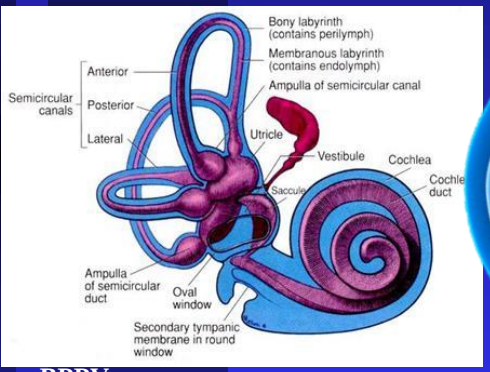
Cerebral cortex

Forces required

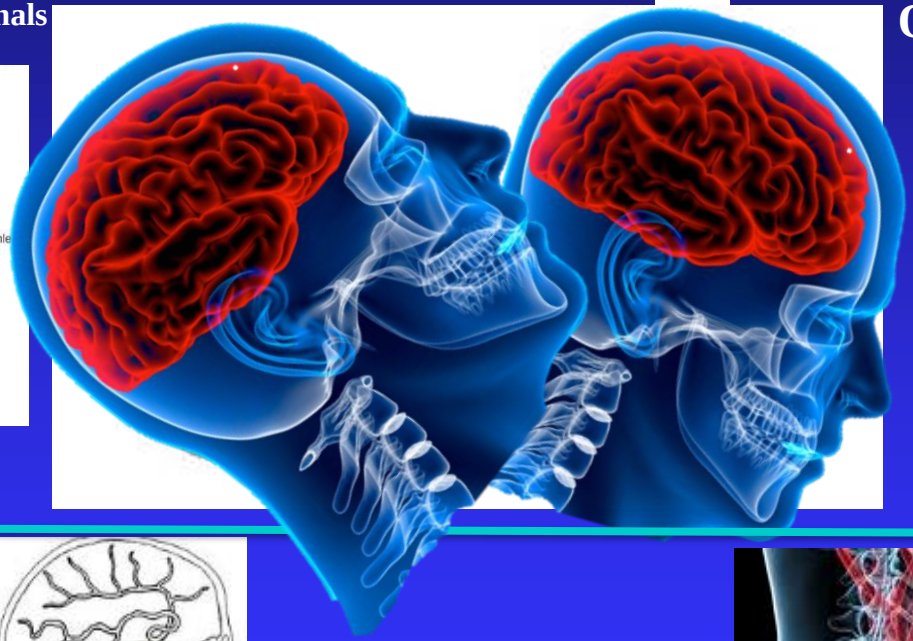
60-160g

Peripheral Vestibular

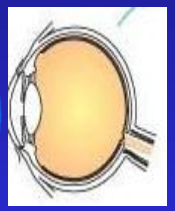
Utricle, Saccule, Semicircular canals

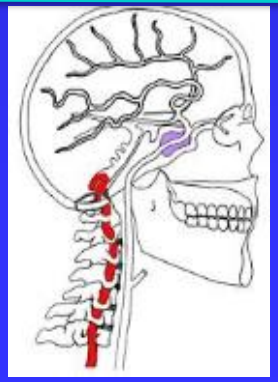


BPPV
Labyrinthine concussion
Perilymph fistula



Ocular





Cervical

4.5 g

Vertebral artery

Cervical afferents
Muscles, joints, ligaments

Marshall et al 2015, Broglio et al 2011, Spitzer et al 1995, Kolev and Sergeva 2016

Potential damage to sensorimotor control structures

Coexisting whiplash + concussion – Hynes et al 2006, Viano et al 2005

Vestibular in whiplash- 35% BPPV, perilymph fistula Dispenza et al 2011, Ernst 2005

Vestibular in concussion up to 81%- Grimm et al 1989, Corwin et al 2015

Post trauma vision syndrome- whiplash, concussion- Potanski et al 2014, Padula 1996

If no concussion -more evidence cervical cause in whiplash

BUT more evidence of cervical in concussion now too

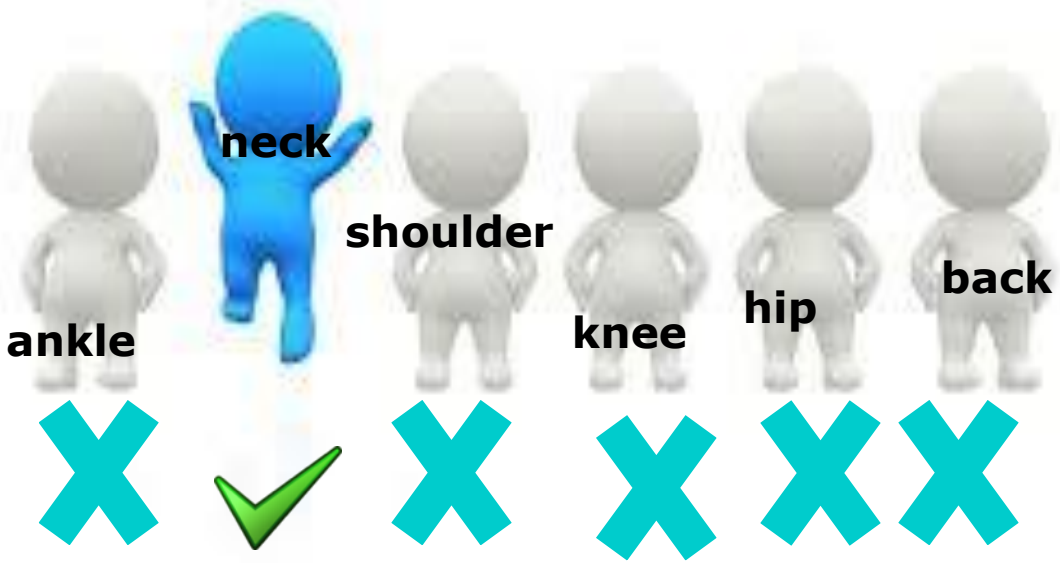
How can the neck cause these symptoms?

