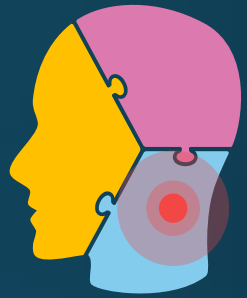
Recognition of the role of the neck in concussion: from research to practice tools



A/Prof Julia Treleaven

j.treleaven@uq.edu.au

𝕏 @JuliaTreleaven

Neck and Head Research Unit

The University Of Queensland
AUSTRALIA

CREATE CHANGE

Outline

- Role of cervical spine
- Recognition- screening
- Assessment cervical spine post concussion
- Management cervical spine post concussion
- Prevention?

Potential damage with head and neck trauma

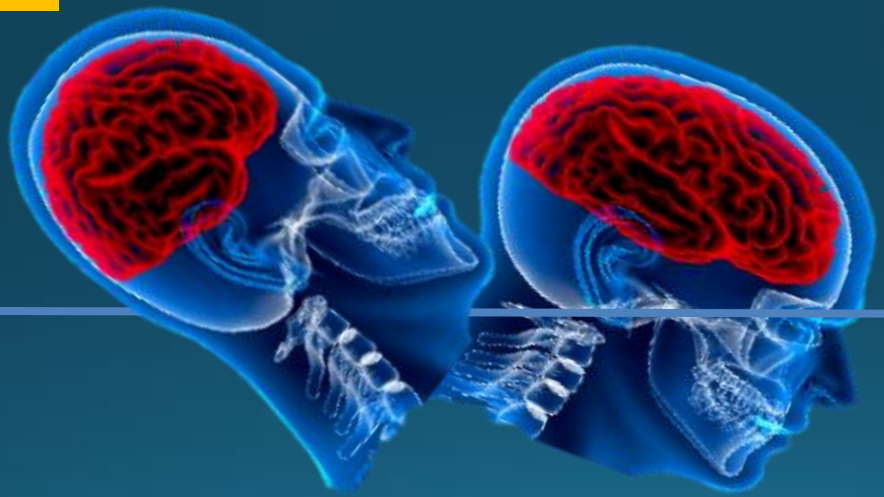
Central Vestibular

Peripheral Vestibular

Ocular

Physiological/ANS

Forces required



60-160g

4.5 g

Cervical

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

Neck pain impairments

- Range of motion
- Dysfunction of cervical joints –upper
- Neuromotor control cervical, scapula
- Morphological changes muscles
- Local mechanical hyperalgesia
- Altered central pain processing- whiplash
- Nerve sensitivity

Sensorimotor control disturbances
dizziness, visual disturbances

Headache

Common symptoms and signs to PCS

Jull et al 2019

Sensorimotor How neck can cause proprioceptive dizziness?

Anatomy

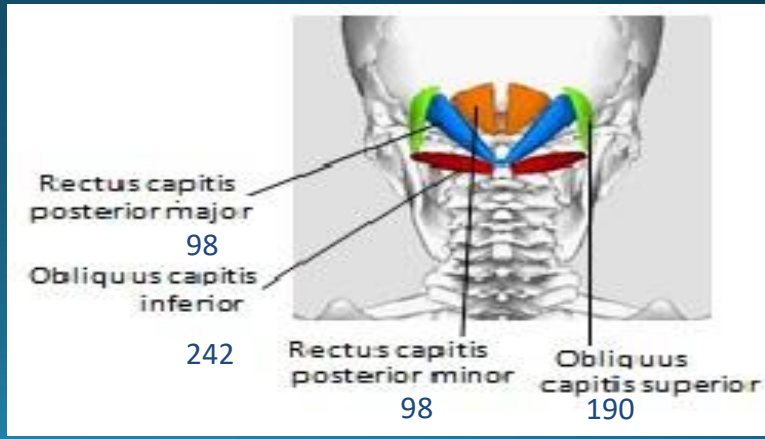
High % muscle spindles

Reflex connections– CCR, COR, TNR

CNS connections – vestib nuclei, superior colliculus

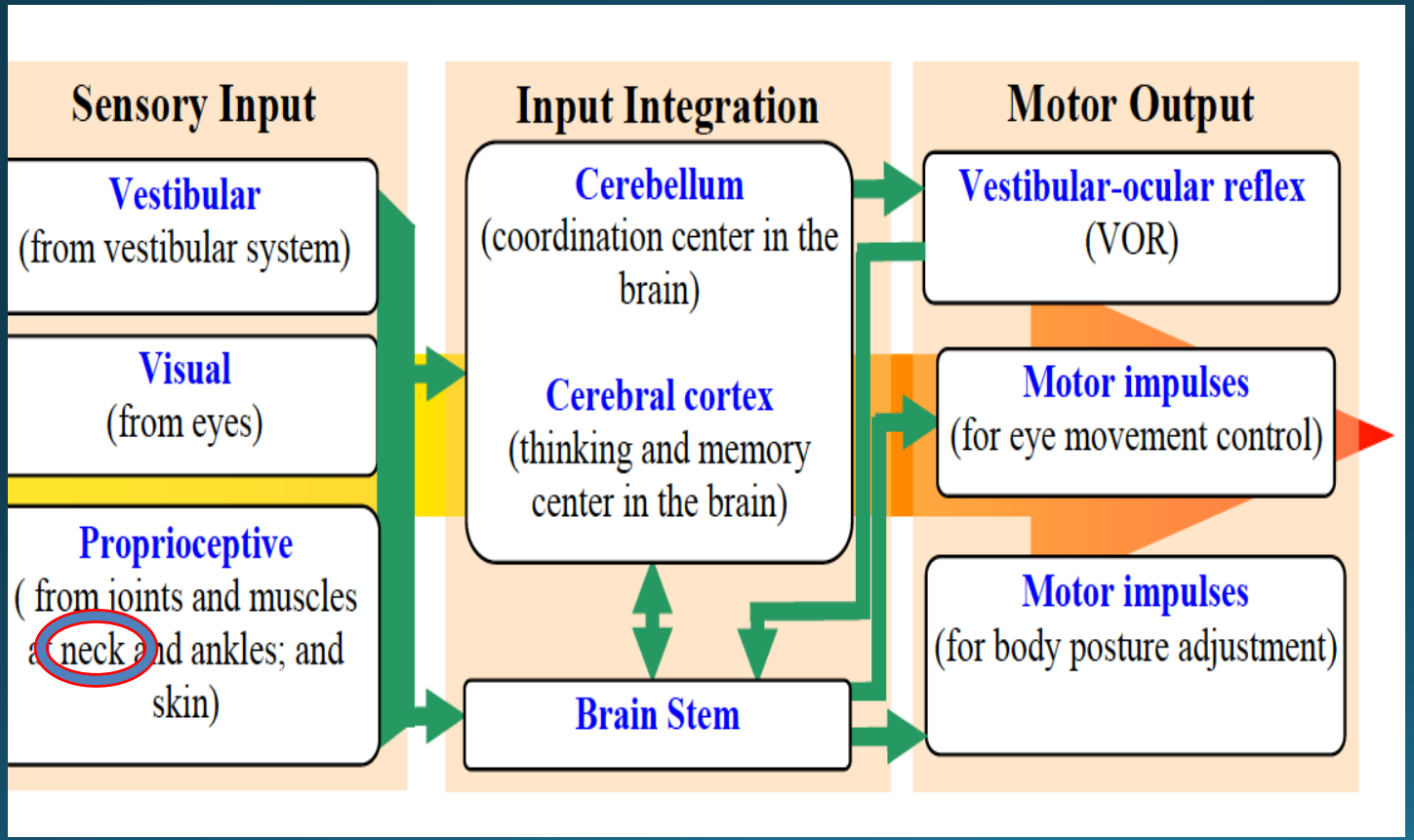
Experimental disturbance

Neck can substitute for decline visual, vestibular



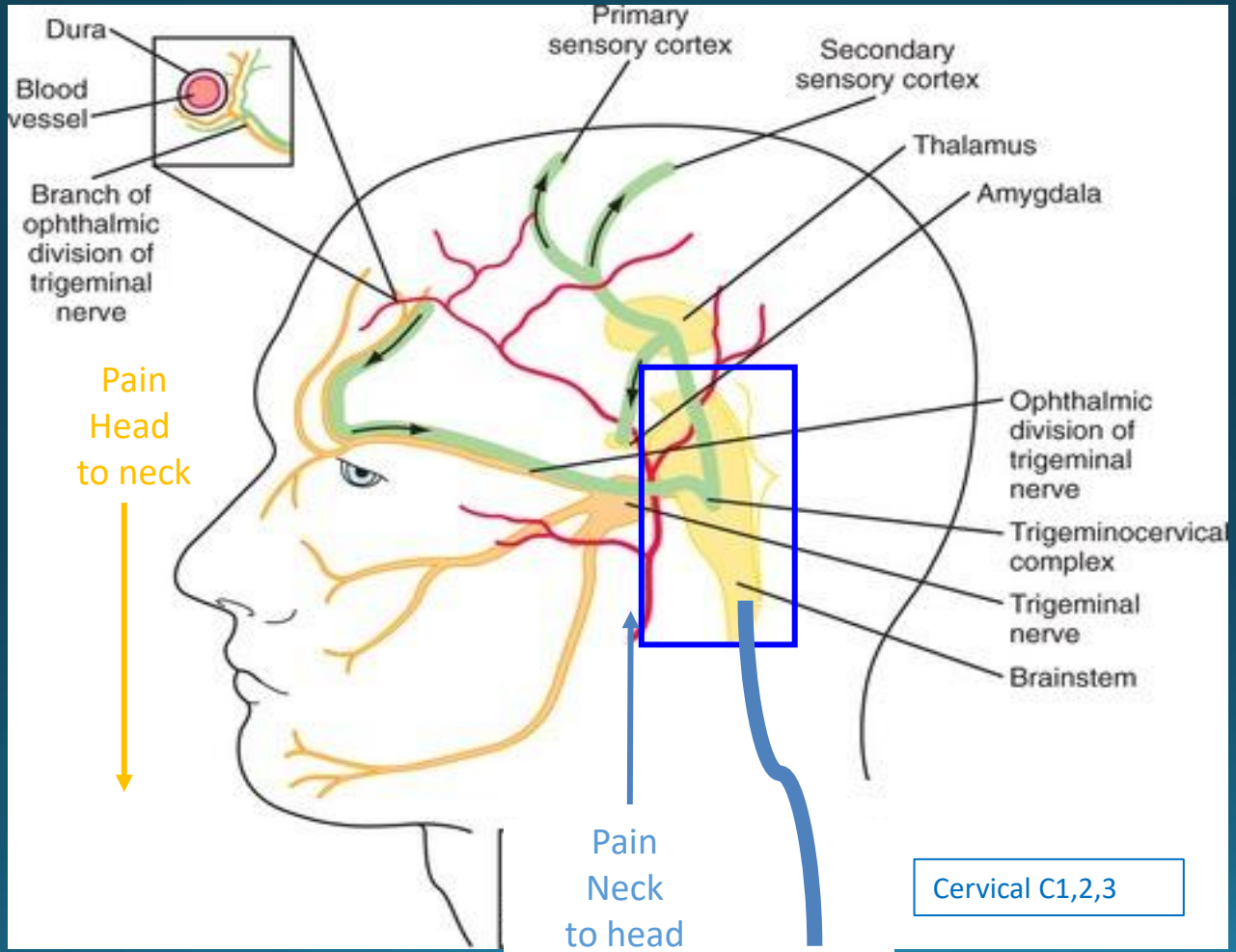
(Kulkarni et al 2001, Boyd Clark et al 2002, Liu et al 2003)

Sensorimotor control



Dizziness/ unsteadiness
Visual disturbances
Loss of balance

Sensory- How can neck cause headache?



Why neck important in post concussion ?

01

Neck can cause headache, dizziness , visual disturbances

02

Neck pain common

- 20- 69%

03

Neck pain = Poorer outcome

04

Evidence of neck impairments post-concussion

Kennedy et al 2017, 2021, Umoto et al 1993, Shehata et al 2009, Vargo et al 2016, Cheever et al 2021,2022, Provance et al 2020, Ellis et al 2018

King et al 2019, Kennedy et al 2017, Treleaven et al 1994, Galea et al 2022, Schneider et al 2018, Streifer et al 2019, Nutt et al 2022, Mitchell et al 2023, Garrett et al 2023

Concussion group- grouped according to impairments

Treleaven et al 2025

- Post mTBI- 4 weeks- 6 months 18-60 years symptomatic n=34
- Matched healthy controls- data used to determine cutoffs for impairments outside 95% CI

Cervical MSK and sensorimotor

Neck flexor endurance
Manual examination
Kinematics

Proprioception
Smooth pursuit neck torsion
Balance – AP direction

Vestibular/ Ocular

Near point convergence
Optokinetic nystagmus
Nystagmus- Spont & Gaze
Skew eye deviation
Saccades
vHIT
BPPV tests
Tandem walk
Balance

Physiological

Buffalo concussion treadmill test

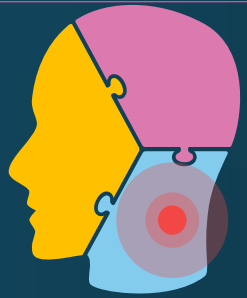


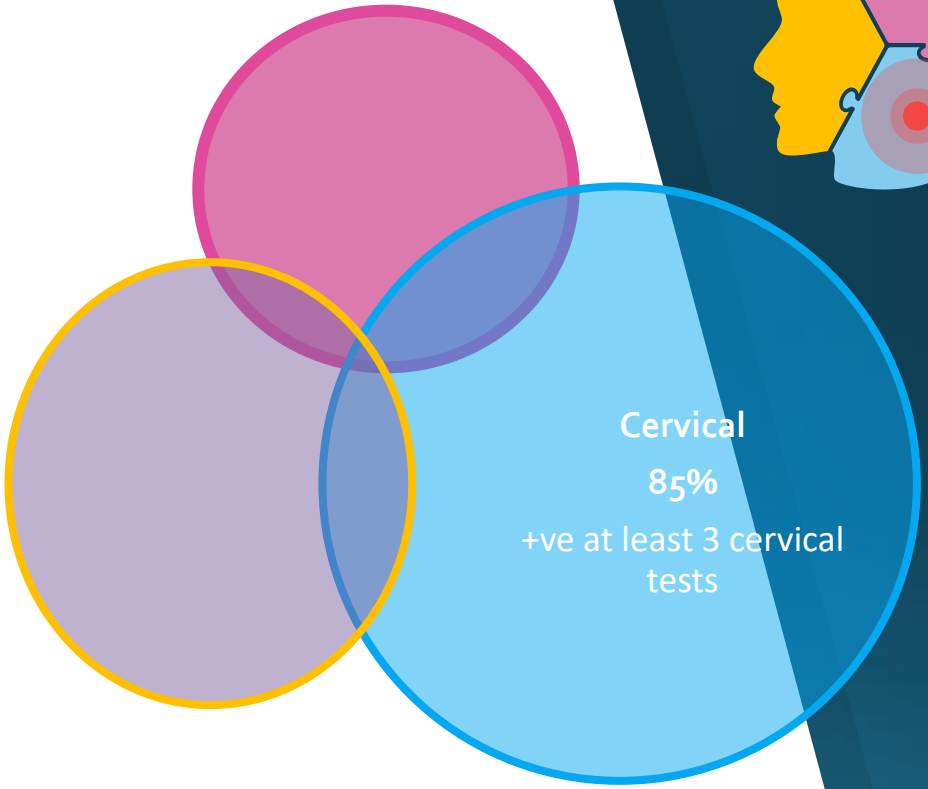


Results

Treleaven et al 2025

Cervical impairments- consistent with a cervical musculoskeletal disorder



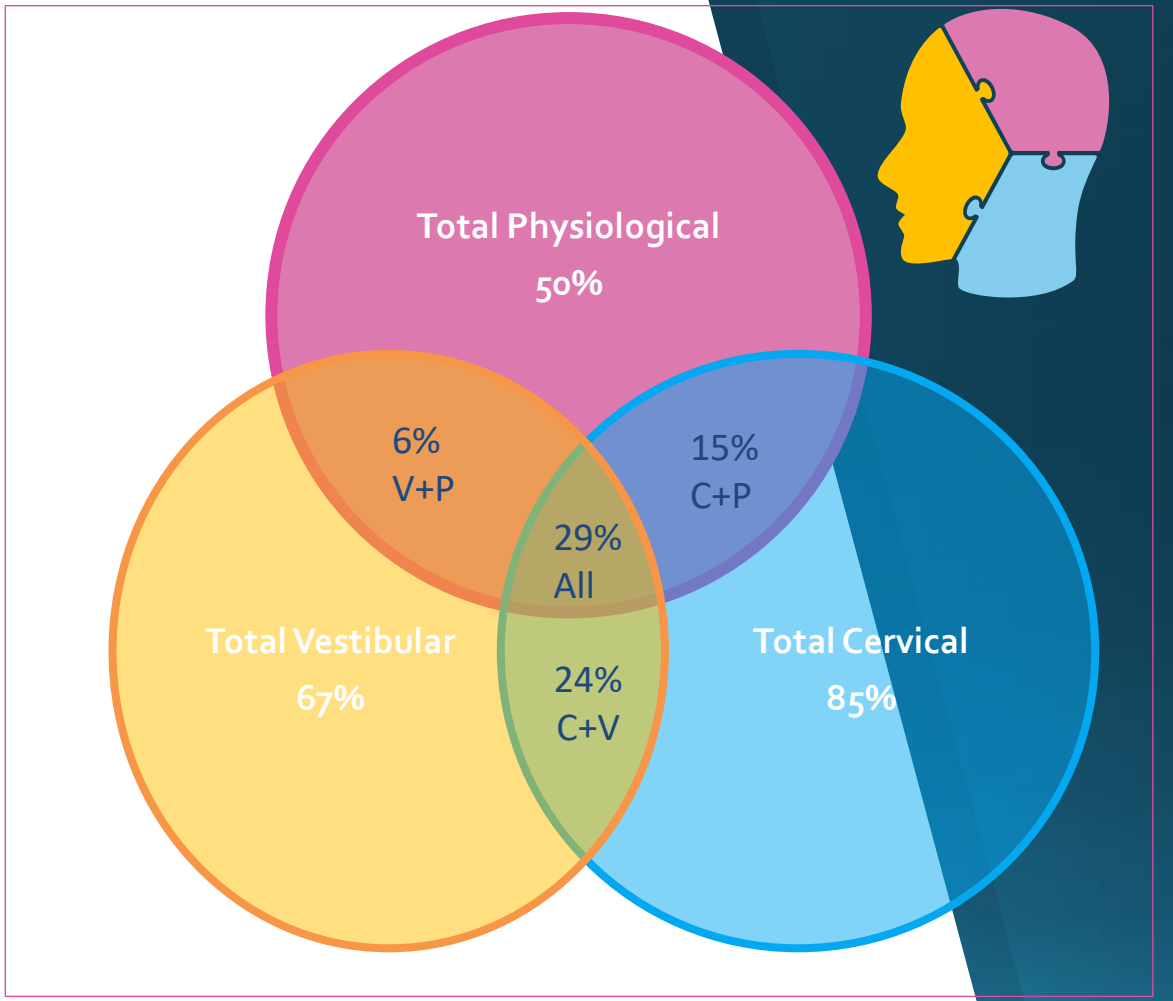


- Need to consider cervical
- Need skills to to recognise and treat cervical
- Implications for symptoms- drivers

Results

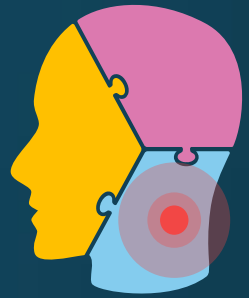
Treleaven et al 2025

Multiple system common
at least 2- 74%
All 3 – 29%



- Confirms need multimodal assessment
- Need skills/ personnel to recognise and treat all of these

