

Sensorimotor impairment in neck pain

Worthing, 3rd May 2017

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Musculoskeletal Physiotherapist
Specialising in Neck Pain

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Have we disengaged rehabilitation from day to day function?

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Ankle sprain rehab
-V-
Neck pain rehab

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Experimental & Clinical Features of Neck Pain

“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

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Sensorimotor impairment in neck pain

Introduction

- The neck subserves the specialised sense organs

Sensorimotor impairment

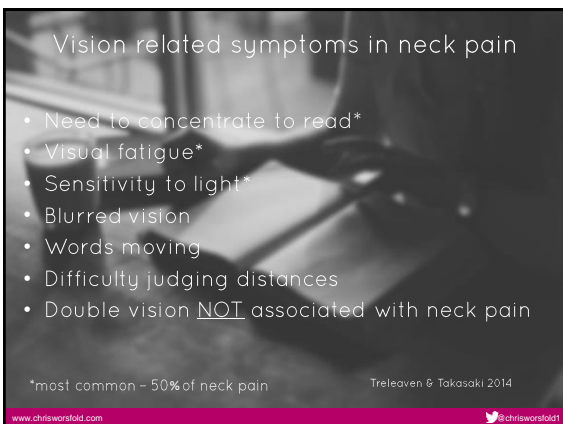
- proprioception
- oculomotor control
- postural stability

Muscle performance

- mental imagery
- base of support
- histology & morphology
- muscle performance
 - strength
 - stability
 - coordination
 - speed
 - rigidity / stiffness







Causes of sensorimotor impairment

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

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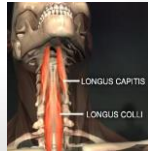
Sensorimotor disturbance



Vestibulo-Ocular Reflex



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



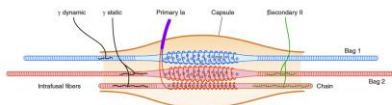
Cervico-Ocular Reflex

Gosselin et al (2004)
Schieppati et al (2013)
Villierme et al (2005)
Stapley et al (2006)

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Sensorimotor disturbance: muscle spindles

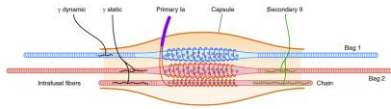


- High density of muscle spindles in small intrinsic deep dorsal and suboccipital muscles (Peck 1964, Richmond & Bakker 1962)
- Localised in slow twitch fibres - role in postural control
 - LA injected into cervical tissues = ataxia (deJong et al 1977)
 - Neck vibration = postural control (Fujikko et al 1999)
 - Neck fatigue = postural control (Gosselin et al 2004)

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What is the mechanism affecting cervical afferent activity ?

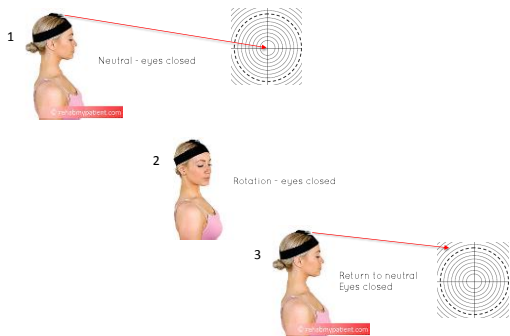


- No evidence of muscle damage in whiplash
 "Prolonged symptoms following whiplash injury cannot be explained by biochemically measurable muscle damage." (Scott and Sanderson 2002)
 - Fatty infiltration (Elliott et al 2006)
- Cervical muscular fatigue - 'overactivity' (Stapley et al 2006)
- Disturbed 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

Joint Position Error = 5.5cm

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)

Head laser
Head Fastrak sensor
Chest laser
Chest Fastrak sensor

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876 • Physical Therapy Volume 94 Number 6 June 2016

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

Tatjana R. Stanton, Magdy B. Lulic, S. Jane Chalmers, C. Lorren Moseley

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 prognosis.

Research supported by the Australian Government Department of Health and Ageing.