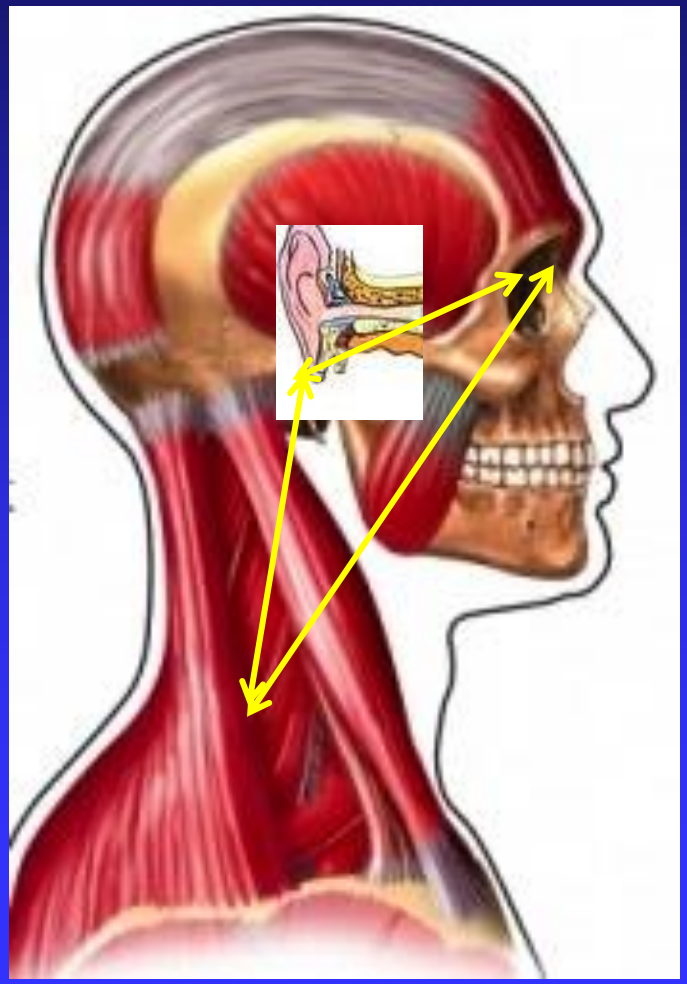
Important sensory organ

Relevance for function

Experimental alteration of afferents

Directly connects to inner ear and eyes
High percentages muscle spindles
Reflex connections to eyes and inner ear





Sensorimotor control

Sensorimotor control
Afferent integration
and tuning

CNS

Eye
movement
control

Visual
System

Cervico-ocular
reflex

Cervical Afferents

Vestibulo-
collic reflex

Vestibular
System

Vestibulo-ocular reflex

Cervico-collic reflex

Postural
stability

Cervical motor

Head
movement
control

Tonic neck
reflex

Vestibulo-
spinal reflex

Lower limb motor

Neck pain impairments

- Range of motion
- Dysfunction of cervical joints –upper
- Neuromotor control muscle function- cervical, scapula
- Morphological changes in muscles
- Local mechanical hyperalgesia
- Altered central pain processing- whiplash
- Nerve sensitivity
- Psych considerations- general and specific stress, fear avoidance

altered cervical afferent input

sensorimotor control disturbances

Evidence of altered sensorimotor control in whiplash

- **Dizziness, visual disturbances** Treleaven et al 2003, Treleaven and Takasaki 2014

- **Proprioception**- cervical joint position and movement sense/ accuracy

Kristjannson et al 2003, Treleaven et al 2003; Oddsdottir and Kristjansson 2012; Lee et al 2014, Kristjannson and Oddsdottir; 2010
Woodhouse et al 2010, Bahat et al 2015, Treleaven et al 2003, 2006, Chen and Treleaven 2014

- Balance-Altered static and dynamic standing Karlberg 1996, Michelson et al 2003,

•Treleaven et al 2005,Treleaven et al 2006, Juul-Kristensen et al 2013, Field et al 2007

- **Co-ordination** Impaired trunk head, arm, han

•Treleaven et al 2012, Sandlund et al 2008

Possible causes to consider

Anxiety

Psychological

Financial gain

Ageing

Medication

Medical condition

Disturbed Sensorimotor

Peripheral vestibular
- BPPV
- Menieres
- Perilymph fistula
- Vestibular neuritis
- Acoustic neuroma

Visual
- Post trauma
- Visual Midline shift

Central vestibular
- Mild Head injury/ concussion
- Vestibular migraine
- Vertebral artery dissection
- Vertebrobasilar insufficiency

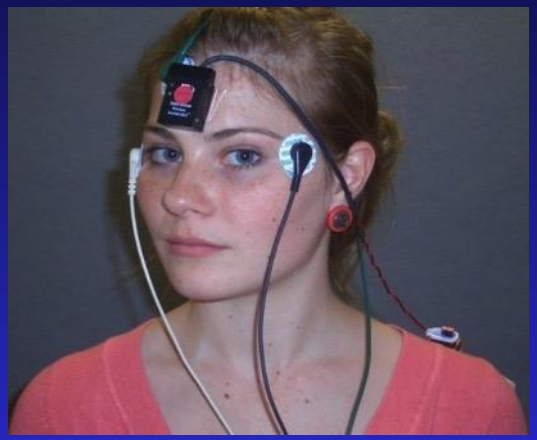
Cervical
- Abnormal afferent input

Evidence of altered sensorimotor control in whiplash

Oculomotor

- Smooth pursuit- neck torsion

Heikkila et al 2003, Hildingson et al 1990, Tjell et al 1998,Treleaven et al 2005



