Sensorimotor Impairment in Whiplash Injury & Neck Pain

Chris Worsfold MSc PGDipManPhys MMACP
Musculoskeletal Physiotherapist
Specialising in Neck Pain

c.worsfold@tonbridgeclinic.co.uk
@chrisworsfold1
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
Experimental & Clinical Features of Neck Pain

FEAR

Contralateral Cervical Lateral Glide Technique
Vicenzino et al 1998, 1999
Coppieters et al 2003

CBT / Education for Stress / Fear / Catastrophisation
Sullivan et al 2005

Reduce peripheral nociception
Smith et al 2014

Oculomotor control

The Three Pillars of Sensorimotor Control of the Neck

Proprioception
Oculomotor control
Postural stability
Sensorimotor impairment: overview

- Symptoms of sensorimotor impairment
- Objective examination:
  - Proprioception / Joint Position Error
  - Oculomotor control
  - Postural Stability
  - Evidence base

Symptoms of sensorimotor impairment:

- Not a true vertigo ‘illusion of movement’ – room spinning
- Dizziness / giddiness
- Light headedness / feeling off balance
- Unsteadiness
- Walking on cotton wool
- 33% neck pain vs 74% neck trauma (Humphreys et al 2002, Treleaven et al 2003)

Sensorimotor disturbance:

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

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.
- Important role in postural control:
  - LA injected into cervical tissues = ataxia (deJong et al 1977)
  - Neck muscle vibration = postural control (Pyykkö et al 1989)
  - Neck muscle fatigue = postural control (Gosselin et al 2004)

Sensorimotor control: laser & target

Joint position error: the laser & target method.
Validity of 'laser & target' method:
- Good 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)

Assessing Joint Position Error - research

<table>
<thead>
<tr>
<th>Healthy Controls</th>
<th>Whiplash</th>
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<tbody>
<tr>
<td>Heikkila (1996)</td>
<td>2.73cm ± 1.89cm</td>
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<tr>
<td>Heikkila (1998)</td>
<td>2.79cm ± 1.89cm</td>
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</tbody>
</table>

N= 27, mean of ten trials.

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 (Stapley et al 2014)

Disruption body image 65% 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. 3cm / Abnormal > 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.

Oculomotor control in whiplash:

- 62% impaired (Heikilla 1998)
- Low level evidence – impaired oculomotor control associated with poor prognosis (Hildingsson et al 1993).
- Disturbed afferent input vs brain stem involvement.
SPNT: Smooth Pursuit Neck Torsion Test (Tjell & Rosenhall 1998)

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

Sensorimotor control: Smooth Pursuit Neck Torsion Test

- Left Neck Torsion
- Positive test: saccades, dizziness.

Sensorimotor control: postural stability

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

- Neck torsion = greater postural deficits in standing in WL (Yu et al 2011).

"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)

Sensorimotor control rehabilitation

- Comfortable / Narrow / Tandem / 1-Leg
- + Eyes Closed
- + Foam
- Dynamic: stepping, head turn walking, tandem walk
- Oculomotor
- Eye movements: smooth pursuit / smooth pursuit neck torsion
- Joint Position Error
- Points in range
Sensorimotor treatment: laser & target

Image courtesy of Research in Sports Medicine from Pinsault & Vuillerme 2009
Sensorimotor control rehabilitation

“Work on what turns on the dizziness”

- Progression
  - Target: dot – word – business card
  - Position: sit – stand – tandem stand - walking
  - Speed: slow – medium – fast
  - Range: small – medium - large
  - Neck Torsion: neutral – 30 degs – 45 degs
  - Vision: Unrestricted – Restricted Peripheral
  - Duration: 30s 2 x day – 1-2 min 3 x day – 5 min 5 x day

Late sensorimotor rehabilitation

Contralateral Cervical Lateral Glide Technique
Vicenzino et al 1998, 1999
Coppieters et al 2003

CBT / Education for Stress / Fear / Catastrophisation
Sullivan et al 2005

Reduce peripheral nociception
Smith et al 2014

Deep Neck Flexor exercise
Smith & Rethlefsen 2013
Sensorimotor control: the evidence

• Oculomotor training alone reduces pain and improves ROM (n= 60, neck exs, Revel et al 1994)
  – 8 week oculomotor & laser training.
  – VAS change for training group 21.8mm decrease.
  – decreased medication usage.

Sensorimotor control: the evidence

• 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
  – Proprio -8.4 NDI
  – CCF -6.9 NDI
• Both improved proprioception

(Jull et al 2007)

Sensorimotor control: the evidence

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

N. Beinert, J. Taube

Abstract: Balance training is a non-invasive treatment that may improve cervical sensorimotor function and reduce neck pain. The purpose of this study was to investigate the effect of balance training on cervical sensorimotor function and pain in individuals with chronic neck pain. Thirty-eight participants were randomized into a balance training group (n=21) and a control group (n=17). The balance training group engaged in specific exercises targeting the cervical sensorimotor system, while the control group participated in a standard care protocol. Outcome measures included pain intensity, cervical sensorimotor function (kinesiophobia), and functional capacity. The results showed a significant improvement in cervical sensorimotor function and a decrease in pain intensity in the balance training group compared to the control group. These findings suggest that balance training could be a useful adjunctive therapy for individuals with chronic neck pain. Further research is needed to explore the long-term effects and mechanisms of balance training on cervical sensorimotor function and pain. (Beinert & Taube 2013)
Contralateral Cervical Lateral Glide Technique
Vicenzino et al 1998, 1999
Coppieters et al 2003
Muscle strengthening
Smith et al 2003
Reduce peripheral nociception
Smith et al 2014

? CBT / Education for Stress / Fear / Catastrophisation
Sullivan et al 2005

Proprioception / balance exercise
Jull et al 2007

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Acknowledgements: