www.chrisworsfold.com

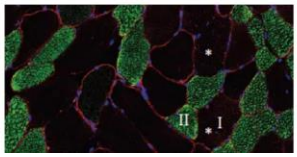
PAIN IN THE NECK

— NOTES FROM A NECK PAIN CLINIC —

Home Resources Speaking Contact

3 neck pain diagnostic tests

Neck pain: *can we learn anything from histochemistry?*



Oculomotor control

"Brilliant course. Great evidence-base."

The Neck: Clinical Rehabilitation

CHRIS WORSFOLD

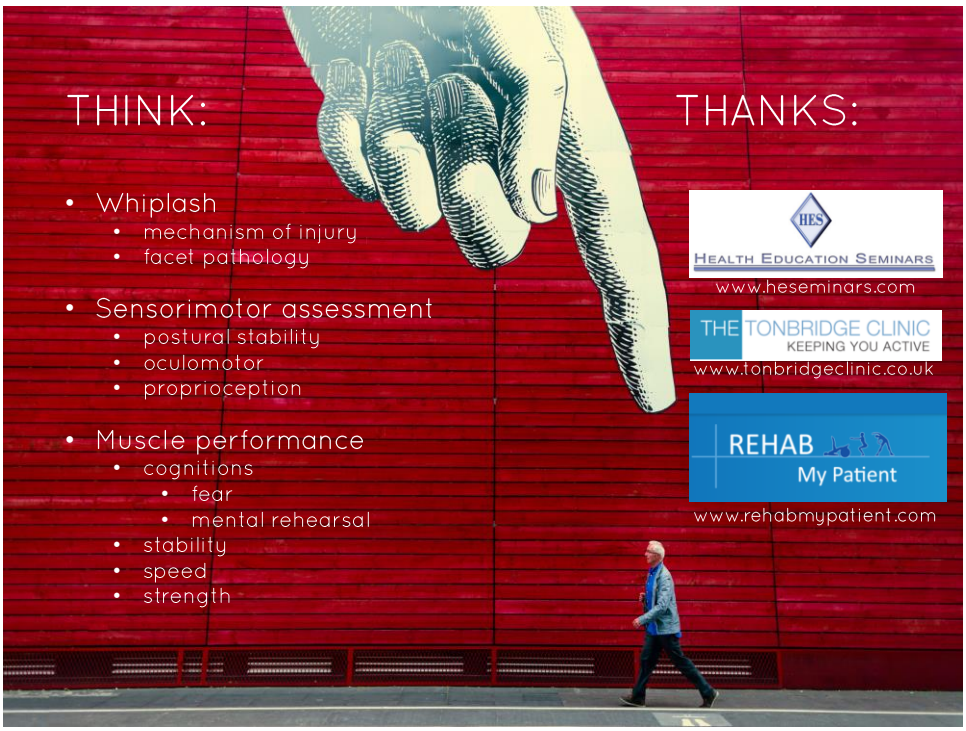
MSc PGDipManPhys MCSP MMACP

Physiotherapist specialising in Neck Pain

"He was probably one of the best speakers I have heard. Professional, informative, relaxed, well paced, fun, pertinent, clinically-based, practical, conceptual."

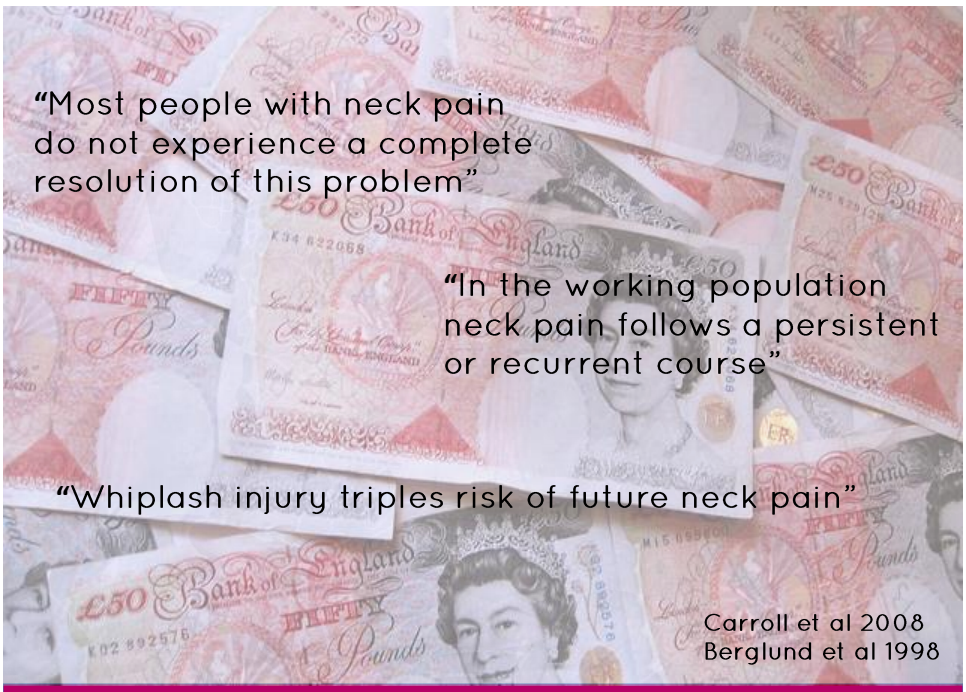
www.chrisworsfold.com


THE NECK: SENSORIMOTOR IMPAIRMENT IN SPORT
ONE DAY COURSE SCHEDULE
CHRIS WORSFOLD MSc PGDipManPhys MCSP MMACP
PHYSIOTHERAPIST SPECIALISING IN NECK PAIN
Schedule
0900 - 0930 Kinematics, pathology & concussion
0930 – 1100 Muscle performance
1130 – 1300 Sensorimotor impairment
1300 - 1345 LUNCH
1345 – 1500 Progressing treatment & case study
1500 – 1630 Case discussion
1630 Close
www.chrisworsfold.com
@chrisworsfold1


THINK:
Whiplash
mechanism of injury
facet pathology
Sensorimotor assessment
postural stability
oculomotor
proprioception
Muscle performance
cognitions
fear
mental rehearsal
stability
speed
strength
THANKS:
HES
HEALTH EDUCATION SEMINARS
www.heseminars.com
THE TONBRIDGE CLINIC
KEEPING YOU ACTIVE
www.tonbridgeclinic.co.uk
REHAB My Patient
www.rehabmypatient.com

Case Study

- Mr A has 8 week history of headaches, neck pain & dizziness following a rugby tackling injury.
- What would you include in your initial assessment?

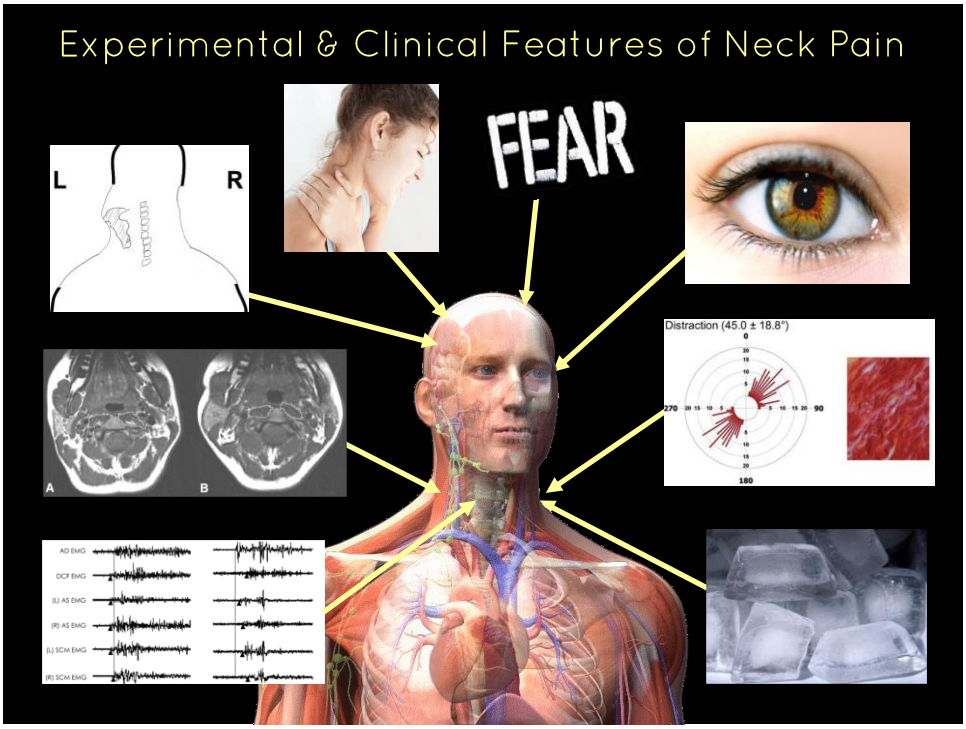


"Most people with neck pain do not experience a complete resolution of this problem"

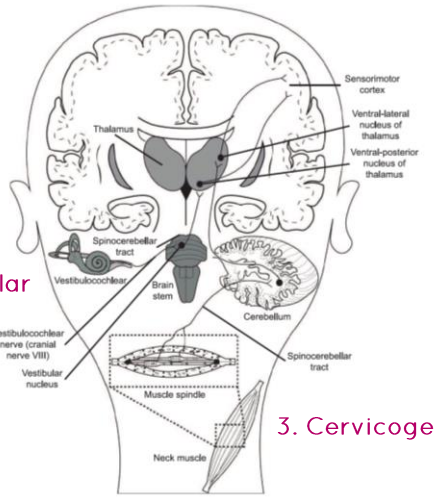
"In the working population neck pain follows a persistent or recurrent course"

"Whiplash injury triples risk of future neck pain"

Carroll et al 2008
Berglund et al 1998



Concussion

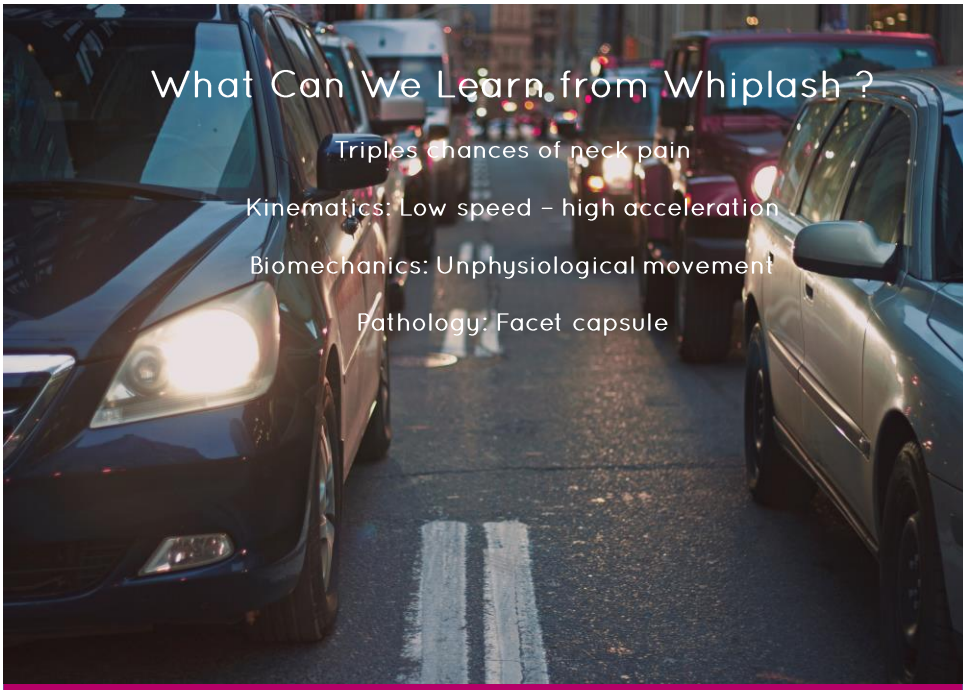


1. Physiological

2. Vestibulo-ocular

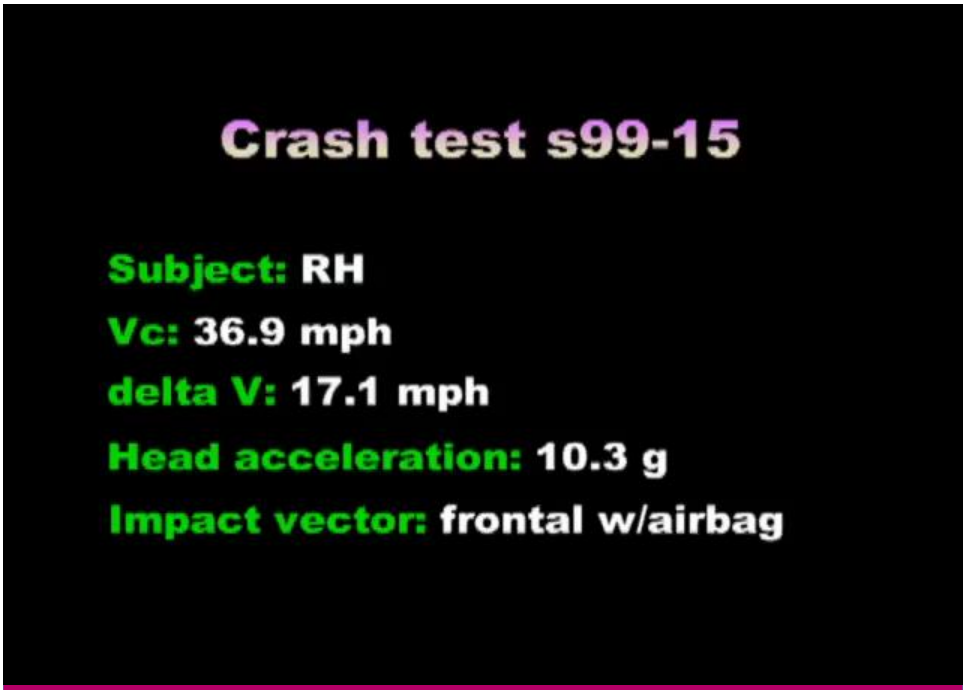
3. Cervicogenic

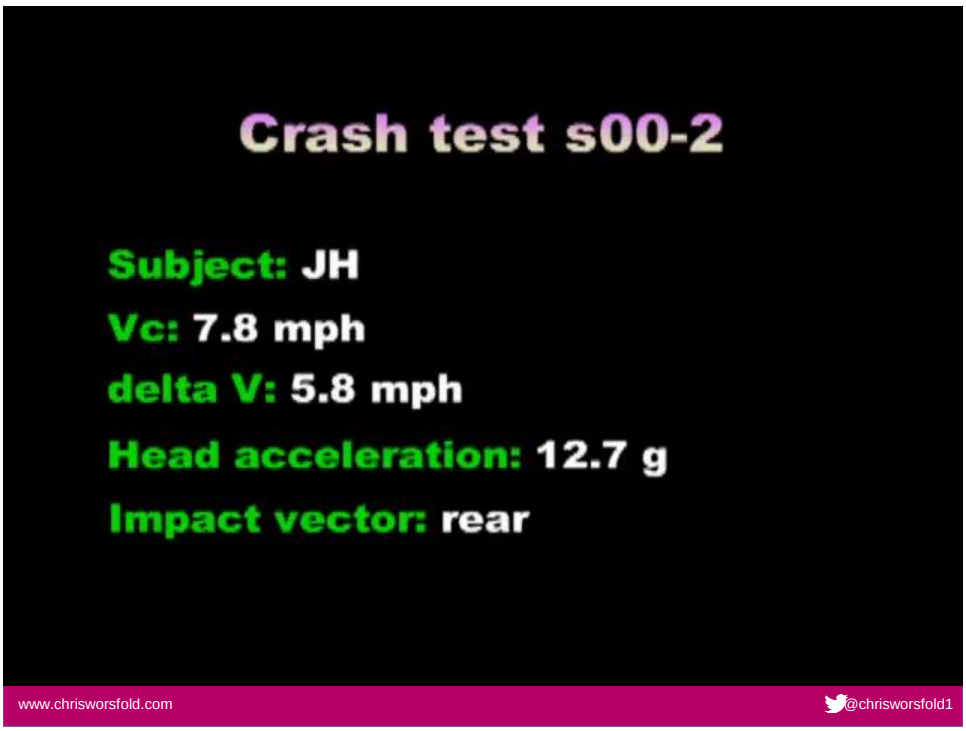
Cheever et al Journal of Athletic Training 2016;51(12):1037–1044



Kinematics: low speed, high acceleration

Crash number and year of crash	Gender and direction of impact (front, rear)	V_c (mph at time of crash)	Δ V (change in mph, or delta V)	Head linear resultant acceleration (g)
15 (99)	M (F)	36.9	17.1	10.3
2 (00)	M (R)	7.8	5.8	12.7

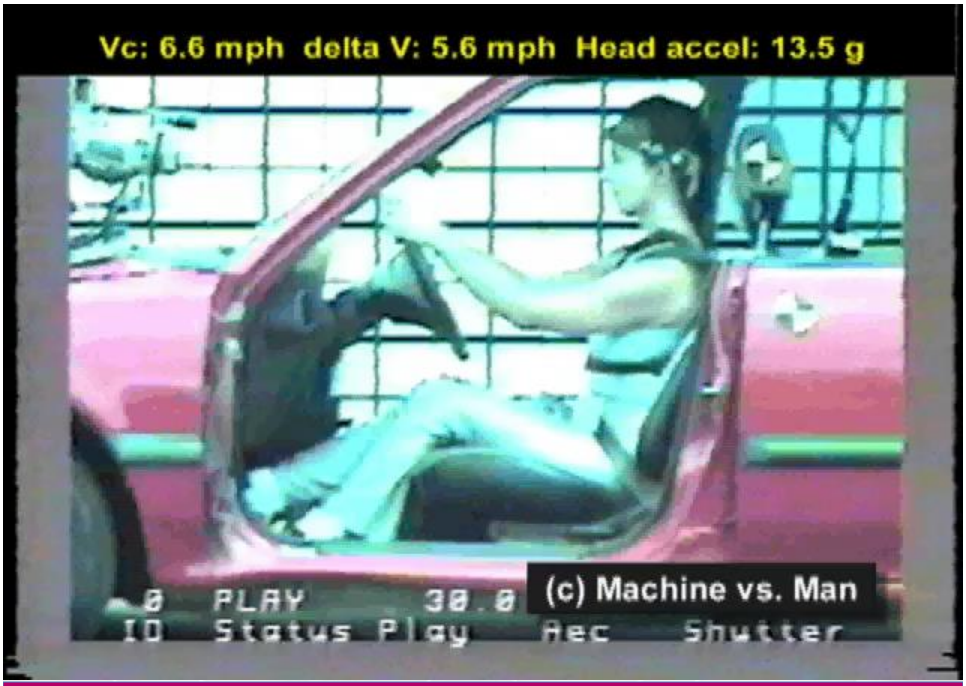

Crash test s99-15
Subject: RH
Vc: 36.9 mph
delta V: 17.1 mph
Head acceleration: 10.3 g
Impact vector: frontal w/airbag
www.chrisworsfold.com
@chrisworsfold1


Crash test s00-2
Subject: JH
Vc: 7.8 mph
delta V: 5.8 mph
Head acceleration: 12.7 g
Impact vector: rear
www.chrisworsfold.com
@chrisworsfold1

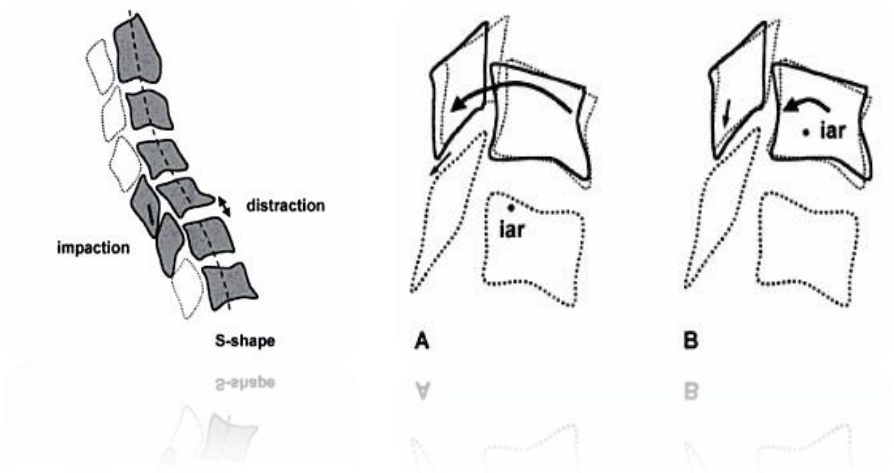
Biomechanics

- Major point of contact is seatback
- Lumbar extension 20ms
- Thoracic extension 60ms – 'ramping'
- Sigmoid deformation cervical spine
  - Upper cervical flexion / Lower cervical extension
- Muscle contraction onset 100-125ms after onset of vehicle acceleration
- Full cervical extension upper & lower
- 'Rebound phase' from extension into flexion

www.chrisworsfold.com @chrisworsfold1

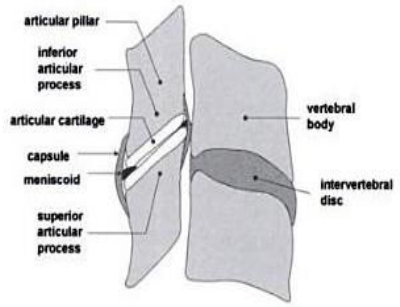


Biomechanics: Sigmoid deformation & Instantaneous Axis of Rotation ('IAR') shift



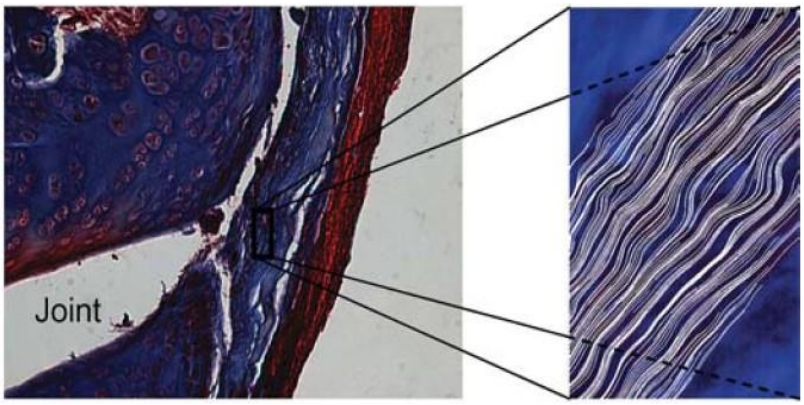
Pathology: Facet Joint

- Facet capsule is thin, loose ligament.
- Instantaneous Axis of Rotation change.
- Pinching facet joints.
- Synovial fold pinching.



Courtesy of Neurology & Trauma Open University Press

Pathology: Facet Joint



Collagen fibre organisation in rat facet capsular ligament (Masson Trichrome staining)

Image Courtesy of Siegmund et al Traffic Injury Prevention 2009

Pathology: Facet Joint Capsule

- Normal strain 1-10%with ADL
- Activate nociceptors 13%strain
- Persistent sensitivity & fibre organisation altered 21%strain
- Mechanoreceptors & nociceptors saturated 40%strain
- Cadaveric specimens: strains of 29-40%recorded
- Neck rotation doubles strain

Image Courtesy of Siegmund et al Traffic Injury Prevention 2009

(Dong et al 2008; Quinn et al 2007)

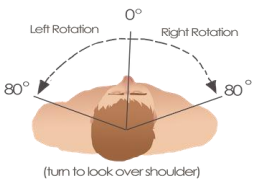
Case Study

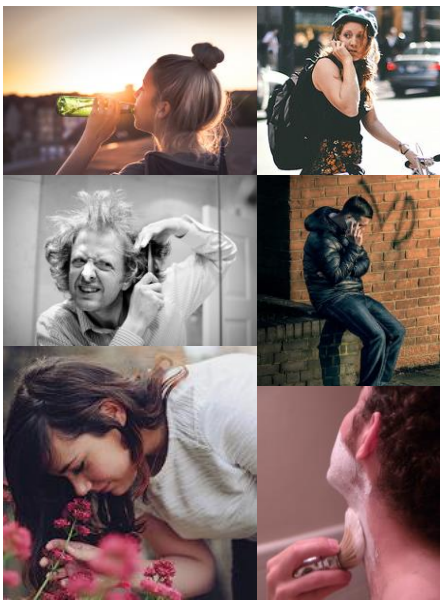
- Mr A has 8 week history of headaches, neck pain & dizziness following a rugby tackling injury.
- What would you include in your initial assessment?
- Tandem stand: eyes closed 10seconds max.
- Proprioception: 10cm left cervical rotation
- SPNT +ve left torsion: saccades, dizziness, increased effort
- Gaze stability: headache, dizziness and difficulty performing test with cervical flexion / extension

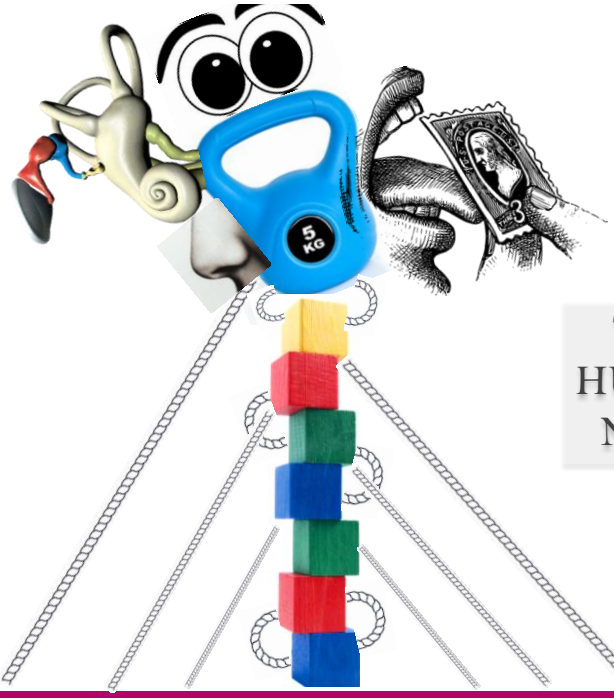
Neck pain: muscle performance

- The mind
  - mental imagery
  - the role of fear in neck muscle performance
- Histology & morphology
- Muscle performance
  - strength
  - stability
  - co-ordination
  - speed
  - rigidity / stiffness
  - respiratory
- Assessing muscle performance
- Managing muscle performance

Have we disengaged rehabilitation from day to day function?



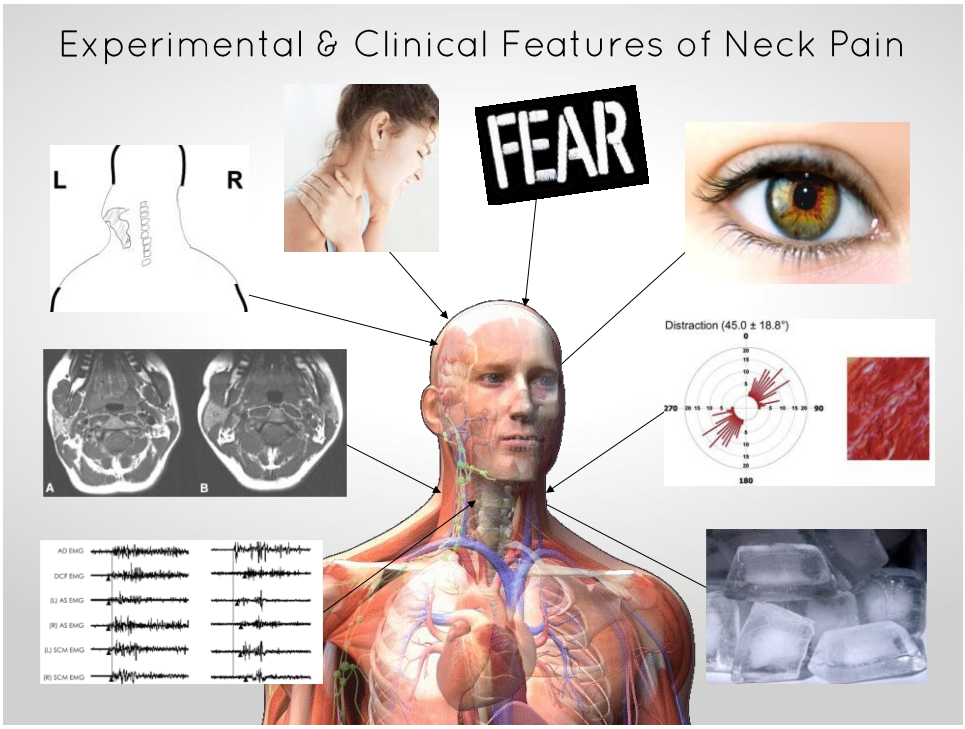




THE HUMAN NECK

Ankle sprain rehab
-V-
Neck pain rehab

Experimental & Clinical Features of Neck Pain



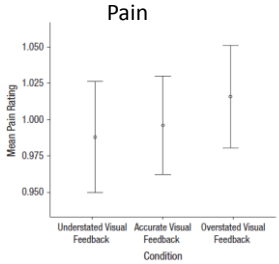
Range of motion tests do not reflect nociceptive drivers of pain

Bogus Visual Feedback Alters Onset of Movement-Evoked Pain in People With Neck Pain

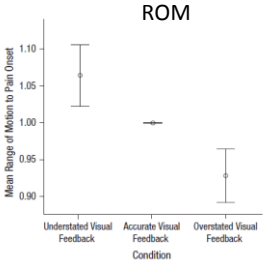
Psychological Science
1–8
© The Author(s) 2015
Reprints and permissions:
sagepub.com/journalsPermissions.nav
DOI: 10.1177/0956797614563339
pss.sagepub.com
SAGE

Daniel S. Harvie[1], Markus Broecker[2], Ross T. Smith[2], Ann Meulders[3], Victoria J. Madden[1], and G. Lorimer Moseley[1]
[1]Sansom Institute for Health Research, University of South Australia; [2]School of Information Technology and Mathematical Science, University of South Australia; and [3]Research Group on Health Psychology, University of Leuven

Pain



ROM



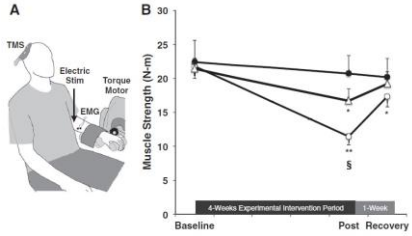
Mental imagery attenuates immobilisation induced muscle loss by 50%

J Neurophysiol 112: 3219–3226, 2014.
First published October 1, 2014; doi:10.1152/jn.00386.2014.

The power of the mind: the cortex as a critical determinant of muscle strength/weakness

Brian C. Clark,[1,2,3] Niladri K. Mahato,[1] Masato Nakazawa,[1,4] Timothy D. Law,[1,5] and James S. Thomas[1,2,6]

MI training. MI training was performed 5 times/wk. For each session, subjects performed 52 imagined maximal contractions of the casted wrist flexor muscles in a quiet room. The duration of each imagined contraction was 5 s, followed by 5 s of rest. Training was performed in four blocks of 13 imagined contractions each with 1 min of rest between the blocks. During the imagery sessions, subjects were

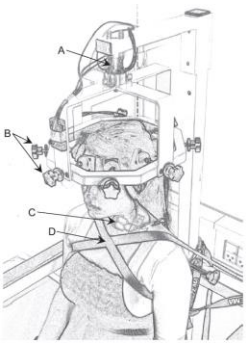


Arch Phys Med Rehabil Vol 93, November 2012

Current Pain and Fear of Pain Contribute to Reduced Maximum Voluntary Contraction of Neck Muscles in Patients With Chronic Neck Pain

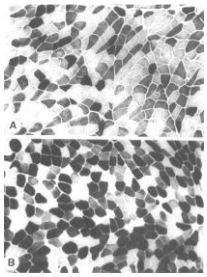
René Lindstroem, DC, Thomas Graven-Nielsen, PhD, Deborah Falla, PhD

"Strength gains in rehabilitation can be due to reduced fear"

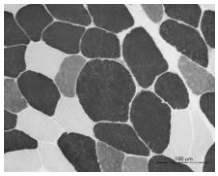


Neck pain: histology & morphology

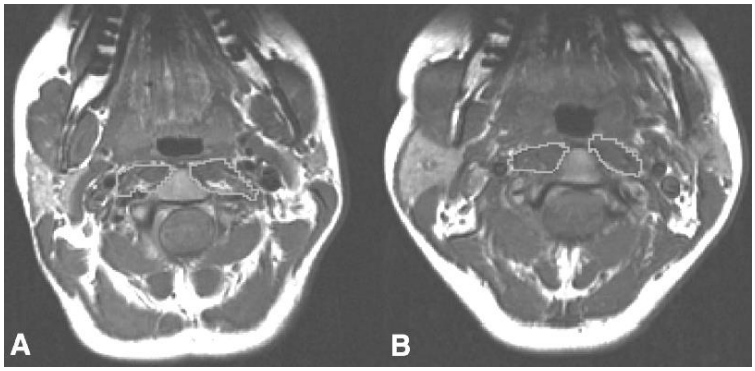
- Fibre-type transformation
  - evidence of fibre type changes in muscles of cervical spine in chronic neck pain from Type I (slow-twitch oxidative) to Type IIB (fast-twitch oxidative fibres) (Uhlig et al 1995)



- Megafibres
  - Cinderella hypothesis: low threshold motor units overloaded in sedentary occupations
  - Megafibres / 'moth eaten' / 'ragged red' / impaired microcirculation (Andersen et al 2008)



Neck pain: histology & morphology



Muscle fatty infiltrate in whiplash

(Elliott et al 2008, 2009, 2010)

Neck pain: strength & endurance

Isometric Cervical Strength Normals

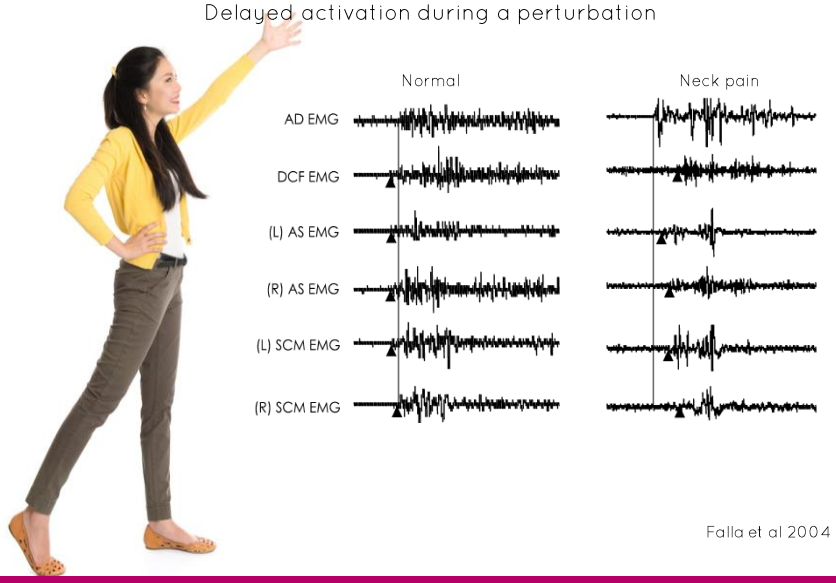
Cervical Muscle Group	Chiu et al (2002)	Ylinen et al (2004)	Vernon (1999)	Jordan et al (1999)
Flexors	74.5N	75.7N	46N	59N
Extensors	93.3N	187.1N	79N	78N

Isometric Cervical Strength Neck Pain

Cervical Muscle Group	Chiu et al (2002)	Ylinen et al (2004)	Prushansky et al (2005)
Flexors	56.7N	53.8N	20.6N (Male) 9.8N (Female)
Extensors	67.5N	132N	24.6N (Male) 14.7N (Female)

Neck pain: co-ordination

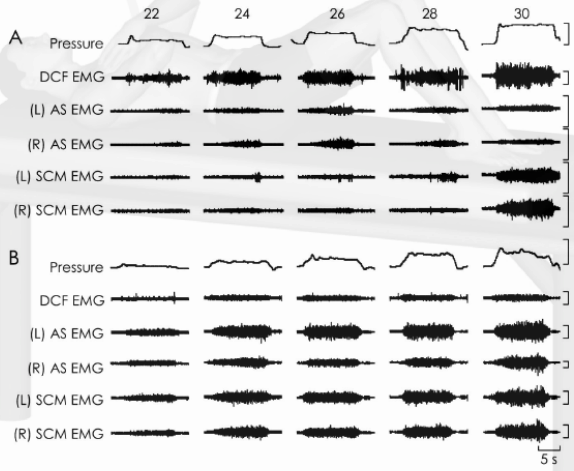
Delayed activation during a perturbation



Falla et al 2004

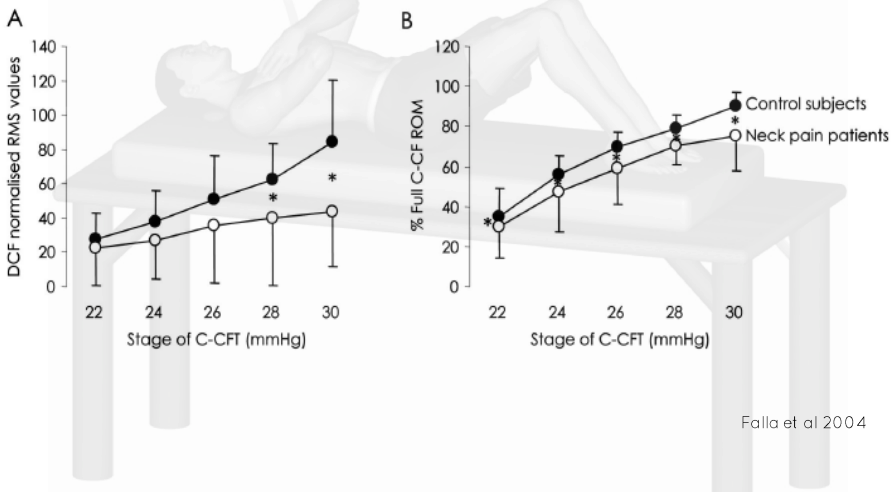
Neck pain: reorganisation

Reorganisation of cervical flexor muscle activity during craniocervical flexion



Falla et al 2004

Neck pain: range of motion as surrogate for deep neck flexor activity



Falla et al 2004

Manual Therapy xxx (2013) 1–7

Contents lists available at SciVerse ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math

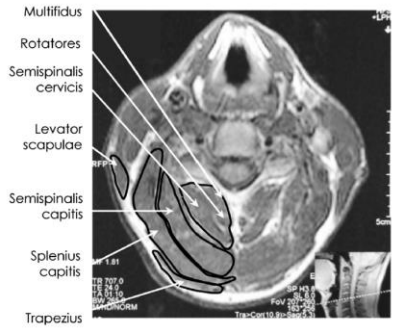
Review article

Function and structure of the deep cervical extensor muscles in patients with neck pain

Jochen Schomacher [a], Deborah Falla [b,c,*]

[a] Florastrasse 5, Küsnacht ZH, Switzerland
[b] Pain Clinic, Center for Anesthesiology, Emergency and Intensive Care Medicine, University Hospital Göttingen, Göttingen, Germany
[c] Department of Neurorehabilitation Engineering, Bernstein Focus Neurotechnology Göttingen, Bernstein Center for Computational Neuroscience, University Medical Center Göttingen, Georg-August University, Göttingen, Germany

