Can the neck contribute to persistent post-concussion symptoms? A prospective descriptive case series

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Abstract

Background

Persistent post-concussion symptoms can arise from a range of sources, including the neck. There is little description of neck assessment findings in people with persistent post-concussion symptoms.

Objectives

To assess people with persistent symptoms following a concussion to determine if the neck has also been injured, and evaluate the potential for the neck to contribute to their symptoms.

Methods

A consecutive series of participants (n=20) referred for neck assessment were prospectively recruited from two providers of a multidisciplinary concussion service for people with persistent symptoms. Data were collected at initial assessment and on completion of neck treatment, which included standard questionnaires (Rivermead post-concussion symptoms questionnaire, neck disability index, dizziness handicap inventory); patient-reported measures of headache, dizziness and neck pain; physical examination findings and details of co-morbidities.

Results

Participants were a mean of 7.5 weeks post-concussion (median 5 weeks). On neck assessment, 90% were considered by the clinician to have a neck problem contributing to their current symptoms.
Multiple findings were consistent with this view, including: moderate-severe neck disability index scores (mean 33.4, SD 9.5), frequent neck pain (85%), frequent moderate-severe pain on occiput-C4 segmental assessment (85%), positive flexion-rotation test (45%), and muscle tenderness (50-55%).

Conclusion

Multiple findings were indicative of concurrent neck injury, particularly involving the upper cervical spine. These neck-related findings are important to recognise as they have the potential to contribute to persistent post-concussion symptoms, and may respond to neck treatment.

Key words: brain concussion, cervical spine
Introduction

Concussion is a condition that can affect anyone, at any stage of life. The incidence of mild traumatic brain injury is estimated at 749 cases (709–790) per 100 000 person-years. Approximately half (47.9%) of people report substantial persistent symptoms one year following injury. The economic and social burden of concussion injury is increasingly recognised, with these New Zealand data reflecting international trends. For the purposes of this paper, concussion is considered synonymous with mild traumatic brain injury.

Clinicians must consider the neck as an alternative source of symptoms when evaluating people following a potential concussion. While concussion is defined as a brain injury, it is well recognised that persistent post-concussion symptoms can arise from other structures. Many hallmark post-concussion symptoms are not specific to concussion, and several of the most common symptoms including headache, dizziness, and neck pain are also characteristics of neck conditions. Persistent post-concussion symptoms “… do not necessarily reflect ongoing physiological injury to the brain.” (p. 842). This is reflected in several studies that draw parallels between whiplash associated disorder and concussion: similar cognitive deficits, biomechanical injury forces and injury occurrence. It is also consistent with descriptions of upper cervical dysfunction in people with post-concussion headache. Multimodal assessment – including a focused physical examination – must identify specific issues that may contribute to persistent symptoms.

Concussion can affect multiple systems concurrently and assessment and management of persistent symptoms are best performed by a multidisciplinary team on an individual basis. When neck-related problems potentially contributing to persistent post-concussion symptoms are identified, clinicians can offer specific tailored treatment. This has great potential, as high-quality randomised controlled trials report that neck-related headaches, dizziness and neck pain can be effectively treated by physical therapists. In sports-related concussion, a combination of
neck and vestibular physical therapy can decrease time to medical clearance to return to sport in people with persistent headaches, dizziness and neck pain. It is reasonable to consider that offering evidence-based treatment for neck-related symptoms may reduce the impact of persistent post-concussion symptoms.

While our understanding of concussion continues to improve, the specific role of the neck in people with persistent post-concussion symptoms is not well understood. It remains unclear how neck problems should be identified post-concussion, the extent to which the neck contributes to symptoms, or if treatment of the neck is effective. Symptoms alone have limited value in distinguishing between neck and brain injury in people with concussion. Preliminary research suggests that the physical examination may be more likely to identify neck (particularly upper neck) problems when they are present after concussion, and highlights the need for further prospective study. The purpose of this study was to assess people with persistent symptoms following a concussion who were referred for neck assessment within a multidisciplinary concussion service, to determine (1) if the neck had also been injured, and (2) evaluate the potential for the neck to contribute to their symptoms.

Methods

This prospective case series was conducted within a multidisciplinary concussion service. Ethical approval for this research was received from the University of Otago Human Ethics Committee (H16/089) and Accident Compensation Corporation Ethics Committee (#314). This study was prospectively registered with the Australian New Zealand Clinical Trials Register, registration number ACTRN12616001183471.

Clinical setting
Participants were prospectively recruited from two providers of a multidisciplinary concussion service. This service is nationally funded, and provided by local contract holders nationwide. It is designed to provide further assessment and care for people with persistent post-concussion symptoms, who are at risk of a prolonged recovery. The service accepts referrals from medical practitioners (most commonly general practitioners). The concussion service provides a multidisciplinary assessment to confirm the diagnosis, evaluate the source(s) of symptoms, consider any barriers to recovery, and develop an individual management plan. A ‘key worker’ (either a physical therapist or occupational therapist) performs an initial assessment for new referrals, which is then reviewed along with any other clinical notes available by a multidisciplinary team including a medical doctor, neuropsychologist, occupational therapist, and physical therapist. The team then decides what assessments are necessary for each patient and these are performed. Other specialists are consulted as appropriate. Information from these assessments is collated and overall recommendations for management are developed. As the concussion service providers were in a main city to which people from surrounding areas might travel to access, the individual management plan could be completed where the person lived by local clinicians.

All patients using the concussion service received basic support from the key worker (an occupational therapist or physical therapist) including education about concussion, advice on how to manage a graduated return to daily activities, and case management.

Participants

This study included patients who received a neck assessment from one of three experienced physical therapists with postgraduate training in orthopaedic manual therapy. Where neck treatment was completed with a study physical therapist, the treatment was tailored to the patient’s needs, and the initial measures were repeated at the final appointment on completion of neck treatment. Data were collected from the physical therapy assessment, and from the concussion service providers.
Selection criteria

Key workers in the concussion service screened consecutive patients for eligibility. The selection criteria were based on current clinical practice at both sites. Patients were eligible to participate if they had persistent (> 10 days) headaches, dizziness and/or neck pain; a history suggesting the neck might contribute to their symptoms; and attended a referral for neck assessment with a study physical therapist. Patients were excluded if they had contraindications to manual neck assessment (e.g. fracture, inflammatory joint conditions, and infection), other significant neurological conditions, or were under 16 years. All participants provided written informed consent, and their rights were protected.

Recruitment was performed over a two month period at two clinic sites, with an initial target of 30 participants. As a descriptive study, the recruitment target reflected referral expectations.

Data collection

Data were recorded at the initial physical therapy neck assessment, and again at the final appointment for neck treatment provided by the study physical therapists. Data collected included demographic data, the Rivermead Post-Concussion Symptoms Questionnaire (RPQ), Neck Disability Index, and the Dizziness Handicap Inventory, patient-reported findings, and physical assessment using a standard assessment form (Appendix A). The cause of concussion was recorded according to the ICD-10 external cause classification, grouped into falls (unintentional), transport accidents, exposure to mechanical force (e.g. struck by/against an object), and assault (interpersonal violence).

The RPQ measures the severity of a range of post-concussion symptoms, and is recommended as a core measure of traumatic brain injury related symptoms. Scores ≥2 indicate that the symptom has increased since the concussion injury. In addition, the RPQ-3 and RPQ-13 subscales are reported. The Neck Disability Index and Dizziness Handicap Inventory measure the impact of neck disability and dizziness on daily activities.
Subjective and physical examination findings were recorded on a standard assessment sheet developed in collaboration with the clinicians, and reflecting their routine clinical practice (Appendix A). Headache frequency (headache days in the last week), duration (hours) and severity (0-10 numeric scale) were recorded\(^1\). Dizziness frequency was recorded on a 6-point scale\(^2\), (0 = never, 1 = less than once per month, 2 = 1-4 episodes of dizziness per month, 3 = 1-4 episodes of dizziness per week, 4 = dizziness once daily, 5 = dizziness more than once a day or constant), and dizziness duration on a similar scale (0 = nil, 1 = dizziness lasting up to 10 seconds, 2 = dizziness lasting up to a minute, 3 = dizziness lasting up to five minutes, 4 = dizziness lasting up to 10 minutes, 5 = dizziness lasting longer than 10 minutes or constant). Dizziness severity/intensity was measured using a 0-10 numeric scale\(^4\). Neck pain severity was recorded using the numeric pain rating scale (calculated as the average of the current, best and worst neck pain in the last 24 hours on a scale 0-10 for each).

Physical measures included neck range of motion using a Cervical Range of Motion Instrument (Performance Attainment Associates), the flexion-rotation test\(^3\), a segmental assessment of the neck recording pain and stiffness from the occiput-C4\(^5\), and tenderness of the paraspinal and suboccipital muscles. Descriptive measures included if headaches were provoked by movement, the analysis of the assessing physical therapist, and amount of neck treatment recommended (recorded as hours and time-span). The analysis of the assessing physical therapist includes judgement if the neck is considered to be contributing to the patient’s current symptoms from their most recent concussion injury. If the clinician determined the neck to be contributing to patients’ current symptoms then neck treatment was recommended as appropriate. Treatment for pre-existing conditions is not permitted in this service. Neck treatment is only recommended if symptoms are considered to arise from the recent concussion injury.

Further details were retrieved from the multidisciplinary concussion service reports, including details of co-morbidities and other treatment received. Where the multidisciplinary team recommended and included specific follow-up treatment (as distinct from the initial assessment) in the care plan,
this was recorded as ‘other treatment received’. Furthermore, the extent to which neck and vestibulo-ocular treatment was received concurrently was recorded as ‘overlap in neck and vestibulo-ocular treatment’. Note this was due to neck and vestibulo-ocular assessment/treatment being completed by separate, specialised physical therapists. Lastly, adverse effects from treatment were monitored.

Data analysis

In line with recommendations for case series design, most results are presented individually as descriptive statistics – frequency (percentage) for categorical data or mean (standard deviation) for continuous data. Median values have been presented where appropriate to ensure the data were represented accurately, and differences noted. For the segmental findings, mean pain scores of three or less were excluded to better represent moderate-severe cases and exclude ‘normal’ tenderness.
Results

Participant flow through the concussion service and study is detailed in Figure 1. After screening, 20 individuals completed the initial neck assessment, and 11 completed neck treatment with the study physical therapists including post-treatment re-assessment. A majority of people attending the concussion services were referred for a neck assessment (29 of 39, 74%; including two who saw non-study physical therapists), and most of those eligible continued on to participate (20 of 26, 77%; excluding one considered later not to have a concussion).

Demographic characteristics of participants (n=20) are presented in Table 1, and the symptom characteristics are presented in Table 2. Participants were a mean of 7.5 weeks post-concussion (median 5 weeks). All participants reported headaches. The headaches were frequent (mean 5.6 headache days in the past week), of variable duration (mean 8.9 hours, SD 10.4), and of moderate severity (mean 4.7 out of 10). Fifteen participants reported dizziness. The dizziness was typically frequent (median 5 out of 5), of short duration (median 2 out of 5), and of moderate severity (mean 4.7 out of 10).

Physical examination and analysis findings are presented in Table 3, with further detail on segmental findings shown in Figure 2. ‘Other’ physical examination findings commonly documented were lower cervical or cervicothoracic junction pain in four patients, and tightness/tenderness in trapezius or sternocleidomastoid in six patients. Overall, 18 (90%) participants were considered to have a neck problem that was contributing to their current post-concussion symptoms. For these participants a mean of 3.4 hours (SD 1.6) of neck treatment was recommended over 4.3 weeks (SD 1.8).

Treatment information, including co-morbidity and overlap in treatment for participants completing neck treatment (n=11) is reported in Table 4. The median timespan of treatment was three weeks.

While all patients were considered to have vestibular / functional balance co-morbidities, treatment for this did not always overlap with neck treatment. There were three cases where no overlap occurred (case IDs 1, 2, and 6). These participants received vestibular treatment only after neck
treatment was completed. Pre- and post-neck-treatment comparisons for headache and dizziness variables (frequency, duration and severity), and neck pain are presented in Figures 3-5. This highlights that changes in one variable (e.g. headache frequency), were not always reflected in others. No adverse effects from treatment were reported.