- Gaze stability

Gripp et al 2010, Treleaven et al 2011

- Eye Head Co-ordination

Gripp et al 2010, Treleaven et al 2011

- Cervico-ocular reflex

Montford et al 2006 , Kelford et al 2007

- Convergence insufficiency

Burke et al 1992, Giffard and Treleaven submitted

Sensorimotor examination

Symptoms

Description
Frequency
Duration
Severity
Loss of balance
Exacerbating features
Concurrent symptoms
Onset
History
Past history trauma
Present past Medical history
Medications

Sensorimotor examination

Presentation/ History

VBI testing, +- cranial nerves, co-ordination Thomas et al 2016

Sensori-motor **Head position sense/ movement sense**
Balance- static, dynamic
Oculomotor
- **Smooth pursuit neck torsion**
- **Gaze stability**
- **Eye head co-ordination**

Trunk head co-ordination

?? Cervical rotation test – head still, trunk rotate and hold

+- VOMS- Vestibular oculomotor screening

+- Vestibular tests Hallpike Dix- BPPV, head thrust, head shaking nystagmus, motion sensitivity

+- Visual midline, accommodation

Cervical sensorimotor examination

Cervical musculoskeletal- most WAD

Neck torsion vs en bloc*

Sensori-motor **Proprioception** Joint position sense (>4.5°)*

Movement sense

Oculomotor

- Smooth pursuit neck torsion*
- Gaze stability
- Eye head co-ordination

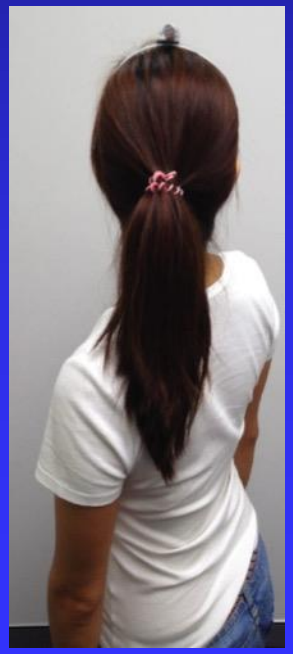
Trunk head co-ordination*

* Potential discriminatory tests

Cervical sensorimotor examination

Balance

- Static standing- eyes closed
- Tandem walk
- Step test -how many in 15 seconds
- Timed 10 m walk without and with head turns/ head up and down


Vestibular Ocular Symptoms Screening

Aim-
Prompt referral to appropriate professional for full assessment and management if required.

Good screen, but may miss eg subtle peripheral vestibular VOR, BPPV

-

May need specialised testing

May have co-existing and need to determine which to address first
What order should this be?

Musculoskeletal

Vestibular physiotherapist

Behavioural Optometrist/ Vision therapist

Vestibular Ocular screening

Mucha et al 2014, Kontos et al 2016

Vestibular/Ocular-Motor Screening (VOMS) for Concussion

Vestibular/Ocular Motor Test:	Not Tested	Headache 0-10	Dizziness 0-10	Nausea 0-10	Fogginess 0-10	Comments
BASELINE SYMPTOMS:	N/A					
Smooth Pursuits						
Saccades – Horizontal						
Saccades – Vertical						
Convergence (Near Point)						(Near Point in cm): Measure 1: _____ Measure 2:_____ Measure 3:_____
VOR – Horizontal						
VOR – Vertical						
Visual Motion Sensitivity Test						