- Increased activation superficial extensors
- Reduced activation deep neck extensors



Meisingset et al. BMC Musculoskeletal Disorders (2015) 16:56
DOI 10.1186/s12891-015-0517-2

BMC Musculoskeletal Disorders

RESEARCH ARTICLE Open Access

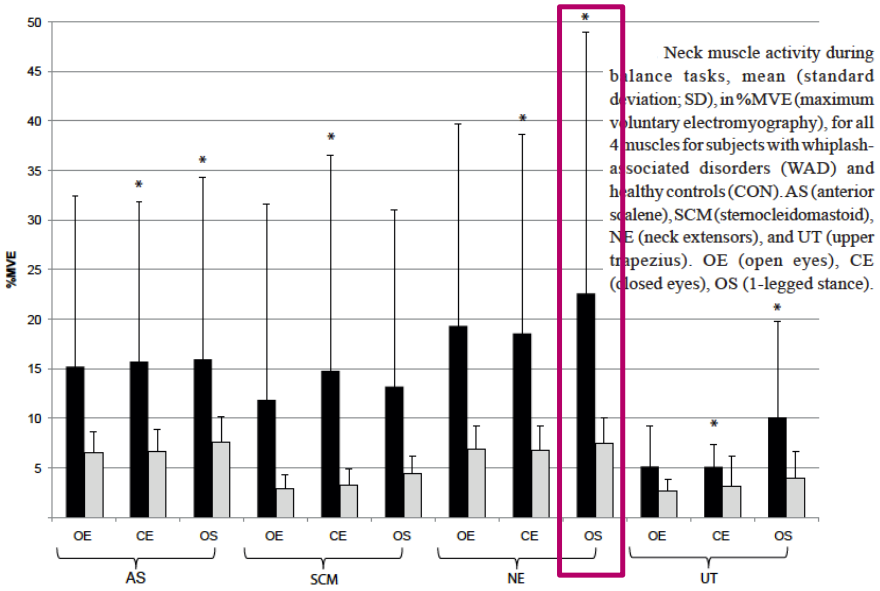
Evidence for a general stiffening motor control pattern in neck pain: a cross sectional study

Ingebrigt Meisingset[1*], Astrid Woodhouse[1], Ann- Katrin Stensdotter[1], Øyvind Stavdahl[2], Håvard Lorås[1], Sigmund Gismervik[1,3], Hege Andresen[4], Kristian Austreim[1] and Ottar Vasseljen[1]

	Neck pain (n = 75)	Healthy controls (n = 91)
Neck flexibility		
CM (°)[1]	12.3 (11.3-13.3)	16.5 (15.6-17.4)
CM (°)[2]	12.9 (11.9-14.0)	16.0 (15.1-16.9)
CM (°)[3]	13.7 (12.4-15.0)	15.4 (14.4-16.3)
Peak velocity (°/s)[1]	70.6 (62.5-78.7)	115.6 (108.4-122.8)

The theory emphasizes increased stiffness as an important motor adaptation to acute pain to protect or avoid movement of a painful body part. However, after the acute stage protective stiffening may no longer serve a purpose. The long term consequences of increased stiffness may be decreased movement and movement variability, and consequently increased load on the spine

Neck pain: increased muscle rigidity in standing



Neck muscle activity during balance tasks, mean (standard deviation; SD), in %MVE (maximum voluntary electromyography), for all 4 muscles for subjects with whiplash-associated disorders (WAD) and healthy controls (CON). AS (anterior scalene), SCM (sternocleidomastoid), NE (neck extensors), and UT (upper trapezius). OE (open eyes), CE (closed eyes), OS (1-legged stance).

Juul-Kristensen 2013

Persistent neck pain & respiratory muscle weakness

- Reduced max voluntary ventilation (MVV), max inspiratory & expiratory pressures & peak expiratory flow
- 15-20% reduction – does not exceed cut offs (20%)
- The higher the NDI, the greater the impairment
- Respiratory muscle weakness correlates with reduced neck muscle strength, kinesiophobia & catastrophising
- Respiratory function should be assessed & treated

American Thoracic Society / European Respiratory Society 2002, Dimitriades et al 2012, Wirth et al 2014

Neck pain: muscle performance summary

Delayed activation to postural perturbation
Reduced velocity of motion

Speed

Reduced activity in deep neck flexors & extensors

Stability

Neck muscle weakness
Impaired microcirculation
Fibre-type transformation

Strength

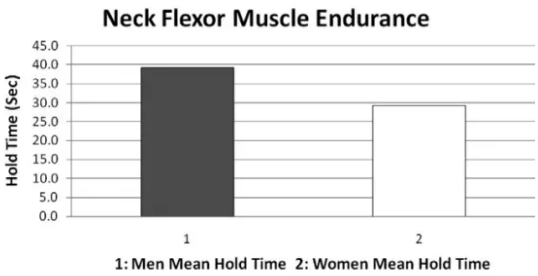
Increased activity in superficial flexors and extensors
Increased rigidity & stiffening in balance tasks

Relaxation

Stability I: flexor endurance test 'Straight leg raise' of the neck

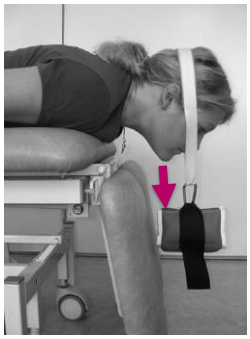
- Lift head 2cm (measured from back of the head to the plinth)
- Time until the chin begins to 'thrust' is measured in seconds
- Chin 'thrust' is determined in two ways: by light finger pressure over the point of the subject's chin, and by observation.

Inter & intra-rater reliability good > 0.80



Domenech et al. 2011
Olson et al 2006

Stability I: endurance tests to exhaustion



Dorsal normals
2Kg women = 8.5 minutes
4kg men = 7 minutes

Ventral normals
Women = 30 seconds
Men = 2.5 minutes

Inter & intra-rater reliability good > 0.80

Peolsson et al 2007

Stability II: deep neck flexors

- Deep Neck Flexors (DNF)
- Pressure biofeedback 5-stage craniocervical flexion
  - Starting pressure 20mmHg
  - Target 22 – 24 – 26 – 28 - 30mmHg
  - Hold each stage for 10 seconds

Stability III: deep neck extensors

Stability IV: side flexors

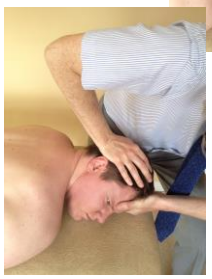
Neck muscle performance I

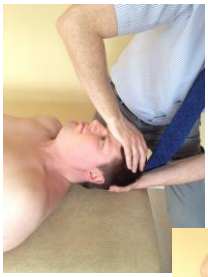
Head lifts

Neck muscle performance II

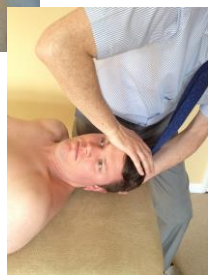
Manual resistance isometric

Extension

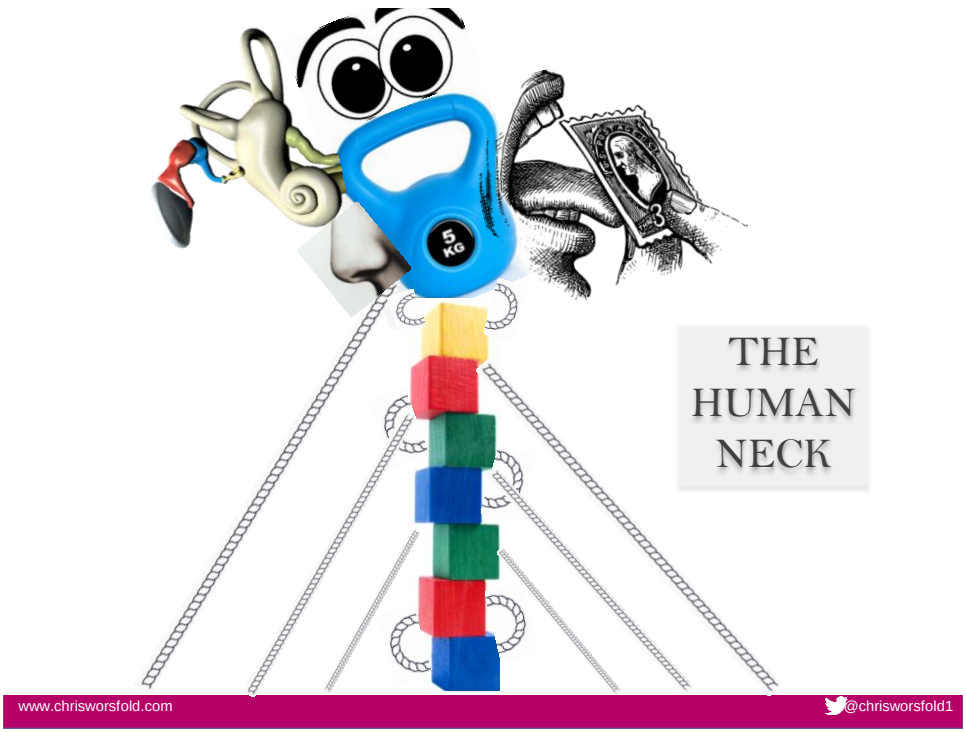




Flexion




Sensorimotor impairment
• proprioception
• oculomotor control
• postural stability
www.chrisworsfold.com
@chrisworsfold1


5 KG
THE HUMAN NECK
www.chrisworsfold.com
@chrisworsfold1

Symptoms of **cervical** sensorimotor impairment

- <u>Not</u> a true vertigo 'illusion of movement' – room spinning

- Dizziness / giddiness
- Light headedness / off balance
- Unsteadiness
- Walking on cotton wool
- 33% neck pain (Humphreys et al 2002)
- 74% neck trauma (Treleaven et al 2003)

Vision related symptoms in neck pain

- Need to concentrate to read*
- Visual fatigue*
- Sensitivity to light*
- Blurred vision
- Words moving
- Difficulty judging distances
- Double vision NOT associated with neck pain

*most common – 50% of neck pain

Treleaven & Takasaki 2014

Causes of sensorimotor impairment

- Cervical arterial dysfunction
- Side effects of medication / anxiety – but no association (Treleaven et al 2006)
- Peripheral vestibular lesions – Benign Paroxysmal Positional Vertigo (BPPV)
  (Dispenza et al 2011, n=18, BPPV △ in 30%)
- 'Cervical afferent disturbance'

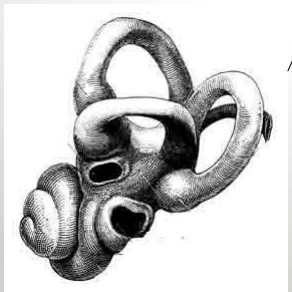
Causes of sensorimotor impairment: concussion

'Specific areas of the brain, such as the **cerebellum, cerebral cortex, thalamus, reticular formation,** and **brainstem,** are responsible for integrating sensory information from the vestibular apparatus and sensory organs to allow an athlete to move and orient body position to space and time'

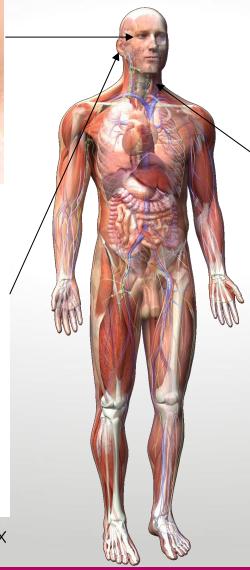
Kontos et al 2017 Journal of Athletic Training 2017;52(3):256–261

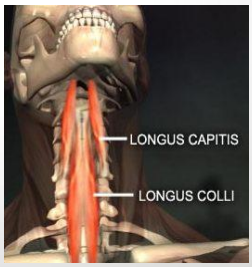
Sensorimotor disturbance

Muscle spindle input augmented with input from visual and vestibular system: Extensive anatomical connections.



Vestibulo-Ocular Reflex

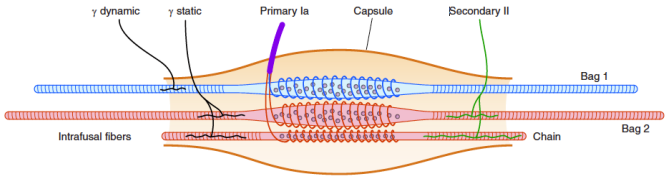




Cervico-Ocular Reflex

Gosselin *et al.* (2004)
Schiepatti *et al.* (2003)
Vuillerme *et al.* (2005)
Stapley *et al.* (2006)

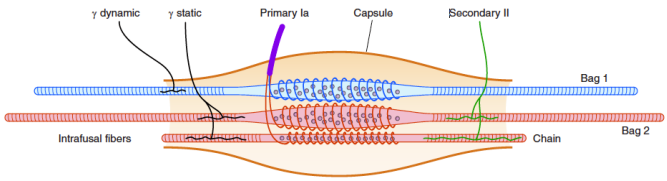
Sensorimotor disturbance: muscle spindles



- High density of muscle spindles in small intrinsic deep dorsal and suboccipital muscles (Peck 1984, Richmond & Bakker 1982)

- Localised in slow twitch fibres – role in postural control
  - LA injected into cervical tissues = ataxia (deJong et al 1977)
    - Neck vibration = postural control (Pyykko et al 1989)
    - Neck fatigue = postural control (Gosselin et al 2004)

What is the mechanism affecting cervical afferent activity ?

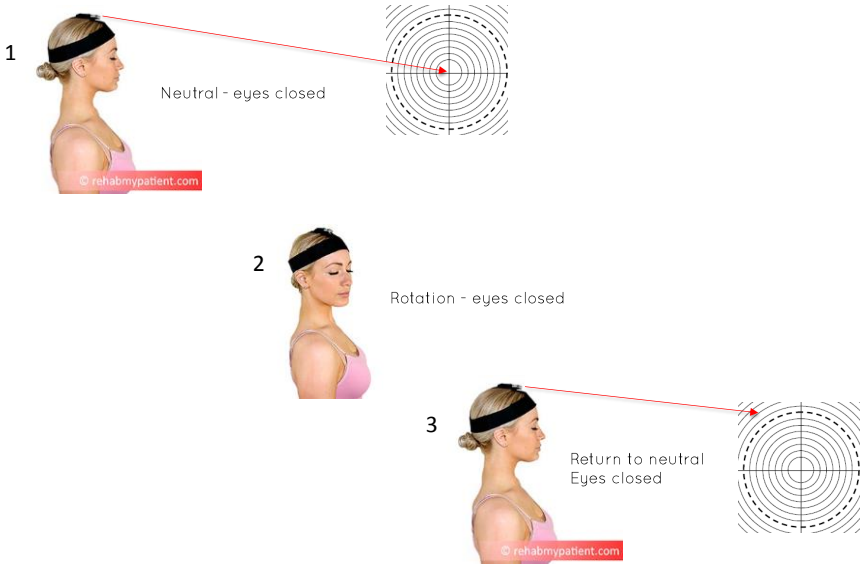


- No evidence of muscle damage in whiplash
  "Prolonged symptoms following whiplash injury cannot be explained by biochemically measurable muscle damage." (Scott and Sanderson 2002)
  - Fatty infiltration (Elliott et al 2006)
- Cervical muscular fatigue - 'overactivity' (Stapley et al 2006)
- Disturbed afferent input - mechanoreceptors / dorsal root ganglion trauma
  - Stress response & sympathetic nervous system

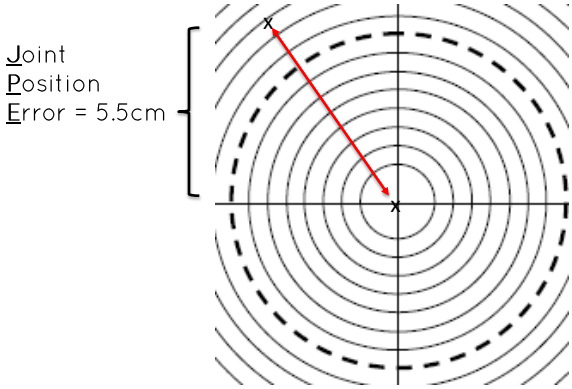
Assessing Proprioception

- Sherrington (1900)
  - Defined proprioception as awareness of body position and orientation.
  - The sixth sense / conscious awareness
- Contralateral angles: matched and compared or body segment repositioned in space without the aid of vision.
- Neck has no side for comparison!

Sensorimotor control: laser & target

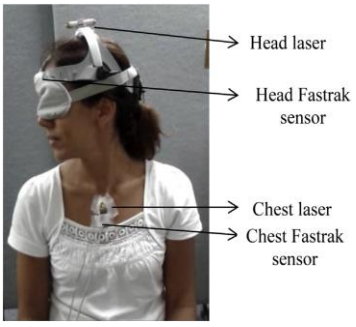


Sensorimotor control: laser & target



Assessing Joint Position Error - research

- Validity of 'laser & target' method:
  - mod to strong correlations with Fastrak (Chen et al 2013)
- Reliability of 'laser & target' method:
  - Most studies report ICC above 0.75 (Jørgensen et al 2014)



876 ■ Physical Therapy Volume 96 Number 6 June 2016

Evidence of Impaired Proprioception in Chronic, Idiopathic Neck Pain: Systematic Review and Meta-Analysis

Tasha R. Stanton, Hayley B. Leake, K. Jane Chalmers, G. Lorimer Moseley

T.R. Stanton, BScPT, MScRS, PhD, The Sansom Institute for Health Research, The University of South Australia, School of Health Sciences, GPO Box 2471, Adelaide, South Australia 5001; Pain-Adelaide Consortium, Adelaide

Background. Despite common use of proprioceptive retraining interventions in people with chronic, idiopathic neck pain, evidence that proprioceptive dysfunction exists in this population is lacking. Determining whether proprioceptive dysfunction exists in people with chronic neck pain has clear implications for treatment prescription.

Manual Therapy xxx (2015) 1–9

Contents lists available at ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math

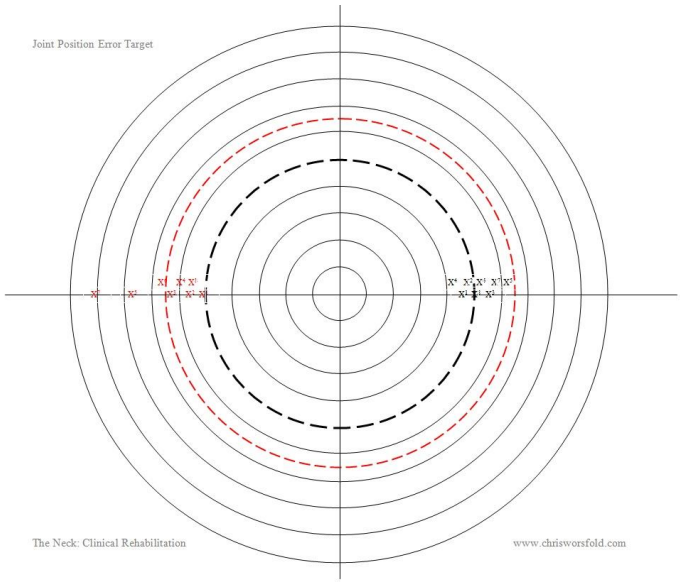
Systematic review

Joint position sense error in people with neck pain: A systematic review

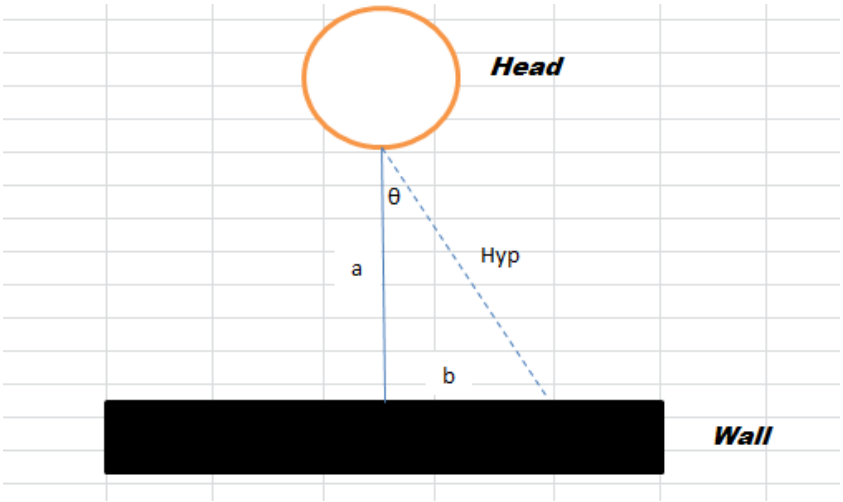
J. de Vries [a, b, *], B.K. Ischebeck [a, c, 1], L.P. Voogt [b, 2], J.N. van der Geest [a, 3], M. Janssen [a, 4], M.A. Frens [a, d, 5], G.J. Kleinrensink [e, 6]

[a] Department of Neuroscience, Erasmus MC, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands
[b] Department of Physical Therapy, Rotterdam University of Applied Sciences, Rochussenstraat 198, 3015 EK Rotterdam, The Netherlands
[c] Spine and Joint Centre, Noordsingel 153, 3035 EM Rotterdam, The Netherlands
[d] Erasmus University College, Rotterdam, P.O. Box 1738, 3000 BR Rotterdam, The Netherlands
[e] Department of Neuroscience-Anatomy, Erasmus MC, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands

Assessing Joint Position Error - target

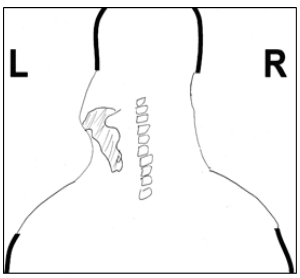


www.chrisworsfold.com @chrisworsfold1



Assessing Joint Position Error - research

- JPE increases with age (Vuillerme et al 2007)
- No predictive utility – not related to outcome.
- Dizziness = increased JPE (Treleaven et al 2003)
- Vestibular vs Whiplash subjects = no difference but whiplash group main complaint dizziness / unsteadiness (Treleaven et al 2008)
- JPE has strong correlation with laterality judgment in recurrent neck pain (Elsig et al 2014)



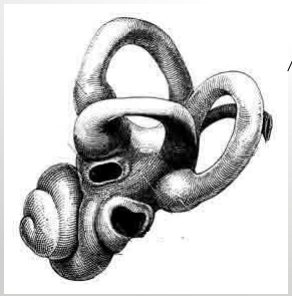
Disrupted body image 6/52 following whiplash injury. Shaded area indicates site of pain. (Worsfold 2011, unpublished data).

Assessing Joint Position Error - summary

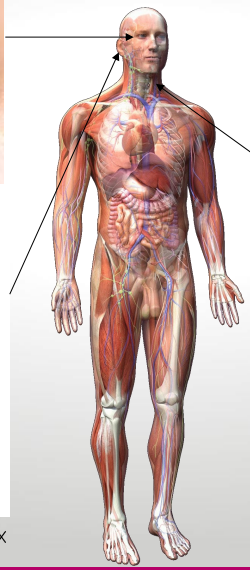
- Good reliability with laser and target with mean of six trials.
- Appears to discriminate between normals and whiplash subjects.
- Normal approx. 5cm Abnormal > 6.5cm
- May not be a specific test of cervical afferent function.

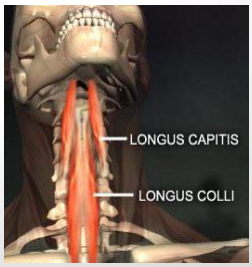
Sensorimotor disturbance:

Muscle spindle input augmented with input from visual and vestibular system: Extensive anatomical connections.



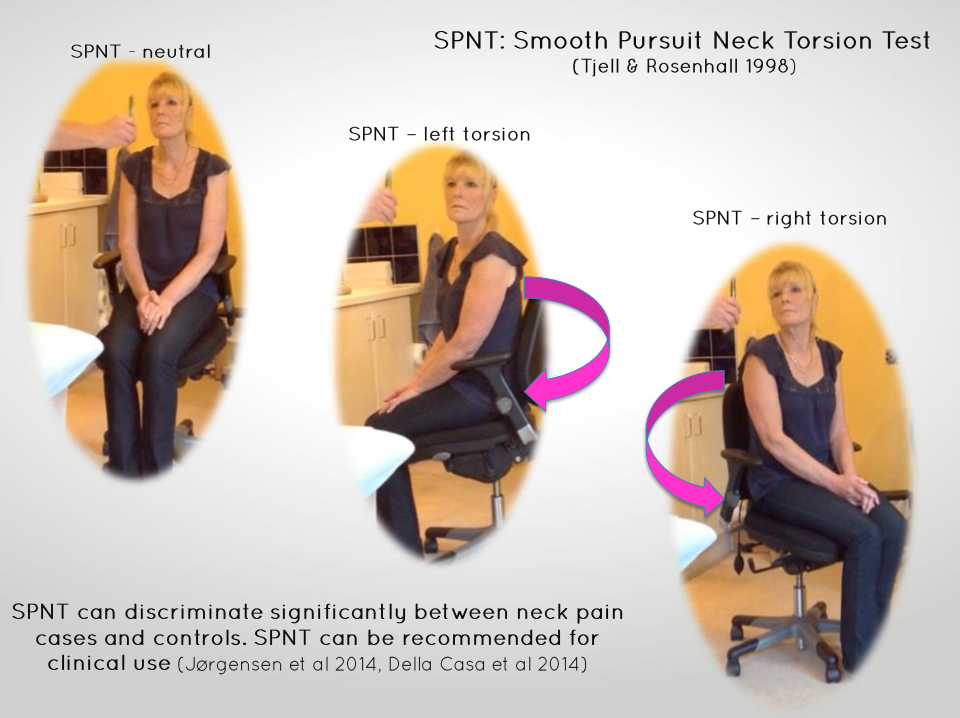
Vestibulo-Ocular Reflex





Cervico-Ocular Reflex

Gosselin *et al.* (2004)
Schiepatti *et al.* (2003)
Vuillerme *et al.* (2005)
Stapley *et al.* (2006)



Ischebeck *et al. BMC Musculoskeletal Disorders* (2016) 17:441
DOI 10.1186/s12891-016-1284-4

BMC Musculoskeletal Disorders

RESEARCH ARTICLE Open Access

Eye movements in patients with Whiplash Associated Disorders: a systematic review

Britta Kristina Ischebeck[1,2*], Jurryt de Vries[3,2], Jos N Van der Geest[2], Malou Janssen[2], Jan Paul Van Wingerden[1], Gert Jan Kleinrensink[2] and Maarten A Frens[2,4]

N=14 studies

"Studies show deficits in eye movement in patients with whiplash.'