Ongoing cervical deficits compared to age matched healthy controls even in those recovered



Recovered post concussion-n=32 Asymptomatic	Symptomatic n=34
↓Range of motion ↓**Flexor endurance** ↑**Joint signs**	↓Range of motion ↓**Flexor endurance** ↑**Joint signs** ↓Velocity ↓Accuracy 85% **Cluster of signs at least 3 MSK or at least 2 and one cervical sensorimotor**

Prevention

Galea et al 2021, Treleaven et al 2025

Why important

Neck not always considered/ assessed

Mohai et al 2022

Treatments differ- better outcomes if treat the right things

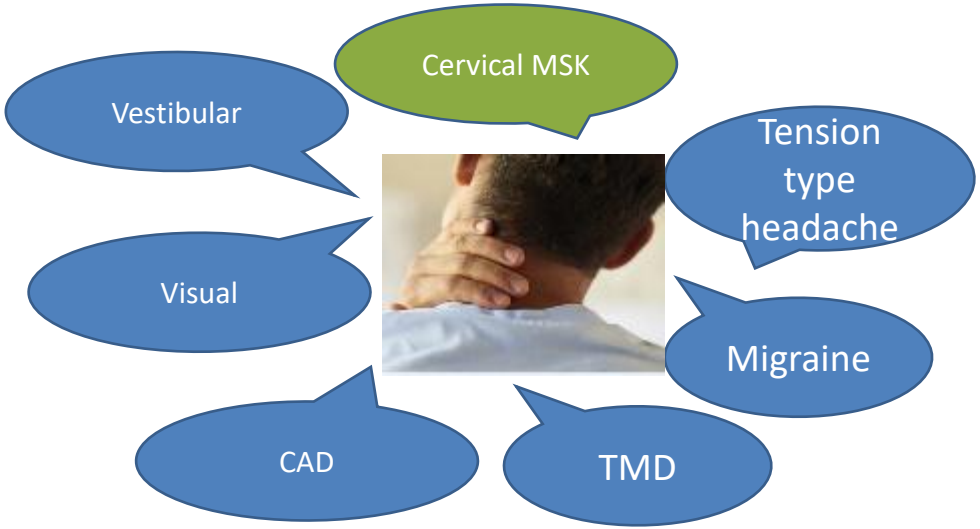
Hammerle et al 2019, Schneider et al 2014

Prevention? Ongoing impairments

BUT Presence of neck pain - Not simple

Neck pain – + Cervical musculoskeletal disorder

Liang et al 2021
Thomas and Treleaven 2021
Teo et al 2019
Knapstad et al submitted



Role of the neck- headache and dizziness – also not simple

+

- Secondary
- Co-morbid
- Mixed/ co-existing
- Primary Cervical MSK
- Compensatory
- Not Cervical MSK

Need for a skilled examination

Cervical Screening

Range of motion

Palpation

Proprioception

Neck flexor endurance

- Good screen but may get false negatives/ positives - need specialised testing
- Incidental findings?
- Co-existing and need to determine which to address first – what is the main driver
- If present- need to refer on for further/ more extensive assessment

Recognition Symptoms Screening

Neck pain-
Dizziness, Headache, Visual disturbances
Fatigue etc

- **Nature**
- **Duration**
- **Aggrav easing factors**
- **Concurrent symptoms**

CGH- unilateral, no side shift, aching, moderate, episodic

CGD - Vague unsteadiness , episodic, minutes, neck positions and movements

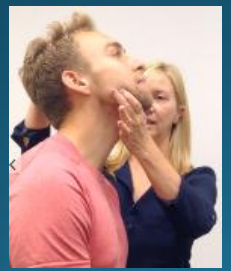
- But symptoms alone cant help DD
- Not necessarily complain of neck pain or stiffness
- Neck pain doesn’t always mean coming from the neck

Leddy et al 2015, Kennedy et al 2017

Cervical screening- Range of motion

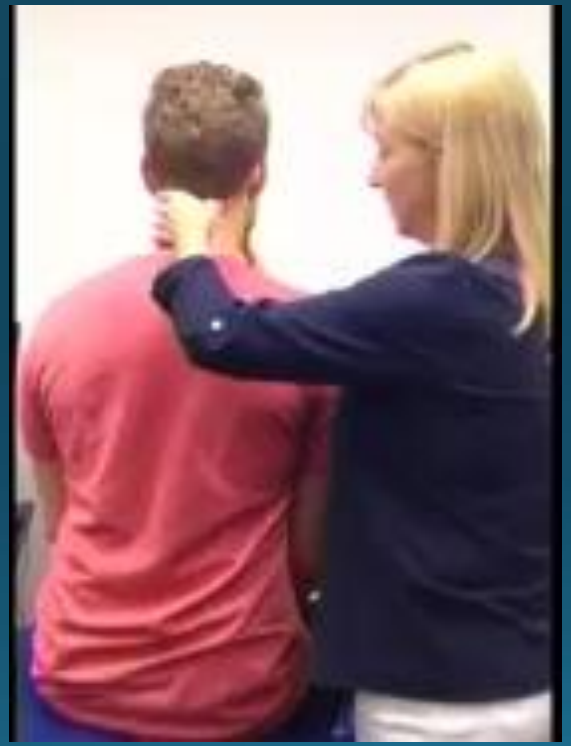
Cervical range, pain or tightness, reproduction headache or dizziness, gentle overpressure if no symptoms
But Treleaven et al 1994- no differences in ROM (degrees), need other factors