Discussion

This prospective case series describes multiple findings indicative of concurrent neck injury in 18 of 20 participants with persistent post-concussion symptoms. Participants were recruited from a multidisciplinary concussion service and represent those with persistent symptoms (mean 7.5, median 5 weeks post-concussion at initial assessment), consistent with previous descriptions.

The neck-related findings have the potential to contribute to participant symptoms, and may respond to neck treatment.

Concussion and neck injuries can be concurrent. While previous studies have proposed given limited support to the role of the neck, to date there has been a lack of prospective data describing the nature of neck issues in those with persistent post-concussion symptoms. In this study, physical therapists considered the neck to contribute to current symptoms in 90% of cases referred for assessment. Participants reported neck disability, neck pain, headaches provoked by neck movement/position, muscle tenderness, and cervical segmental pain and stiffness. The presence of multiple neck-related findings lends further support to the idea that the neck has the potential to contribute to symptoms following a concussion injury. This does not diminish the role of brain-injury or other comorbidities (e.g. vestibular or oculomotor dysfunction) in post-concussion symptoms, but highlights the potential for concurrent neck injury in those with persistent symptoms. In these cases there is value in having a member of the multidisciplinary team with the skills to identify and manage neck-related symptoms.
Assessment findings help clarify the nature of neck problems that may present following a concussion. The clinician working with people with post-concussion symptoms who suspects neck involvement might focus on the upper cervical spine. Relevant findings in this series of participants include moderate to severe pain and stiffness on segmental assessment of the upper cervical spine, positive flexion rotation test, asymmetry of neck movement in rotation, and tenderness of the suboccipital muscles. These findings indicate frequent dysfunction at the level of C1/2, a particularly mobile segment involved in axial rotation. Given that headache, neck pain and dizziness are the most common physical symptoms reported post-concussion, findings consistent with upper cervical spine dysfunction are relevant. People with cervicogenic headache or dizziness, and no history of concussion also report pain, stiffness, positive flexion rotation test, movement asymmetry and suboccipital muscle tenderness. The convergence of findings might suggest a focus on neck range of movement, the flexion-rotation test, palpation and segmental assessment could be appropriate to identify neck contributions to symptoms in people with persistent post-concussion symptoms. The nature of neck findings in this study are consistent with neck problems for which treatment is available. This is good news, as identifying a neck disorder opens a pathway for treatment which can be followed in addition to other post-concussion care. The clinicians identified three main categories of neck problems: (1) possible cervicogenic headache, (2) possible cervicogenic dizziness, and (3) neck injury. The broad term ‘neck injury’ reflects issues identified with the neck not related to headaches or dizziness. While a working diagnosis of possible cervicogenic headache might be challenged, the clinicians gathered appropriate relevant subjective and physical information to make an informed decision. Specific findings such as frequent pain at C1-2, and positive flexion-rotation tests support the clinical reasoning.

A challenge in persistent post-concussion symptoms is the high potential for headaches to arise from multiple sources (e.g. brain, neck, oculomotor etc.). For a physical therapist trying to decide if
conservative neck treatment is worth exploring, a low-threshold clinical diagnosis of possible cervicogenic headache might be appropriate, particularly considering that manual therapy and exercise have good evidence for treating cervicogenic headache. All participants had signs of concurrent vestibulo-ocular issues. Therefore, the presence or absence of cervicogenic dizziness was unclear. A neck injury was considered to affect approximately half of those assessed based on the history, questionnaires, and examination, and might be less controversial to identify.

Participants’ symptoms changed from pre- to post-neck treatment assessments. Given the observational study design, these improvements are certainly not all attributable to neck treatment. Early support from the key worker might influence participant recovery and outcomes. At the time of initial assessment participants were a mean of 7.5 weeks (median 5 weeks) post-concussion, a stage where fast symptom resolution is no longer expected, and active rehabilitation is recommended. The period of time between the pre- and post-treatment assessments was relatively short (mean 3.2 weeks; eight participants completed treatment within three weeks). That substantial symptom improvements are observable for multiple and chronic symptoms within a short period suggests the overall model of care is appropriate. Improvements in neck pain in particular, along with headache and dizziness variables lend some additional support to clinician impressions of a cervicogenic contribution to symptoms. Although, the extent of neck involvement relative to other variables is unclear. Participants who did not achieve resolution of headache or dizziness reported changes in frequency, duration or severity which may be clinically relevant. These preliminary results suggest that neck treatment is worth exploring with further controlled studies.