Sensorimotor control: postural stability
Increased AP sway in whiplash subjects > idiopathic neck pain > normal (Field et al 2008)
50% non-dizzy whiplash subjects unable tandem stand eyes closed (Field et al 2008)
74% dizzy whiplash subjects unable tandem stand eyes closed (Treleaven et al 2008)
www.chrisworsfold.com
@chrisworsfold1


Sensorimotor control: dynamic postural stability
– Gait disturbances in neck pain: decreased step width, step length & speed (Uthaikhup et al 2013)
– Functional test deficits in neck pain: slower tandem walk and step test in WL (Stokell et al 2011)
– Neck torsion = greater postural deficits in standing in WL (Yu et al 2011).
www.chrisworsfold.com
@chrisworsfold1

"A battery of balance tests that include comfortable, narrow and tandem stances with eyes open and eyes closed should be included in the routine examination of all neck pain patients even in those not complaining of dizziness or unsteadiness." (Field et al 2008)

Physiotherapy Theory and Practice, 29(1):1–18, 2013

ISSN: 0959-3985 print/1532-5040 online
DOI: 10.3109/09593985.2012.677111

informa
healthcare

SYSTEMATIC REVIEW

Standing balance in patients with whiplash-associated neck pain and idiopathic neck pain when compared with asymptomatic participants: A systematic review

Anabela G. Silva, PhD,[1] and Ana Lúcia Cruz, MSc[2]

[1]*Physiotherapist, Adjunct Professor, School of Health Sciences, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*Physiotherapist, Senior Lecturer, School of Health Sciences, University of Aveiro, 3810-193 Aveiro, Portugal*

N=12 studies

"Both patients with idiopathic neck pain & patients with whiplash have poorer balance than healthy controls.'

Sensorimotor control assessment

- Postural stability
  - Comfortable / Narrow / Tandem / 1-Leg
  - Eyes Closed
  - Foam
- Joint Position Error
  - Laser & target
- Oculomotor
  - Eye movements: smooth pursuit + neck torsion
  - Saccades
  - Gaze stability

Neck pain: progressing treatment

- Psychological impairment
- Sensorimotor impairment
- Muscle performance
- Concussion management

REMINDERS
IRRITABLE
DREAMS
STRONG
PICTURES
JUMPY
INTRUSIVE
FLASHBACKS
FEELINGS
AVOIDANCE

IES

Name: Date:

On 04/8/16 (date) you experienced bike accident (life event). below is a list of comments made by people after stressful life events. please check each item indicating how frequently these comments were true for you *during the past 7 days or other agreed time period.* if they did not occur during that time, please mark the *"not at all"* column

		Frequency			
		not at all 0	rarely 1	sometimes 3	often 5
1	I thought about it when I didn't mean to			✓	✓
2	I avoided letting myself get upset when I thought about it or was reminded of it	✓			
3	I tried to remove it from memory		✓	✓	
4	I had trouble falling asleep or staying asleep, because of pictures or thoughts about it that came into my mind				
5	I had waves of strong feelings about it				✓
6	I had dreams about it			✓	
7	I stayed away from reminders of it	✓			
8	I felt as if it hadn't happened or it wasn't real			✓	
9	I tried not to talk about it	✓			
10	Pictures about it popped into my mind				✓
11	Other things kept making me think about it				✓
12	I was aware that I still had a lot of feelings about it, but I didn't deal with them				✓
13	I tried not to think about it		✓		
14	Any reminder brought back feelings about it				✓
15	My feelings about it were kind of numb		✓		

Total score = (>25) 2 + 9 = 11 (30) 41

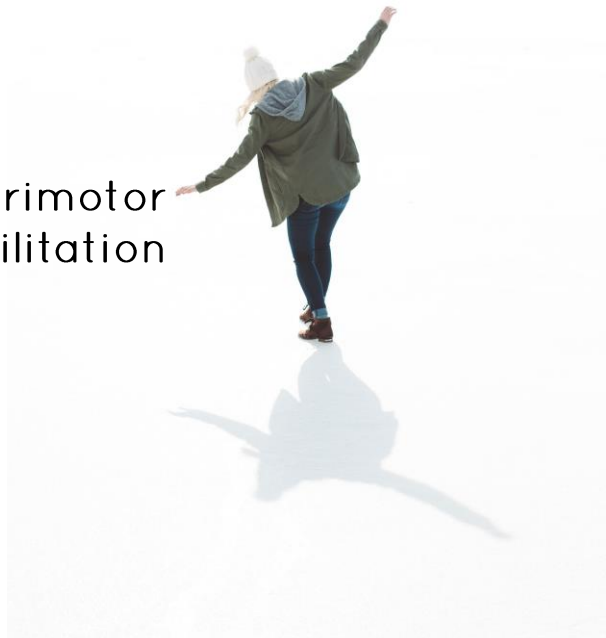
CBT decreases post traumatic stress symptoms & pain related disability

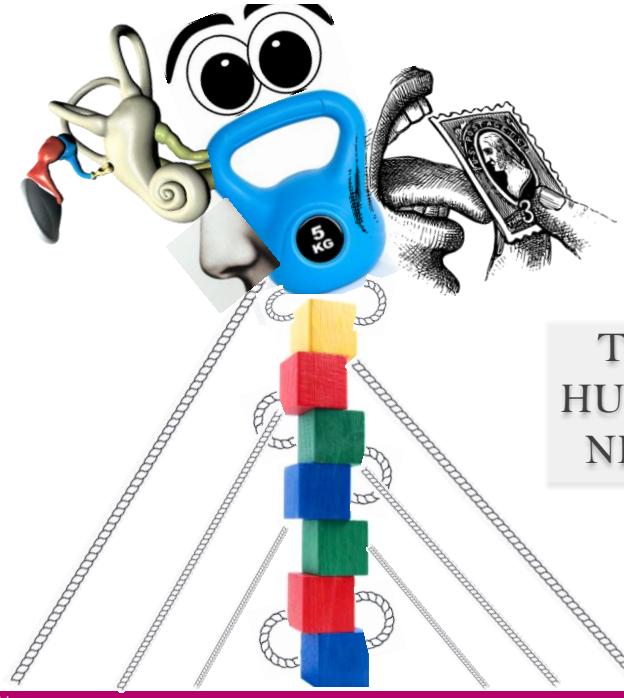
I thought about it when I didn't mean to
I avoided letting myself get upset when I thought about it or was reminded of it
I tried to remove it from memory
I had trouble falling asleep or staying asleep, because of pictures or thoughts about it that came into my mind
I had waves of strong feelings about it
I had dreams about it
I stayed away from reminders of it

Rx recommendations: refer on if IES (shown here) > 25.
Do NOT screen prior to 6/52
Scores < 26 offer stress management: relaxation / exercise

Horowitz et al 1979
Dunne et al 2012

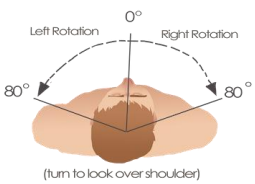
Sensorimotor rehabilitation

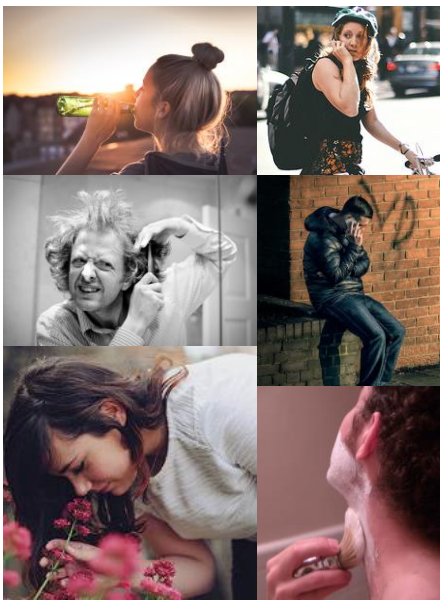




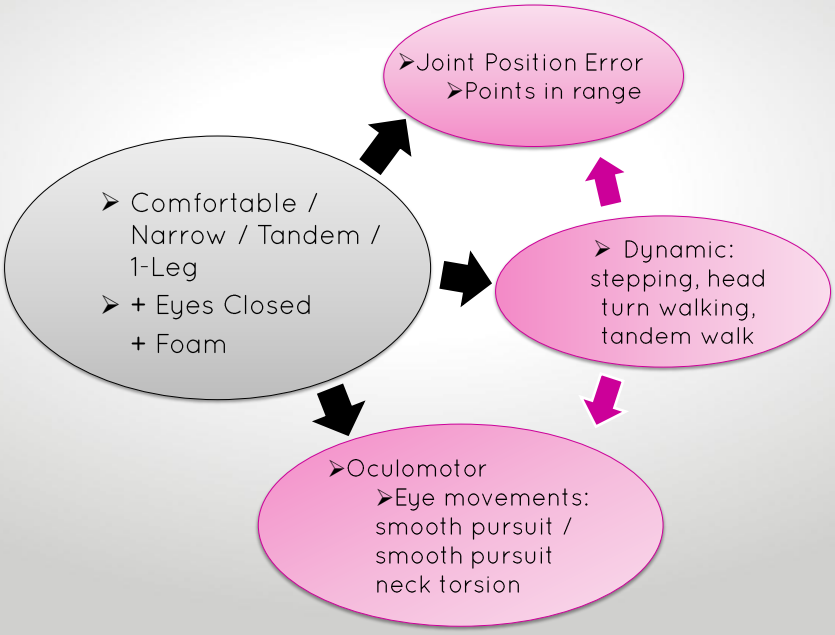
THE HUMAN NECK

Have we disengaged rehabilitation from day to day function?

