Neck injury-Basketball player

Yu-Tsai Tu¹, Shih-Wei Chou²,³, Katie P. Wu³, Chao-Yi Huang³, Yin-Chou Lin³, Alice May-kuen Wang²,³

School of Medicine¹, Graduate Institute of Rehabilitation Science², Chang Gung University; Department of Physical Medicine and Rehabilitation, Chang Gung Memorial Hospital³, Taiwan

Shih-Wei Chou, Department of Physical Medicine and Rehabilitation, Chang Gung Memorial Hospital, Taiwan, 199 Tun-Hwa North Road, Taipei 105, Taiwan, Tel. 886-3-3281200 Ext.3846, Fax 886-3-3274850, e-mail F91033@cgmh.org.tw, smalldopen@yahoo.com.tw

Abstract
This case report describes the examination, intervention, and outcome of a 20-year-old male with post-traumatic cervicogenic headache (CEH) and neck-posture problems of 7-year duration. Assessment using clinical and radiological techniques, and special equipments and protocols revealed muscle and joint problems in the neck. Physical therapy to the neck his headache and neck-posture problems. The pathophysiology is discussed and highlights importance of assessing neck proprioception function in cases of whiplash associated disorder (WAD).

Key word: Sensory organization test, balance, neck injury, cervicogenic headache

Introduction
Trauma to neck causes damage to bone or soft tissue; this can affect the neck proprioceptors and/or the vestibular and visual systems (1). Posture control can thus get affected (2, 3). So apart from CEH, the patients may have non-rotatory vertigo and unsteadiness (4). Those with neck-pain may find it difficult to resume the original position of the head, after an active head movement (3). This may indicate an alteration in neck proprioception (1, 3). Routine clinical examination or imaging techniques may not detect damage to bone or soft tissue causing neck pain (2). We report a male who sustained 7-year of chronic headache after a whiplash injury and he received a specific exercise program emphasizing neck fitness for treatment of cervicogenic headache (5). Range of motion (ROM) and isometric strength of the neck, and the sensory organization test (SOT) were measured and compared before and after intervention. In our study, the SOT for balance performance seems to be applicable in evaluating neck function in those who suffer from cervicogenic headache or whiplash injuries. It can also be used to assess functional outcome before and after the intervention.

The Case
A 20-year-old male patient who is a varsity basketball player, came to our clinic with the chief complaint that he had difficulty in finding a basket by the coach. In 2001, his head was hit during a game without losing his consciousness. The right occipital region was directly blowed without fracture. After that accident, he experienced right temporal headache off and on, sometimes the symptoms advancing to the neck region. This right hemicranial pain/neck pain was not throbbing in nature. However, it soon became chronic-fluctuating in character, and worsened after basketball games and practice. Six weeks prior visiting our clinic, his headache was described as persistent with short-lasting and only about 60% pain remissions. The headache was not accompanied by any aura or prodrome. Occasionally, episodes of tinnitus and blurred vision occured. Unfortunately, he was dismissed from the team due to aggravated performance.

The result of posture observation showed that the patient assumed a head left-tilting posture while shot. He had muscle tightness and tenderness over the right splenius cervicis/capitis, upper trapezius, and sternocleidomastoid (SCM) muscles by manual palpation. Radiography of cervical spine lateral view revealed mild malalignment at C5-6 levels in neck flexion (Figure 1), which is also known as kinking (6).

Active ROM and isometric strength of the neck were measured. The MICROFET3 (Hoggan Health Industries, USA), a combination force evaluation and ROM testing system, was used. The ROM and isometric strength were each measured three times, respectively, for six different neck motions including flexion, extension, left lateral flexion, right lateral flexion, left rotation and right rotation. Active ROM restriction was showed in the left cervical rotation and the right cervical lateral flexion compared to their contra lateral side (table 1). Poor isometric strength was also noted in left cervical lateral flexion compared to their contra lateral side (table 2).

Balance performance was measured by the SOT on the NeuroCom Equitest System (NeuroCom International, USA), which provides six different combinations of sensory inputs for balance (table 3). The SOT has been described in detail elsewhere (7-11) and will be depicted briefly here. The equilibrium scores of conditions 5 and 6 were lower compared to the score of condition 1 (Fig 2).

In July 2006, he started a specific exercise program, including neck stretching, strengthening and propioceptive exercises, massage, and cervical traction, for six weeks (12-14).

Active ROM and isometric strength of his neck, and the SOT were re-evaluated six weeks later. The ROM (Table 1) and isometric strength (Table 2) of six neck motions were significantly improved. The composite score of the SOT was increased from 72 to 79. In sensory analysis, the visual and vestibular ratios were improved (Fig 2). After 6 weeks, his headache rating was reduced by 60%. He experienced improved
vision and his tinnitus became less frequent. He returned to the basketball team due to better shooting skill and accuracy (Fig 3).