Cervical screening- Palpation

Suboccipitals, central and unilateral spine, erector spinae, traps, levator scap, SCMs, scalenes



TMJ

Thoracic

Scapula

Isolated findings – meaningless

Can give false positives

Cervical screening- Proprioception

Clinical Joint position sense test -relocation to neutral rotation, extension

Normal <4.5 degrees

Cervical screening- Neck flexor endurance

Normative values
39 sec Males
29 s Female

Domenech et al 2011

Measures to assist differential diagnosis?

Subjective- description, agg/ rel factors

Eye movement versus head movement

Eye movement -lying versus sitting

Slow versus fast movements

Torsion versus enbloc

Compare neutral to torsion

Slow/ large versus small /fast movements ?

Sustained torsion / head neck diff test

Treleaven et al 2019, Nuesch et al 2024

Compare enbloc to torsion- if both +ve then likely integration sensitivity rather than cervical

Effect of torsion – Smooth pursuit neck torsion test

Daley et al 2018

Effect of neck torsion on balance, JPE, NPC

Giffard et al 2017
Chen et al 2013
Williams et al 2017

Assessment cervical spine post trauma/ concussion:

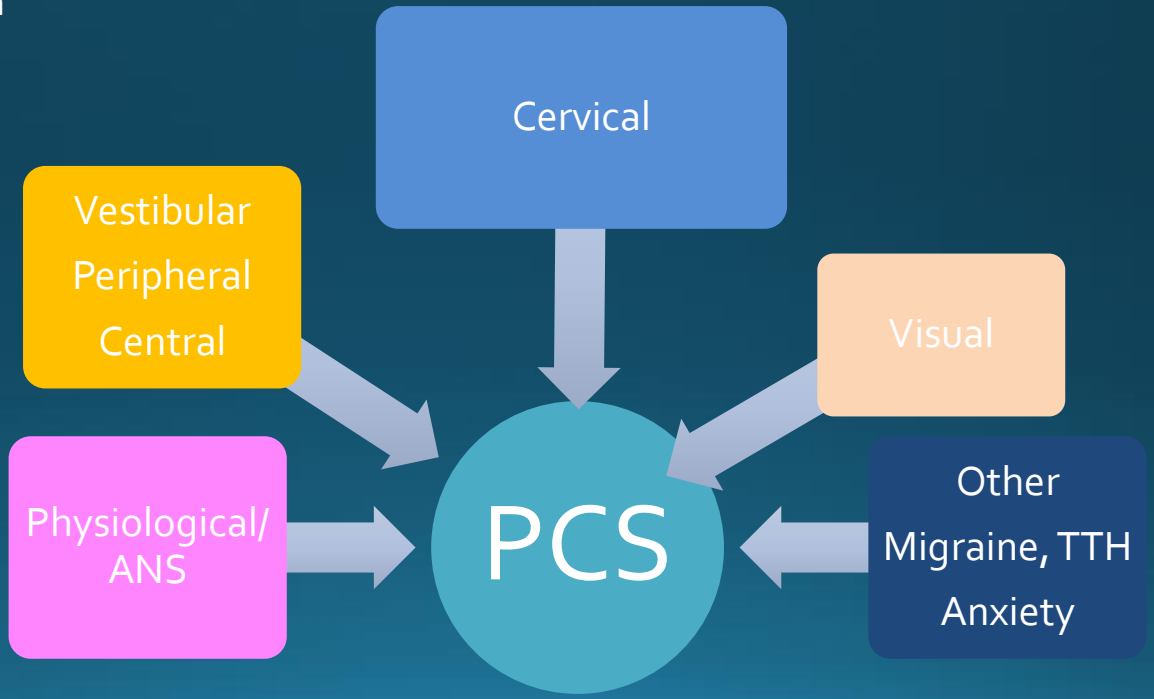
an integrative approach

Role of cervical spine post concussion

Patient interview

Assess impairments, skilled examination