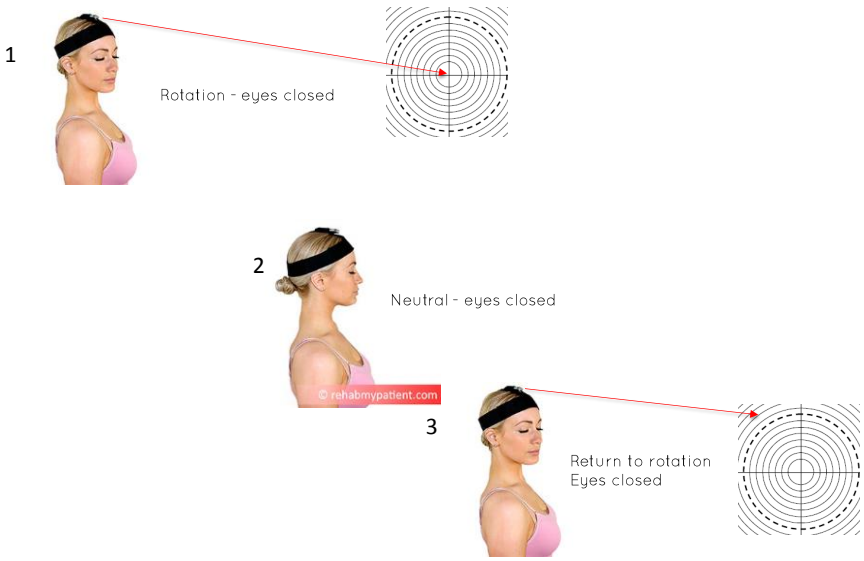


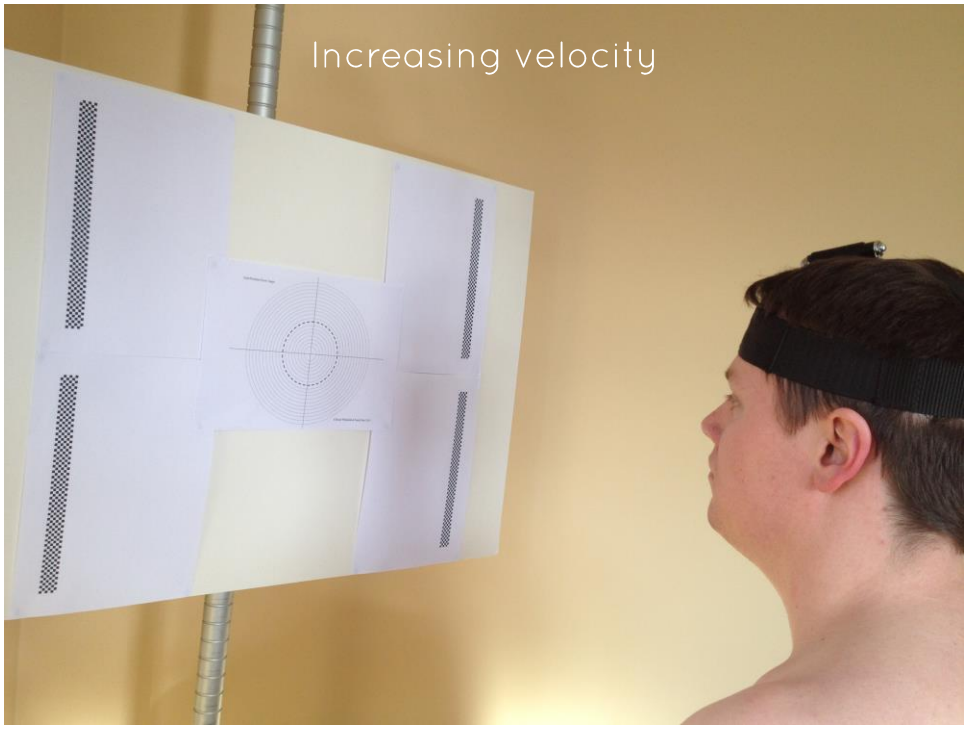


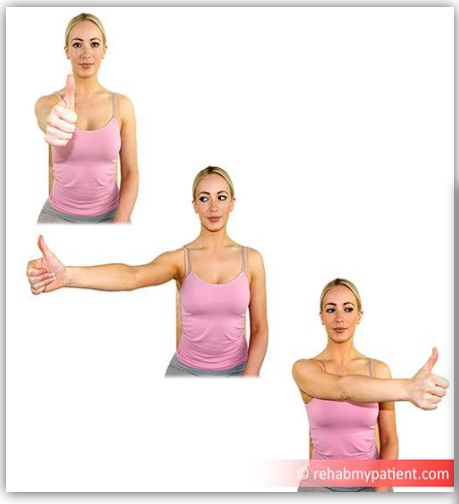
Sensorimotor control rehabilitation

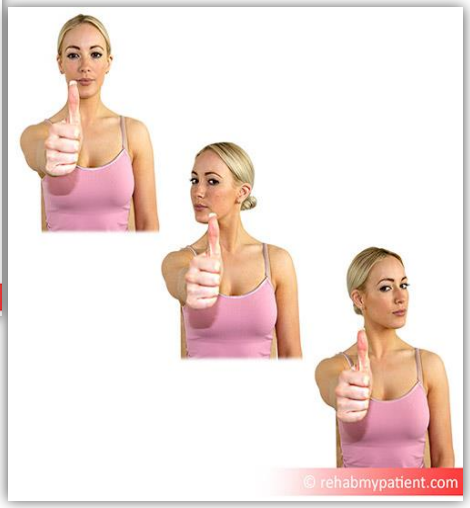


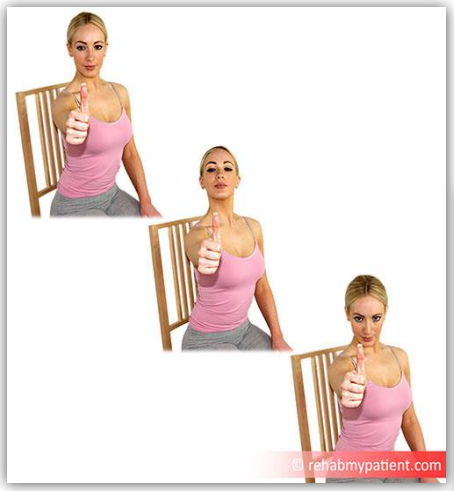
Sensorimotor control: points in range




Increasing velocity


© rehabmypatient.com


© rehabmypatient.com



Sensorimotor control rehabilitation

"Work on what turns on the dizziness"

- Progression
  - **Target:** dot – word – business card
  - **Position:** sit – stand – tandem stand – walking - stepping
  - **Speed:** slow – medium – fast
  - **Range:** small – medium - large
  - **Neck Torsion:** neutral – 30– 45 degs
  - **Vision:** Unrestricted – Restricted Peripheral
  - **Duration:** once / twice day

Late sensorimotor rehabilitation

McCaskey et al. BMC Musculoskeletal Disorders 2014, 15:382
http://www.biomedcentral.com/1471-2474/15/382

BMC Musculoskeletal Disorders

RESEARCH ARTICLE Open Access

Effects of proprioceptive exercises on pain and function in chronic neck- and low back pain rehabilitation: a systematic literature review

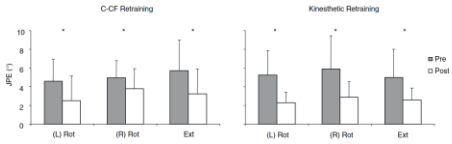
Michael A McCaskey[1,2*], Corina Schuster-Amft[1,5], Brigitte Wirth[2], Zorica Suica[1] and Eling D de Bruin[2,3,4]

The collected data from 18 studies after an extensive search in all relevant databases suggest that no conclusive evidence exists to support the implementation of PrT interventions in back- or neck-pain rehabilitation. On the other hand, most interventions with PrT elements did report some reduction in pain and improvement of functional status,

Proprioceptive & oculomotor control training reduces neck pain and disability


V

- Chronic neck pain n=64 female
- NDI 40%
- Group 1 : Joint position / oculomotor exs 6/52
- Group 2 : Craniocervical flexion (CCF) 6/52
- Both reduced pain
  - Proprioception -16.8%NDI
  - CCF -13.8 %NDI
- Both improved proprioception



(Jull et al 2007)

Balance training improves neck pain

Journal of Motor Behavior, Vol. 45, No. 3, 2013

RESEARCH ARTICLE

The Effect of Balance Training on Cervical Sensorimotor Function and Neck Pain

Konstantin Beinert[1,2], Wolfgang Taube[1]
[1]University of Fribourg, Department of Medicine, Movement and Sports Science, Switzerland. [2]Institute for Applied Science of the Human Movement System, Neustadt a.d. Weinstraße, Germany.



- N=34, subclinical neck pain v control group
- Trained 5/52, 3 x week
- Outcome measures: pain (NPRS) and proprioception (JPE)
- Neck pain decreased pre 3.65 to post 1.97
- Proprioception improved

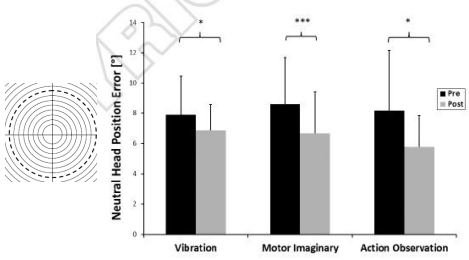
Beinert & Taube 2013

Mental rehearsal improves proprioception

EUR J PHYS REHABIL MED 2015;51:825-32

Cervical joint position sense in neck pain. Immediate effects of muscle vibration *versus* mental training interventions: a RCT

K. BEINERT [1, 2], S. PREISS [2], M. HUBER [2], W. TAUBE [1]



Neck pain: muscle performance summary

Delayed activation to postural perturbation
Reduced velocity of motion

Speed

Reduced activity in deep neck flexors & extensors

Stability

Neck muscle weakness
Impaired microcirculation
Fibre-type transformation

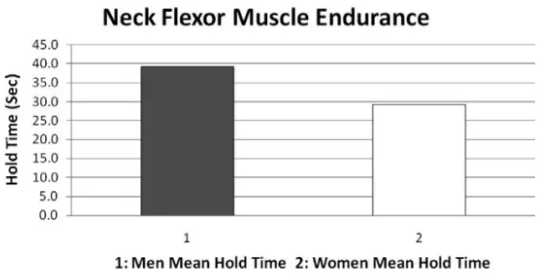
Strength

Increased activity in superficial flexors and extensors
Increased rigidity & stiffening in balance tasks

Relaxation

Stability I: flexor endurance test 'Straight leg raise' of the neck

- Lift head 2cm (measured from back of the head to the plinth)
- Time until the chin begins to 'thrust' is measured in seconds
- Chin 'thrust' is determined in two ways: by light finger pressure over the point of the subject's chin, and by observation.



Inter & intra-rater reliability good > 0.80

Domenech et al. 2011
Olson et al 2006

Stability I: endurance tests to exhaustion

Dorsal normals
2Kg women = 8.5 minutes
4kg men = 7 minutes

Ventral normals
Women = 30 seconds
Men = 2.5 minutes

Inter & intra-rater reliability good > 0.80

Peolsson et al 2007

Stability II: deep neck flexors

- Deep Neck Flexors (DNF)
- Pressure biofeedback 5-stage craniocervical flexion
  - Starting pressure 20mmHg
  - Target 22 – 24 – 26 – 28 - 30mmHg
  - Hold each stage for 10 seconds

Stability III: deep neck extensors

Stability IV: side flexors

Neck muscle performance I

Head lifts

Consider speed / Diaphragmatic breathing / 3 sets to fatigue

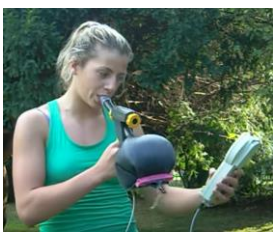
Neck muscle performance II
Head lifts + resistance




Consider speed / Diaphragmatic breathing / 3 sets to fatigue

Respiratory muscle endurance training (RMET) reduces persistent neck pain

- N=15, NDI 22% Pain 4.6 on VAS
- Trained with SpiroTiger 30 mins x 5 days / week for 4 weeks
- Respiratory measures, flexor endurance & chest expansion increased
- Significantly improved pain (-2.4), disability (-6% NDI) & fear avoidance
- Effects due to decreased hyperventilation & hypercapnia

Wirth et al 2016

Original Article

CLINICAL REHABILITATION

Clinical Rehabilitation
1–11
© The Author(s) 2016
Reprints and permissions:
sagepub.co.uk/journalsPermissions.nav
DOI: 10.1177/0269215516651979
cre.sagepub.com
SAGE

Group-based multimodal exercises integrated with cognitive-behavioural therapy improve disability, pain and quality of life of subjects with chronic neck pain: A randomized controlled trial with one-year follow-up

Marco Monticone[1,2], Emilia Ambrosini[2,3], Barbara Rocca[2], Daniele Cazzaniga[2], Valentina Liquori[2], Alessandra Pedrocchi[3] and Howard Vernon[4]

N=170
One 60 mins multimodal exercise – strengthening / speed / function
60 mins group CBT / week for ten weeks
V
General exercise group
One 60 mins session / week

"Highly significant improvement in pain, disability, fear of movement and catastrophisation"

Falla et al 2006: pain & disability improves with both 'strengthening' & 'stability'

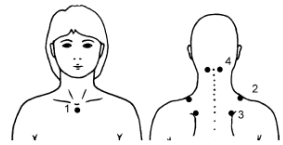
V

- Chronic neck pain n=58 female
- NDI 20%
- Endurance head lift vs CCF 6/52
- Both decreased pain
  - Endurance -2.8 NDI
  - CCF -3.5 NDI
- Endurance reduced fatigue

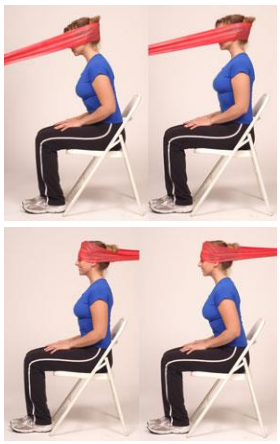
(Falla et al 2006)

Ylinen et al 2005: pain & disability improves 70% long term with strengthening

- 12 month muscle strengthening vs. endurance vs. controls (n=180, female) (Ylinen et al 2005)
- Decreased pain VAS by 60-70% both active groups & 28% control group
- Significant increase in PPT both active groups ($p<0.001$, n=180)



Ylinen et al (2005) Protocol: 3x week: 3 sets 20 reps. Upper limb: shrugs, presses, curls, bent over-rows, flies. Lower limb: squats, sit-ups and back extension. Neck & shoulder stretches 20mins. Aerobic exercise 30 mins. Exercise diary.



Central London Community Healthcare NHS
NHS Trust
Your healthcare closer to home

The Neck Gym Clinician Guide

9 - station exercise protocol

Exercise 5b - head lift + weight

Neck flexor strengthening weight 1

Place an ankle cuff weight around your head. Lie on your back, and lift your head off the floor/bed while tucking your chin in slightly. You should feel the muscles at the front and side of your neck contracting. Use a pillow if that feels more comfortable.

WEEK 3-4: 0.5 Kg weight
WEEK 5 onwards: 1 Kg weight

Sets: 3 | Repetitions: 12

Do we need to address both stability & strength?

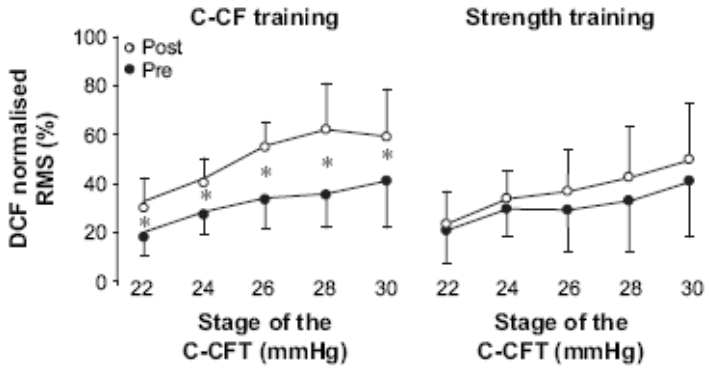


Fig. 1. Normalised RMS values (mean and standard deviation) for the DCF muscles for each stage of the CCFT. Data are presented for the C-CF retraining group and strength-training group both pre and post intervention. *indicates significant difference between pre and post intervention data ($P < 0.05$).