Discussion

Sensory information from somatosensory, vestibular, and visual systems are
integrated to maintain posture control (15). A sensory mismatch between visual, vestibular, and somatosensory inputs may contribute to poor balance in whiplash patients (3, 16). Patients with WAD showed increased body sway, exhibited higher magnitudes of center of pressure movements than the normal, and reduced ability to overcome more challenging balance tasks (3, 13, 17). Evaluation of balance control in the SOT is quantified in a control condition (eyes open and fixed support) and in five other sensory conditions to analyze the impact of absent or misleading sensory inputs (7, 8, 10, 11). Unlike other tests, the SOT is considered as a functional test of balance but not a diagnostic tool (18, 19). The vestibular ratio derived from the SOT was improved in this patient after exercise intervention. Vestibular dysfunction in balance after his neck injuries seems to be correctable by our neck-specific exercise program and correlated to his clinical presentation.

Although some evidence suggests that traumatic damage to the vestibular receptors, neck proprioceptors or the central nervous system can lead to poor postural stability, abnormal cervical afferent input from functionally impaired neck joint and muscle receptors is considered the most likely cause in WAD (20-22). The input from neck joint and muscle receptors may be responsible for the cervical joint position error (JPE)(23). Treleaven (24, 25) described greater cervical JPE in patients with whiplash injury which may primarily reflect the cervical mechanoreceptor dysfunction. Abnormal cervical JPE in rotation is strongly correlated to the balance test with visual conflict and a soft surface support (condition 6) for those whiplash patients experiencing dizziness (25), suggesting that vestibular ratio (condition 5 normalized by condition 1) of the balance is affected by cervical afferent function. The vestibular ratio indicates the ability to use the vestibular system for posture control. Part of the variability may be attributed to the integrity of neck function. On the contrary, neck injuries may deteriorate this ability, resulting in vestibular dysfunction which is secondary to neck dysfunction. Although the SOT is not aimed to diagnose a vestibular lesion, it can be considered as a functional test of balance to evaluate vestibular dysfunction secondary to neck injuries (26-28).

The eye movement control is also influenced in patients with WAD. Tjell and Rosenhall found eye movement control is significantly affected in subjects with WAD more than subjects with brain stem or vestibular disorders when the trunk was rotated 45° with head kept stationary (21). This abnormal eye movement control may be resulted from erroneous postural proprioceptive activity in the neck, which is transmitted via the cervico-collic reflex (CCR) and the cervico-ocular reflex (COR)(21). The visual ratio (condition 4 normalized by condition 1) of the SOT may severe as another parameter to evaluate the neck function of patients with CEH. As the vestibular ratio, the visual ratio of the case presented also demonstrated improvement
with the neck-specific therapeutic intervention, not the visual therapeutic intervention. Neck therapeutic intervention improved the patient’s ability to use their visual system.

Generally, reduced neck mobility is already reported in patients with neck injuries (29). In this patient, all ROM of his neck was reduced, but noticeably improved the after the intervention. However, X-ray of the dynamic cervical lateral views were relative comparable before and after the intervention. In patients with WAD, the corresponding damage to bone or soft tissue is difficult to be diagnosed by imaging studies (30, 31). Image techniques seem to be a diagnostic reference in most situations but not used to evaluate the clinical presentations of patients with WAD. The cervical facet joints with prominent mechanoreceptors and nociceptors appeared to be neck pain generators in patients with whiplash injuries (32-34). The CCR and the COR are both relayed through those receptors and the COR is also related to the muscle tension (21, 32, 35). Both reflexes interact with the vestibulo-ocular reflex (36-38). Cervical facet joint dysfunction leads to erroneous neck proprioceptive activity, resulting in postural instability (35, 39). Our patient had been trained with a neck-specific exercise program. His neck flexibility and strength were both improved after the training program and the cervical proprioceptive input probably have been altered or normalized through the neck-specific training. As a result, the ability to use visual input was improved and accordingly balance improved.

**Conclusions:**

SOT is a quantitative posturography with designed sensory conditions. Although
the SOT may not be diagnostic in assessing visual and vestibular input during balance performance, it may reflect the integrity of neck function via the visual and/or vestibular ratios, hence, serving as a tool for functional assessment. We proposed that the role of neck function during balance performance may be assessed with the visual and vestibular ratios using the SOT. A neck region special exercise training may enhance balance performance in those patients with CEH. Future functional assessment via the SOT after tailored may provide us with more clinical evidence in designing an exercise.

Acknowledgement

David Dodick, M.D. gave editing comments in a previous version of this manuscript.


<table>
<thead>
<tr>
<th>ROM* (°)</th>
<th>Improvement** (%)</th>
<th>Asymmetry index***</th>
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<tbody>
<tr>
<td>(before / after)</td>
<td></td>
<td>(before / after)</td>
</tr>
<tr>
<td>Flexion</td>
<td>33.0 ± 1.0 / 39.3 ± 3.2</td>
<td>19.1</td>
</tr>
<tr>
<td>Extension</td>
<td>71.0 ± 3.0 / 80.3 ± 1.2</td>
<td>13.1</td>
</tr>
<tr>
<td>Lateral flexion to right</td>
<td>37.3 ± 3.5 / 46.3 ± 1.5</td>
<td>24.2</td>
</tr>
<tr>
<td>Lateral flexion to left</td>
<td>42.3 ± 2.3 / 44.7 ± 2.9</td>
<td>5.7</td>
</tr>
<tr>
<td>Rotation to right</td>
<td>83.7 ± 1.5 / 89.7 ± 4.2</td>
<td>7.2</td>
</tr>
<tr>
<td>Rotation to left</td>
<td>77.3 ± 2.1 / 81.7 ± 3.2</td>
<td>5.7</td>
</tr>
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*ROM = mean ± standard deviation.