Smooth pursuits

Saccades

Convergence

VOR

Visual motion sensitivity

Good reliability, cut off score increase in symptoms 2 or more

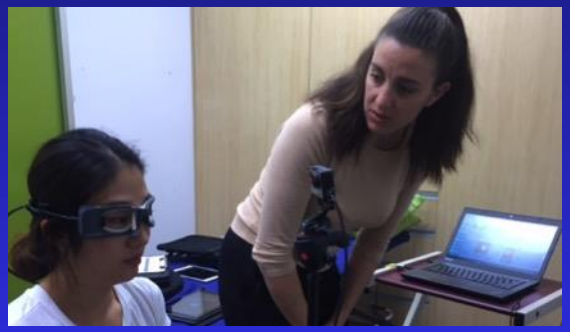
Vestibular physiotherapy examination

Patient interview

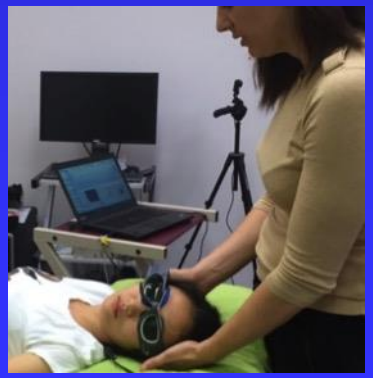
Balance- SOT, Dynamic gait index

Nystagmus- Spontaneous, gaze evoked, optokinetic head shaking

Eye movement
Smooth pursuit
Saccades
Convergence



VOR
VOR Cancellation
Head Thrust in both the horizontal and vertical plane VHIT
Dynamic visual acuity

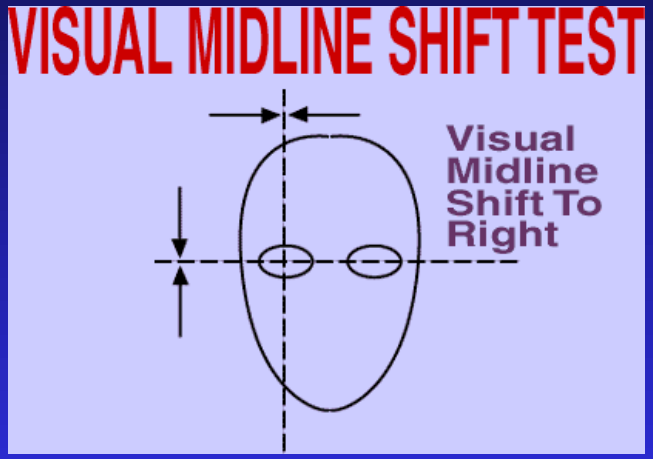


Motion sensitivity
Vision motion sensitivity
Motion sensitivity

Positional manoeuvres
BPPV – Hallpike Dix, head roll

Behavioural optometry examination

- Cover uncover tests- eye alignment malfunction
- Accommodation
- NPC
- Saccades/Fixation
- Smooth pursuits
- Visual midline
- Glare sensitivity
- Visuo-motor tasks



Ocular mal-alignment

Post trauma vision syndrome

Visual midline shift

Vergence problems

Any tests to help differential diagnosis?

Enbloc movements

Eye vs head movement

Effect of neck torsion on eye follow, balance, JPE, convergence

Management

If not fitting cervical dizziness/ sensorimotor

Refer on — medical review/ further investigations
neurologist- vestibular migraine
vestibular physiotherapist
behavioural optometrist

If mixed symptoms and benign
- trial of management addressing cervical spine and sensorimotor control- similarities in approach

Should see changes with improvements in neck and sensori-motor

Combined management – can be concurrent

Order - Cervical before vestibular

- Ocular before others if driver of issues

Management of cervicogenic dizziness/ sensorimotor control

‘Normalise’ afferent input

- Manual therapy Heikkila et al 2000; Reid et al 2008; Gong 2014
- Multimodal physiotherapy Malmström et al 2007
- Acupuncture Heikkila et al 2000, Fattori et al 1996
- Exercises deep muscles Jull et al 2007
- Pain relief
- Improve endurance

PLUS

But – evidence doesn’t improve balance, JPE to normal , dizziness may persist in many. Treleaven et al 2015, Reid et al 2014