Determine interactions/ contributions



Cervical examination

-Range of motion, kinematics

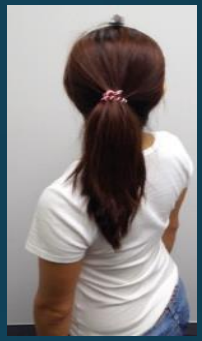
-Manual examination* esp upper cervical

-Neuromotor control/ posture – neck, scapula

-Cervical and scapular muscle strength/endurance

Cluster cervical

Balance, walking- compare inputs



Co-ordination- trunk-head
-eye head

Oculomotor
-Smooth pursuit neck torsion
- Gaze stability

Joint position sense (>4.5°)
Movement sense

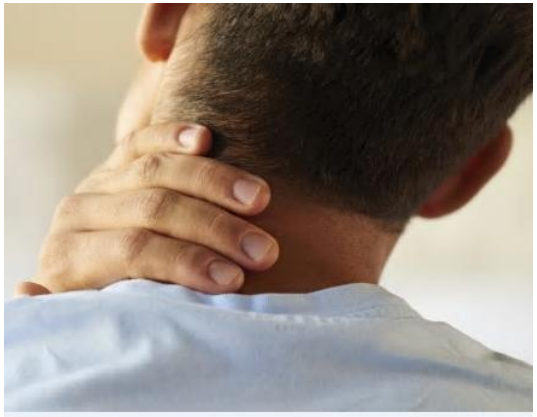
Compare inouts

Role of the cervical spine

Do **signs and symptoms** explain **degree of and the** presentation?

Relationships and drivers?

X✓?



Decisions about cervical role

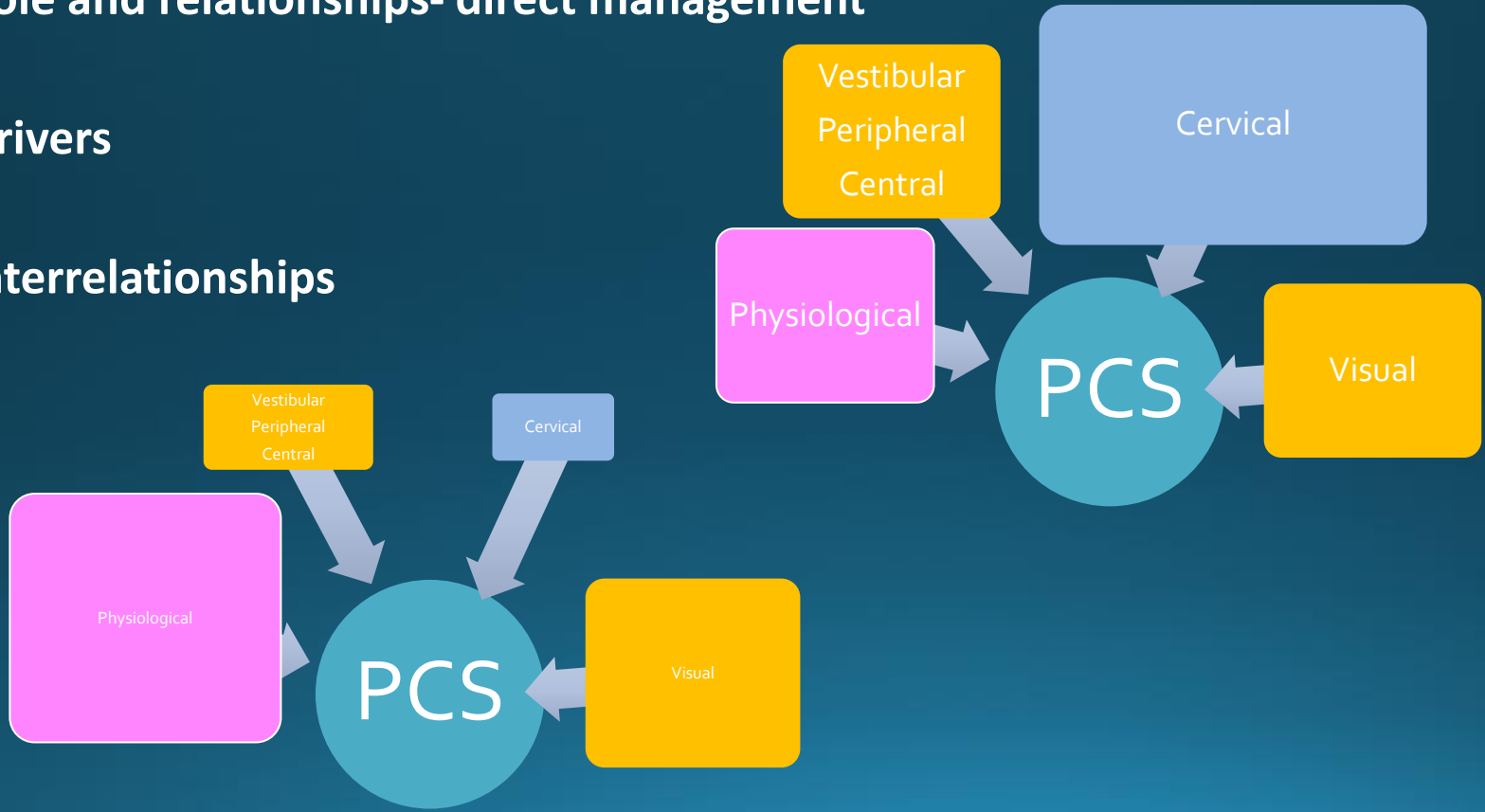
Not CG Referred pain migraine/TTH	Not CGH eg Peripheral Cervical sensitivity	Secondary Cerv MSK From visual or vestib	Primary CGH, CGD
Not CG Red flag- CAD, VBI	Not CG ? Trigger	Not CG Co-morbid cerv MSK	Mixed eg CGH + TTH/migraine, vestibular, visual, ANS

Overall Clinical reasoning decisions

Role and relationships- direct management

Drivers

Interrelationships



Management cervical spine post trauma/ concussion: an integrative approach

Challenges with management

Post concussion – influence neck pain not homogenous, neck pain not homogenous.