**Improvement = (after - before) ÷ before × 100%.

***Asymmetry index = \(|\text{range difference between two sides}| ÷ \text{the range of the more flexible side}\)

The ROMs of six neck motions were all improved, especially in cervical flexion (19.1%), extension (13.1%), and right lateral flexion (24.2%).
<table>
<thead>
<tr>
<th></th>
<th>Isometric strength* (lb)</th>
<th>Improvement** (%)</th>
<th>Asymmetry index*** (before / after)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(before / after)</td>
<td></td>
<td></td>
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<tr>
<td>Flexion</td>
<td>20.0 ± 1.0 / 23.7 ± 4.7</td>
<td>18.5</td>
<td></td>
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<tr>
<td>Extension</td>
<td>16.0 ± 2.0 / 23.0 ± 2.0</td>
<td>35.0</td>
<td></td>
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<tr>
<td>Lateral flexion to right</td>
<td>14.3 ± 0.6 / 13.7 ± 1.2</td>
<td>-4.2</td>
<td>0.28 / 0.07</td>
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<tr>
<td>Lateral flexion to left</td>
<td>10.3 ± 1.2 / 12.7 ± 1.2</td>
<td>23.3</td>
<td></td>
</tr>
<tr>
<td>Rotation to right</td>
<td>11.0 ± 1.0 / 13.7 ± 2.3</td>
<td>24.5</td>
<td>0.00 / 0.21</td>
</tr>
<tr>
<td>Rotation to left</td>
<td>11.0 ± 1.7 / 17.3 ± 1.2</td>
<td>57.3</td>
<td></td>
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</table>

*Isometric strength = mean ± standard deviation.

**Improvement = (after-before) ÷ before × 100%.

***Asymmetry index = | strength difference between two sides | ÷ the strength of the stronger side

Isometric strength were pronouncedly improved, especially in cervical flexion (18.5%), extension (35.0%), left lateral flexion (23.3%), right rotation (24.5%) and left rotation (57.3%)
Table 3. Availability of sensory information by conditions

<table>
<thead>
<tr>
<th>Conditions / Sensory information</th>
<th>Accurate</th>
<th>Compromised</th>
<th>Deprived</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Open&lt;sup&gt;a&lt;/sup&gt;,fixed&lt;sup&gt;b&lt;/sup&gt;,fixed&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Vest, Vis, Som</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>2 Closed&lt;sup&gt;a&lt;/sup&gt;,fixed&lt;sup&gt;b&lt;/sup&gt;,fixed&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Vest, Som</td>
<td>None</td>
<td>Vis</td>
</tr>
<tr>
<td>3 Open&lt;sup&gt;a&lt;/sup&gt;,fixed&lt;sup&gt;b&lt;/sup&gt;,sway&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Vest, Som</td>
<td>Vis</td>
<td>None</td>
</tr>
<tr>
<td>4 Open&lt;sup&gt;a&lt;/sup&gt;,sway&lt;sup&gt;b&lt;/sup&gt;,fixed&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Vest, Vis</td>
<td>Som</td>
<td>None</td>
</tr>
<tr>
<td>5 Closed&lt;sup&gt;a&lt;/sup&gt;,sway&lt;sup&gt;b&lt;/sup&gt;,fixed&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Vest</td>
<td>Som</td>
<td>Vis</td>
</tr>
<tr>
<td>6 Open&lt;sup&gt;a&lt;/sup&gt;,sway&lt;sup&gt;b&lt;/sup&gt;,sway&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Vest</td>
<td>Vis, som</td>
<td>None</td>
</tr>
</tbody>
</table>

Vest: Vestibular; Vis: Visual; Som: Somatosensory; <sup>a</sup>: Eyes. <sup>b</sup>: Support Surface. <sup>c</sup>: Visual Surround.
Figure 1. Cervical X-ray before (upper) and after (lower) intervention showed kinking malalignment at C5-6 levels (noted by circles). This malalignment was hardly improved after intervention.
Figure 2. Sensory organization test before (upper) and after (lower) intervention

SOM (somatosensory ratio) = condition 2 / condition 1; VIS (visual ratio) = condition 4 / condition 1;
VEST (vestibular ratio) = condition 5 / condition 1; PREF (visual preference ratio) = condition 3 + 6 / condition 2 + 5

(a) The equilibrium scores for conditions 5 and 6 were extra-ordinary low. The visual and vestibular ratios were also relatively low, compared to the other two ratios.

(b) After intervention, the composite score was increased from 72 to 79. In sensory analysis, the visual ratio from 0.76 ± 0.20 to 0.95 ± 0.02 and vestibular ratio from 0.49 ± 0.21 to 0.68 ± 0.09 ratios, were obviously improved.
He returned to the basketball team due to better shooting skill and accuracy.