(Jull et al 2009)

Strength training attenuates superficial muscle over activity

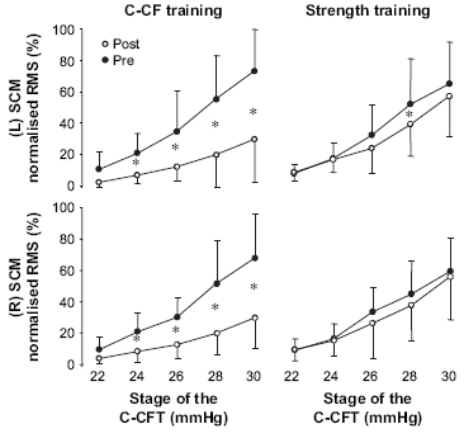


Fig. 2. Normalised RMS values (mean and standard deviation) for the left and right SCM muscles for each stage of the CCFT. Data are presented for the C-CF training group and strength-training group both pre and post intervention. *indicates significant difference between pre and post intervention data ($P < 0.05$).

(Jull et al 2009)

MORPHOLOGICAL CHANGES IN THE CERVICAL MUSCLES OF WOMEN WITH CHRONIC WHIPLASH CAN BE MODIFIED WITH EXERCISE—A PILOT STUDY

SHAUN O'LEARY, PT, PhD,[1,2] GWENDOLEN JULL, PT, PhD,[1] LUKE VAN WYK, PT,[1] ASHLEY PEDLER, PT, PhD,[3] and JAMES ELLIOTT, PT, PhD[4,5] *Muscle Nerve* 52: 772–779, 2015

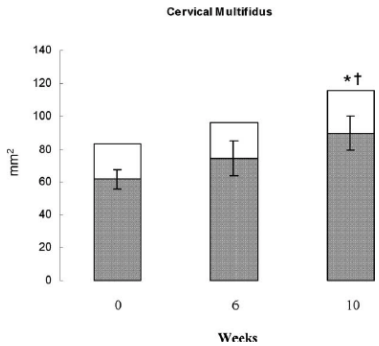


FIGURE 1. Group mean total cross-sectional area (CSA) (entire column) and relative muscle CSA (rmCSA) (shaded portion of column) of the cervical multifidus muscle at 0, 6, and 10 weeks of exercise (in mm^2). The 95% confidence interval error bars are shown for the rmCSA. *Significant difference in CSA vs. baseline. †Significant difference in rmCSA vs. baseline.

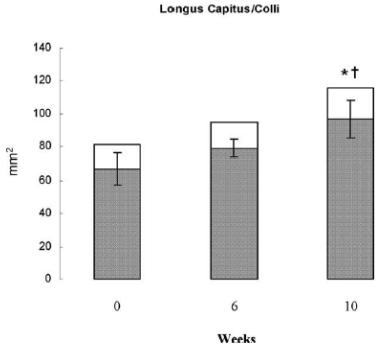


FIGURE 2. Group mean total cross-sectional area (CSA) (entire column) and relative muscle CSA (rmCSA) (shaded portion of column) of the longus capitus/colli muscle at 0, 6, and 10 weeks of exercise (in mm^2). The 95% confidence interval error bars are shown for the rmCSA. *Significant difference in CSA vs. baseline. †Significant difference in rmCSA vs. baseline.

Functional rehabilitation of the neck

'Mirror': head & gaze stability + body rotation

'Pointing up': cervical extension + rotation

'Joy': cervical extension

'Reaching': cervical extension

'Reverse the car': cervical rotation

'Cross the road': walk + step + cervical rotation

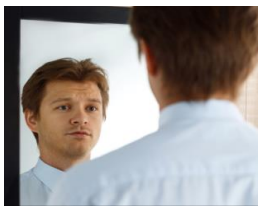
Functional rehabilitation of the neck: rotation

MIRROR:
Looking in mirror
Keep head and eyes still
Turn body left and right

WALK PAST:
Fix eyes on point on wall to left or right
Walk past the point
Turn around & repeat

CROSS THE ROAD:
Look right and left whilst walking forwards

WHAT'S UNDER THERE?
All fours kneeling
Look under chair / settee
Touch cheek against floor



Functional rehabilitation of the neck: extension

LOOK UP & POINT:
At object in room

GOAL!
Look up and elevate both shoulders – smile and cheer!

REACHING AS FAR AS ABLE:
Reach forward to floor
Reach forward at shoulder height
Reach up above head

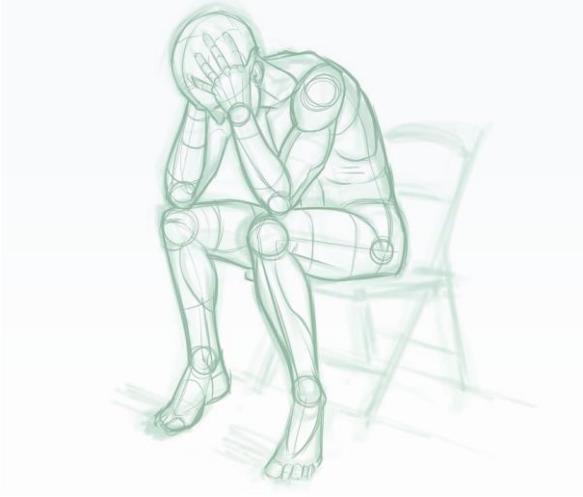
Functional rehabilitation of the neck: flexion

LOOK DOWN:
At feet
Tie shoelace – on step / floor

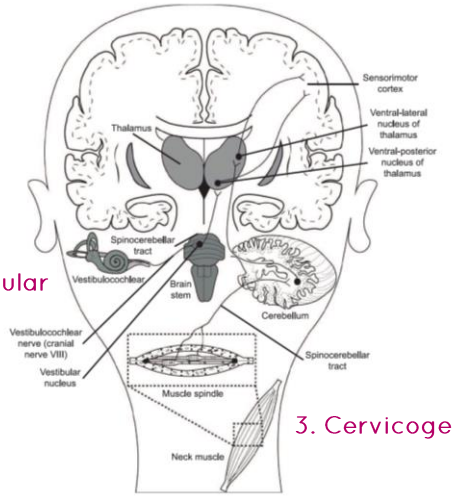
LOOKING DOWN:
At object (e.g. coin) on floor, walk over and past
Repeat passing slightly left & right

DOWN STEPS
Watch feet moving

Concussion management



Concussion management

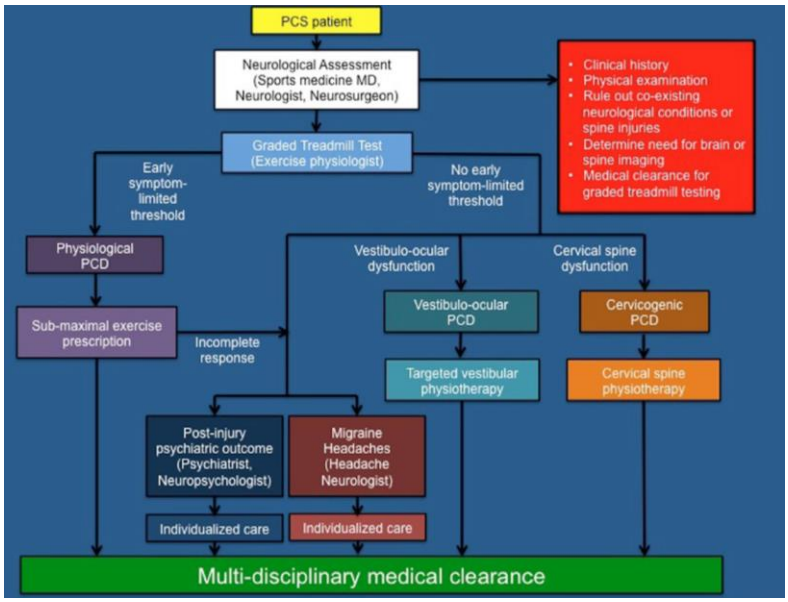


1. Physiological

2. Vestibulo-ocular

3. Cervicogenic

Cheever et al Journal of Athletic Training 2016;51(12):1037–1044



Ellis MJ, Leddy J and Willer B (2016) Multi-Disciplinary Management of Athletes with Post-Concussion Syndrome: An Evolving Pathophysiological Approach. Front. Neurol. 7:136.

TABLE 1 | Summary of proposed pathophysiology, predominant symptoms, physical examination findings, graded treadmill testing results, treatment recommendations, important considerations and multi-disciplinary consultations for post-concussion disorders.

	Physiological PCD	Vestibulo-ocular PCD	Cervicogenic PCD
Proposed pathophysiology	• Persistent alterations in neuronal depolarization, cellular metabolism, and cerebrovascular physiology	• Isolated dysfunction of central and peripheral components of the vestibulo-ocular neurological sub-system	• Isolated mechanoceptive, nociceptive, and proprioceptive dysfunction within the cervical spine neurological sub-system
Predominant symptoms	• Mild to moderate, global, pounding headache at rest • Dizziness, nausea, fatigue, drowsiness, light and sound sensitivity, irritability • Symptoms elicited or exacerbated by reproducible levels of physical (and sometimes) cognitive activity	• Mild to moderate headache and eye strain that is typically absent at rest but elicited or exacerbated by prolonged periods of reading, focusing, or time in complex visuospatial environments • Intermittent blurred vision, diplopia, dizziness, fogginess, motion sensitivity, difficulty focusing or concentrating • Intermittent vertigo during certain head positions	• Mild to moderate, dull, occipital headache that is elicited or exacerbated by activities that require prolonged neck stabilization or movement • Neck pain, stiffness, decreased range of motion, dizziness, fogginess, and postural imbalance
Physical examination findings	• Normal physical examination • Elevated resting heart rate • Orthostatic changes in pulse and/or blood pressure accompanied by symptoms	• Impaired convergence, accommodation, smooth pursuits, saccades, and vestibulo-ocular reflex • Impaired balance and postural stability testing • Positive Dix-Hallpike Maneuver (BPPV)	• Decreased cervical lordosis and range of motion • Sub-occipital and paraspinal neck tenderness • Impaired cervical spine proprioception • Positive cervical dizziness testing
Graded treadmill testing results	• Early symptom-limited threshold	• Patients typically do not experience an early symptom-limited threshold	• Patients typically do not experience an early symptom-limited threshold
Treatment	• Sub-maximal aerobic exercise prescription • Targeted treatment of co-existing vestibulo-ocular dysfunction or cervical spine soft tissue injury	• Targeted vestibular and vision therapy • Otolith repositioning (BPPV) • Sub-maximal aerobic exercise program to maintain aerobic fitness	• Cervical spine manual therapy and proprioception re-training • Gaze and postural stabilization exercises • Sub-maximal aerobic exercise program to maintain aerobic fitness
Important considerations	• Patients who do not achieve complete recovery with sub-maximal exercise prescription should be screened for migraine headaches and post-injury psychiatric outcomes	• Must rule out co-existing neurological and neuro-ophthalmological conditions prior to graded aerobic treadmill testing and physiotherapy	• Must rule out cervical spine structural injury or mechanical instability prior to graded aerobic treadmill testing and physiotherapy
Consulting multi-disciplinary specialists	• Exercise physiologist or kinesiologist	• Vestibular physiotherapist • Neuro-ophthalmologist	• Cervical spine physiotherapist

PCD, post-concussion disorder; BPPV, benign paroxysmal positional vertigo [modified with permission from original source Ellis et al. (5), Taylor & Francis].

Ellis MJ, Leddy J and Willer B (2016) Multi-Disciplinary Management of Athletes with Post-Concussion Syndrome: An Evolving Pathophysiological Approach. Front. Neurol. 7:136.

Dizziness associated with poor prognosis in sport related concussion

Vestibular and oculomotor impairment and symptoms may be associated with worse outcomes

- Acute (< 1 week) concussion
- Subacute (1 week – 3 months) concussion
- 30% experience persistent symptoms following concussion

Dizziness at the time of injury = 6-fold increase in recovery time

Schneider KJ, et al. Br J Sports Med 2014;48:1294–1298
Kontos et al 2017 Journal of Athletic Training 2017;52(3):256–261

Review

Can vestibular rehabilitation exercises help patients with concussion? A systematic review of efficacy, prescription and progression patterns

Murray DA, et al. Br J Sports Med 2017;51:442–451

What are the findings?

- Postconcussion vestibular symptoms can cause significant morbidity and lead to extended time away from work, school and/or sport.
- Vestibular rehabilitation guidelines postconcussion are, to date, consensus based and drawn from comparator vestibular dysfunction studies.
- This review now suggests that vestibular rehabilitation therapy (VRT) is beneficial in mild traumatic brain injury (mTBI)/concussion with evidence supporting earlier return to sport.

Cervicovestibular rehabilitation in sport-related concussion: a randomised controlled trial

What are the new findings?

- Individuals with persistent symptoms of dizziness, neck pain and/or headaches following a sport-related concussion were more likely to be medically cleared to return to sport within 8 weeks of initiation of treatment when they were treated with multimodal physiotherapy.
- A combination of vestibular rehabilitation and cervical spine physiotherapy may facilitate recovery in individuals with persistent dizziness, neck pain and/or headaches following a sport-related concussion.

How might it impact on clinical practice in the near future?

- Cervical spine physiotherapy and vestibular rehabilitation may be considered as treatment options for individuals with persistent symptoms of dizziness, neck pain and/or headaches following sport-related concussion.
- Future research to evaluate the optimal timing of treatment and the effects of covariates such as age, history of concussion and dosage is warranted.

Schneider KJ, et al. Br J Sports Med 2014;48:1294–1298