Manual Therapy
Journal homepage: www.elsevier.com/locate/jmpt

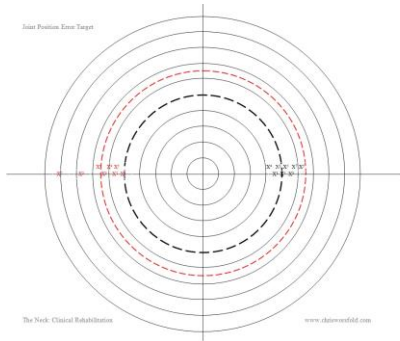
Systematic review
Joint position sense error in people with neck pain: A systematic review

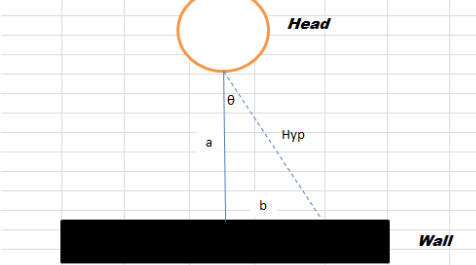
J. de Vries^{a,b,c}, B.K. Ickebach^{a,b,c}, L.P. Voigt^{a,b,c}, J.N. van der Grintz^{a,b}, M. Jansen^{a,b}, M.A. Frens^{a,b,c}, C.J. Kluiters^{a,b,c}

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^bDepartment of Physical Therapy, University of Applied Sciences, Beethovenvaart 100, 3817 BT Almere, The Netherlands
^cCenter for Health and Performance Research, 3000 CA Groningen, The Netherlands

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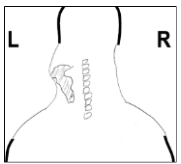
Assessing Joint Position Error - target





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

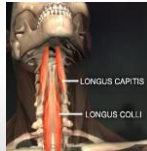
- Good reliability with laser and target with mean of six trials.
- Appears to discriminate between normals and whiplash subjects.
- Normal approx. 5cm Abnormal > 6.5cm
- May not be a specific test of cervical afferent function.

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Sensorimotor disturbance:

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



Cervico-Ocular Reflex

Gosselin et al. (2004)
Schieppati et al. (2013)
Vallbo et al. (2005)
Stapley et al. (2016)

Vestibulo-Ocular Reflex

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SPNT - neutral

SPNT: Smooth Pursuit Neck Torsion Test (Tjell & Rosenhall 1998)

SPNT - left torsion

SPNT - right torsion



SPNT can discriminate significantly between neck pain cases and controls. SPNT can be recommended for clinical use (Jørgensen et al 2014, Della Casa et al 2014)

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 Geest², Malou Janssen², Jan Paul Van Wingerden¹, Gert Jan Kleinersink² and Maarten A Frens^{2,4}

N=14 studies

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

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Sensorimotor control: postural stability

Increased AP sway in whiplash subjects > idiopathic neck pain > normal (Field et al 2009)

50% non-dizzy whiplash subjects unable tandem stand eyes closed (Field et al 2009)


74% dizzy whiplash subjects unable tandem stand eyes closed (Treleaven et al 2006)



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Sensorimotor control: dynamic postural stability

- Gait disturbances in neck pain: decreased step width, step length & speed (Uthakrup 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)



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"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 2006)

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Physiotherapy Theory and Practice, 2013 | 1-18, 2013
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 DOI: 10.3109/09293885.2012.677111

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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, MSc²

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

N=12 studies

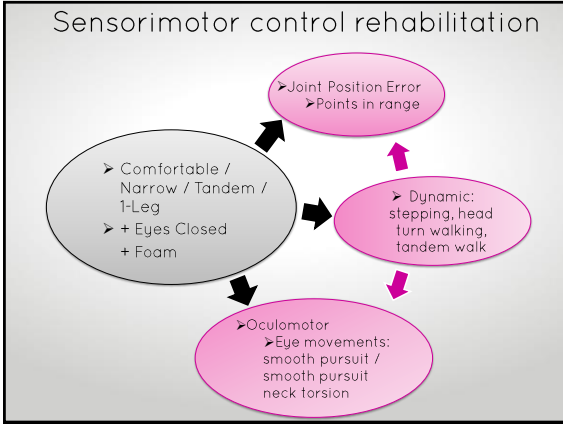
"Both patients with idiopathic neck pain & patients with whiplash have poorer balance than healthy controls."

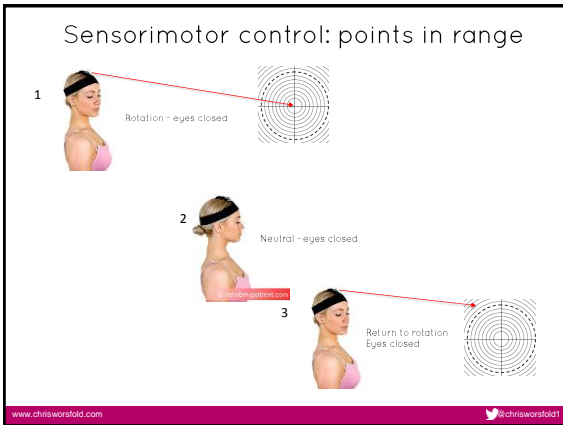
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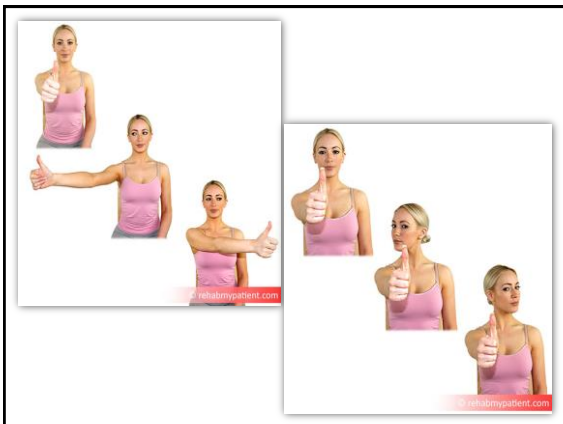
Sensorimotor control assessment

- 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

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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

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Have we disengaged rehabilitation from day to day function?

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Functional rehabilitation of the neck

"Mirror": head & gaze stability + body rotation

"Pointing up": cervical extension + rotation

"Jig": cervical extension

"Reaching": cervical extension

"Reverse the car": cervical rotation

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

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McCaskey et al. BMC Musculoskeletal Disorders 2014, 14:382
http://www.biomedcentral.com/1471-2474/14/382

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-Arnitt^{1,3}, Brigitte Wirth², Zorica Sulca¹ 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,

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Proprioceptive & oculomotor control training reduces neck pain and disability

- Chronic neck pain n=64 female
- NDI 40%
- Group 1: Joint position / oculomotor exs 6/52
- Group 2: Cranio-cervical flexion (CCF) 6/52
- Both reduced pain
 - Proprioception -16.6% NDI
 - CCF -13.5% NDI
- Both improved proprioception

(Jull et al 2007)

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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 MChSP MMAACP
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."

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Experimental & Clinical Features of Neck Pain

Sensorimotor impairment in neck pain

Introduction

- the neck subserves the specialised sense organs

Sensorimotor impairment

- proprioception
- acutomotor control
- postural stability

Muscle performance

- mental imagery
- the speed of fear
- histology & morphology
- muscle performance
 - strength
 - stability
 - co-ordination
 - speed
 - rigidity / stiffness

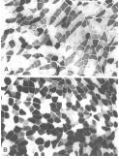
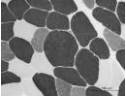
Neck pain: muscle performance

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

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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) (Uhlrig 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)

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Neck pain: histology & morphology



Muscle fatty infiltrate in whiplash

(Elliott et al 2006, 2009, 2010)

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Neck pain: strength & endurance

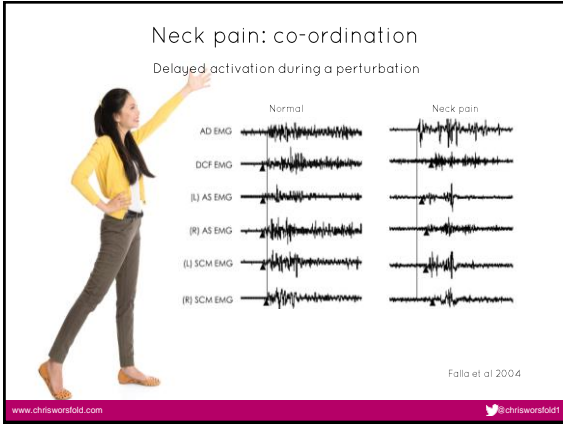
Isometric Cervical Strength Normals

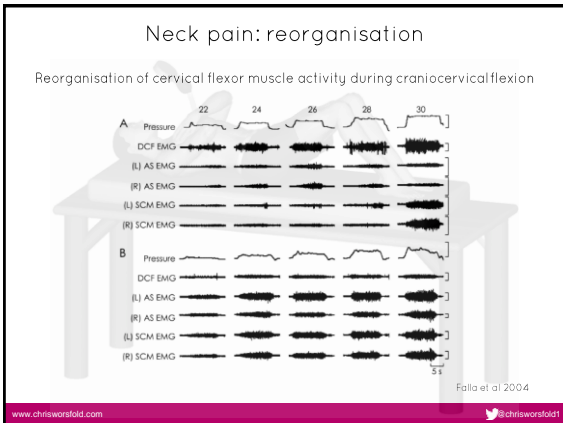
Cervical Muscle Group	Chiu et al (2002)	Ylinen et al (2004)	Vernon (1999)	Jordan et al (1999)
Flexors	74.5N	75.7N	46N	59N
Extensors	93.3N	187.1N	79N	78N

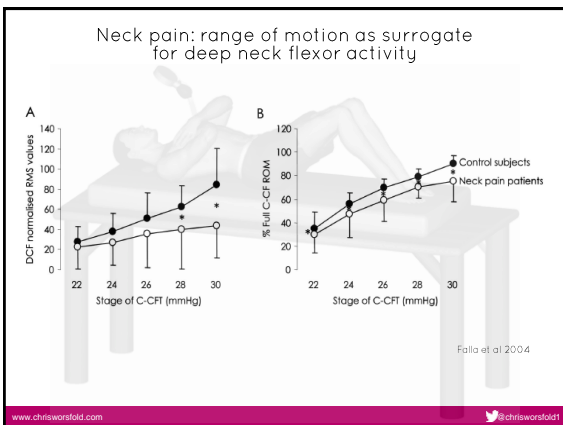
Isometric Cervical Strength Neck Pain

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)

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Neck pain: muscle performance summary

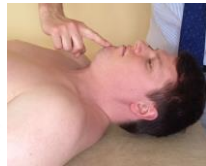
- Delayed activation to postural perturbation
- Reduced relaxation of motion
- Reduced activity in deep neck flexors & extensors
- Neck muscle weakness
- Impaired muscle activation
- Fibre-type transformation
- Increased activity in superficial flexors and extensors
- Increased rigidity & stiffening in balance tasks



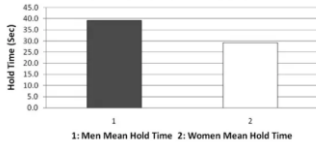
speed
Stability
strength
Relaxation

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.



Neck Flexor Muscle Endurance



Domenech et al. 2011

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



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Stability IV: side flexors



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Neck muscle performance I
Head lifts



Consider speed / Diaphragmatic breathing / 3 sets to fatigue

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Neck muscle performance II

Head lifts + resistance

Consider speed / Diaphragmatic breathing / 3 sets to fatigue

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Neck pain: muscle performance summary

Delayed activation of postural perturbation
Reduced velocity of motion

Reduced activity in cervical neck flexors & extensors

Neck muscle weakness
Impaired motor coordination
Fibre-type transformation

Increased activity in suprahyoid flexors and extensors
Increased muscle co-stiffening in balance tasks

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Original Article

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^{3,4}, Barbara Rocca¹, Daniele Cazzaniga¹, Valentina Liquori¹, Alessandra Pedrocchi³ and Howard Vernon⁴

N=170

One 60 mins multimodal exercise – strengthening / speed / function
60 mins group CBT / week for ten weeks

↓

General exercise group
One 60 mins session / week

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

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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)



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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.



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Central London Community Healthcare 
1400 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 heel. Lie on your back, and lift your head off the floor/mat while locking your chin in tightly. 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

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Do we need to address both stability & strength?

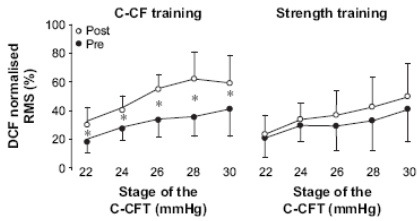


Fig. 1. Normalised RMS values (mean and standard deviation) for the DCF muscles for each stage of the CCF. Data are presented for the C-CF retraining group and strength-training group both pre and post intervention. *indicates significant difference between pre and post intervention data ($P < 0.05$).

(Jull et al 2009)

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Strength training attenuates superficial muscle over activity

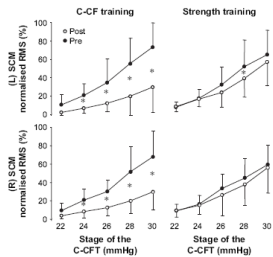


Fig. 2. Normalised RMS values (mean and standard deviation) for the left and right SCM muscles for each stage of the CCF. Data are presented for the C-CF training group and strength-training group both pre and post intervention. *indicates significant difference between pre- and post-intervention data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

(Jull et al 2009)

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THINK:

Function, function, function

It's all in the mind:

- use mental rehearsal for all exercises
- educate to decrease fear

The eyes have it - use eyes in all exercises

Consider speed in all exercises

Assess & address postural & spinal stability

Assess & address weakness

THANKS:

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