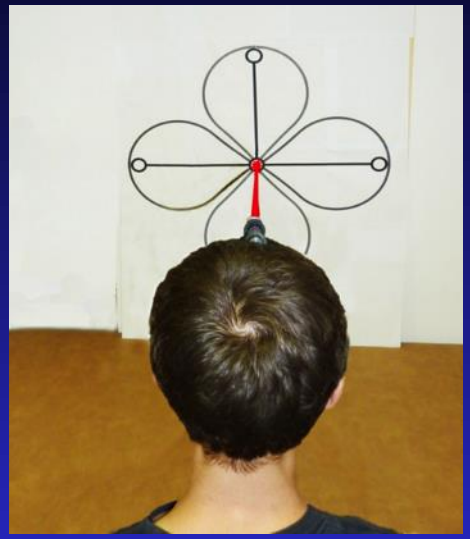
Tailored sensorimotor control exercises

Evidence VRT improved balance and dizziness but not NDI Hansson et al 2006, 2013

Management of cervicogenic dizziness/ sensorimotor control

Cervical joint position and movement sense

Revel et al 1994, Treleaven 2011

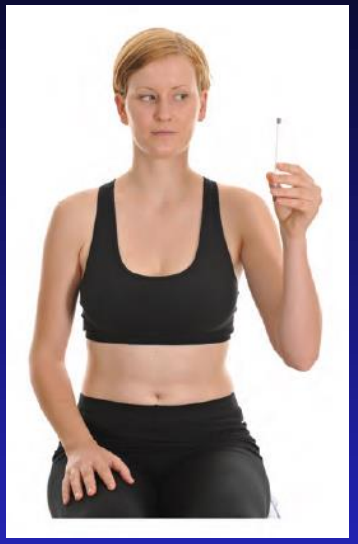


Balance

Management of cervicogenic dizziness/ sensorimotor control

Eye movement

Smooth pursuit
Gaze stability
Eye head co-ord



Trunk, head, arm co-ordination

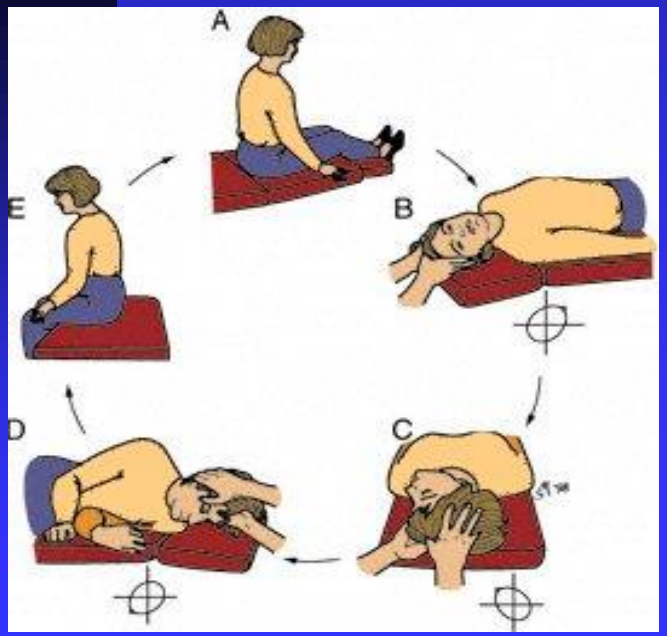
Management – Vestibular rehabilitation

VRT- improved whiplash and post concussion compared to rest
Aslasheen et al2013, Aligene and Lin 2013, Gottshall et al 2010, Hansson et al 2006

Tailored – intergrate systems

- Adapt/ substitute- Gaze stabilising training
- Habituate- Graded exposure- visual motion sensitivity
- Balance retraining