- Presentation - neck pain, headache, dizziness, etc
- Pain types, source- varied nature and severity
- Functional factors
- Impairments- nature and severity, types
- Drivers and triggers

Emphasis on clinical reasoning, assessment and analytical skills

BUT No recipe management approach

Need individual approach with evidence base in mind

Management approach neck pain in concussion

Pain management

Explanation, education, assurance, ergonomic modifications

Manual therapy, specific therapeutic exercise

Adjunct agents – electro-physical agents

Rehabilitate physical impairments

Manual therapy and segmental active exercise

Specific motor relearning and graded therapeutic exercise

Sensorimotor retraining

Strengthening and endurance as required

Restore function

Specific skill training

Graded therapeutic exercise, strength endurance

General exercise

Restore participation

Graduated return to work/sport

Ergonomic modifications

General lifestyle advice

Integrate with other systems

Sensorimotor integration

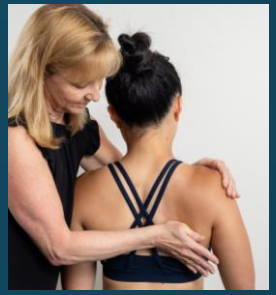
Drivers- eg vision

Vestibular – compensation

Vision- driver

Enable other treatment

Posture, Ergonomic and Work Practice Advice

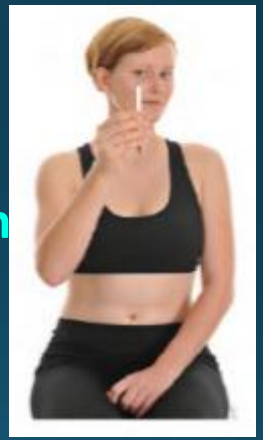


Manage movement and segmental joint dysfunction

Phase 1 - Rehabilitation of neuro and sensorimotor control aspects. Sremakeaew et al 2023





Phase II- Strengthening and endurance program, sensorimotor integration

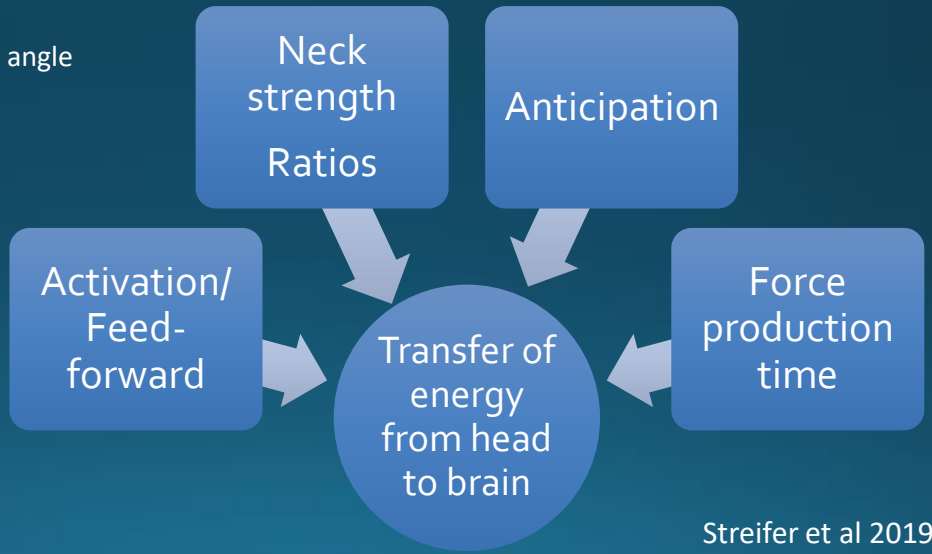




Role of cervical spine in prevention

- Reduce Impact magnitude

Neck girth- cm
Gender
Posture- CV angle
Pain



Streifer et al 2019
Nutt et al 2022
Mitchell et al 2023

Mixed evidence- Cooney et al 2022

Prevention?

- Strength/ Endurance
- Flex/ext ratios
- Segmental mobility
- Head stability
- Head reaction time
- Force production time
- Movement precision

Mitchell et al 2023

Implications:

Don’t forget the neck post-concussion

Neck and Head Research Unit

Co directors A/Prof Julia Treleaven/ Dr Lucy Thomas

E/Prof Gwen Jull

A/Prof Shaun O'Leary

Dr Katrina Williams

Dr Zhiqi Liang

Dr Alana Dinsdale

Dr Viana Vuvan

Students

Any questions?

@JuliaTreleaven

j.treleaven@uq.edu.au

THANKS!

The University Of Queensland
AUSTRALIA