- BPPV- Repositioning manoeuvres, tailored to canal



Management – Behavioural Optometry/ Vision therapy

Evidence Vision therapy –improves post concussion, not in whiplash specifically

Thiagarajan and Ciuffreda 2014, Ciuffreda et al 2008, Broglio et al 2015

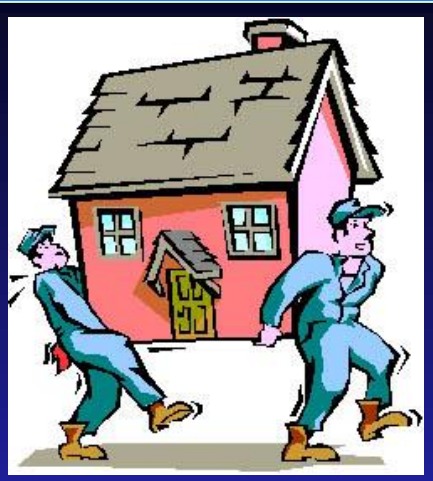
Addressing impairments relating to reading, focusing, CI, accommodation, ocular mal-alignments, glare sensitivity

Treatment - exercises, lights, mirrors, filters, lenses prisms- to improve functional ocular muscle control

Type	Cervical	Vertebral artery	BPPV	Perilymph fistula	Peripheral vestibular	Central Vestibular	Psychological
Description	Unsteadiness Light-headedness	Fainting Vertigo Dizziness	Vertigo	Vertigo Dysequillibrium Motion intolerance	Vertigo Unsteadiness Motion intolerance	Dysequillibrium Motion intolerance	Floating Rocking Fullness in head
Frequency	Episodic	Episodic	Discreet attacks	Episodic/ Constant	Episodic vertigo Constant unsteadiness	Varies	Varies
Duration	Minutes to hours	Several seconds	Seconds	Constant	Seconds to minutes	Varies	Varies
Exacerbated	Increasingneck pain Neck movement	Sustained neck extension and or rotation	Rolling in bed Looking up Lying down	Visual challenges Increased intracranial or atmospheric pressure eg blowing nose Loud noises	Head positions or movement	Spontaneous or provoked	Stress Anxiety Hyperventilation
Relieved	Decreasing neck pain	Neck back to neutral	Subsides if stay in provoking position	Avoiding above activities, rest	Head/ body still	Varies	Relaxation
Associated symptoms	Blurred vision Nausea Neck pain	Dysarthria Hemiparesis Dysesthesia Diplopia Dysphagia Drop attacks Nystagmus Nausea Numbness	Nausea Vomiting	Unilateral tinnitus Aural pressure Hearing loss	Nausea Vomiting Hearing loss Tinnitus Ear fullness	Nausea Imbalance CNS signs	Lump throat Heart palpitations Tight chest
Suggested cause	Abnormal cervical afferent input	Vertebral artery dissection/ insufficiency	Debris in endolymph	Leak of perilymph fluid into middle ear	Vascular injuries Fractures	Brain stem Cerebellum	Anxiety Stress
Primary objective findings	Cervical M/S impairments JPE >4.5 degrees Increased sway Balance neck torsion Positive SPNT Positive Cervical torsion test Positive Trunk head co-ordination test Absence other findings	Possible positive VBI tests VAD- Unilateral severe headache Transient neurological disturbances relating to VA function	Positive Hallpike Dix or Head roll	Positive pressure test Positive Valsalva test	Head impulse Head shake DVA	Spontaneous or gaze evoked nystagmus *Oculomotor deficits Ataxia	Nil
Suggested Treatment	Cervical M/S and tailored sensorimotor	Referral neurologist	Epley or BBQ roll manouever	Referral ENT Surgery	Tailored vestibular rehab central adaptation habituation Cervical M/S and tailored sensorimotor as required	Tailored rehab oculomotor, vestibular, balance and gait Cervical M/S and tailored sensorimotor as required	Meditation Mindfulness Stress management Cervical M/S and tailored sensorimotor as required

Treleaven JOSPT June 2017

Take home messages



- Consider sensorimotor post whiplash
- Assess/ screen – cervical, vestibular, ocular
- Refer for appropriate assessment and management – cervical, vestibular, ocular
- Future directions – improve differential diagnosis
- - contributing factors
- - what is best management?