Persistent post-concussion symptoms are complex, and assessment and treatment of the neck is relatively accessible and affordable.

Limitations

This study is an observational case series designed for descriptive reporting. The outcome data are exploratory, and intended to stimulate ideas for future research and practice. Participants’
healthcare was not controlled or modified, and represents clinical rather than research conditions.

Each participant had history, presentation and set of issues addressed by the concussion service health professionals. This study reports variables routinely collected by the clinicians involved in the concussion service. Participants represent those suspected to have neck problems and referred for neck assessment, rather than all patients accessing the concussion service. Therefore, the generalisability of these results to all patients with post-concussion symptoms is uncertain. We are unable to draw conclusions regarding the extent to which neck problems contributed towards post-concussion symptoms. Persistent post-concussion symptoms are multifactorial, and this study focuses specifically on findings considered relevant to the neck. When considering the pre-post neck treatment data the contribution of the wider concussion service team – in particular key worker support and specific vestibulo-ocular treatment – should be accounted for.

Conclusions

Pain and restriction in the upper cervical spine were similar to those described in cervicogenic headache and cervicogenic dizziness studies. Neck-related findings are important to recognise as they have the potential to contribute to persistent post-concussion symptoms, and may respond to neck treatment. Along with a detailed history, a physical examination including cervical range of motion, the flexion-rotation test, palpation and segmental examination may help clinicians identify neck-related problems.

Key points

Findings: Pain and stiffness in the upper cervical spine were similar to those described in cervicogenic headache and cervicogenic dizziness research.
Implications: Neck-related findings are important to recognise as they have the potential to contribute to persistent post-concussion symptoms, and may respond to neck treatment. Neck assessment may help clinicians evaluate potential sources of persistent post-concussion symptoms.

Caution: The case series design is suitable for descriptive reporting. Further controlled study is needed to clarify the effects of neck treatment on persistent post-concussion symptoms.
FIGURE 1. Participant flowchart

FIGURE 2. Frequency of segmental findings from the occiput to C4 (C0-4). These data represent findings on the left OR right side (n=20), and only include moderate-severe pain scores of four or more.

FIGURE 3. Individual headache data pre vs. post neck treatment (n=11). Participants one, two and six had no overlap with other treatment.

FIGURE 4. Individual dizziness data pre vs. post neck treatment (n=11). Participants one, two and six had no overlap with other treatment.

FIGURE 5. Individual neck pain data pre vs. post neck treatment (n=11). Participants one, two and six had no overlap with other treatment.

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### TABLE 1. Demographic characteristics (n=20)

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<tr>
<th>ID</th>
<th>Age</th>
<th>Gender</th>
<th>Ethnicity</th>
<th>Employment status</th>
<th>Weeks since injury</th>
<th>Cause of concussion</th>
<th>Injury setting</th>
<th>Past history</th>
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<td>1</td>
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<td>Female</td>
<td>NZ European</td>
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<td>Sport</td>
<td>Multiple previous concussions.</td>
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<td>Non-Sport</td>
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</table>

Mean / %  
37 years  
65% female  
35% male  
80% NZ European  
15% Other  
5% Maori  
40% Employed full time  
25% Employed part time  
25% School or tertiary study  
10% Not employed or retired  
7.5 weeks (Median=5 weeks)  
35% Exposure to mechanical force  
35% Transport accident  
25% Fall  
5% Assault  
75% Non-sport  
25% Sport

**Abbreviations:** ID=identifier; NZ=New Zealand
<table>
<thead>
<tr>
<th>ID</th>
<th>Rivermead post-concussion symptoms questionnaire* (RPQ)</th>
<th>Neck disability index (0-100)</th>
<th>Dizziness handicap inventory (DHI)</th>
<th>Headache</th>
<th>Frequency † (days)</th>
<th>Duration (hours)</th>
<th>Severity (0-10)</th>
<th>Provoke by neck movement or positions</th>
<th>Y/N</th>
<th>Frequency (0-5)</th>
<th>Duration (0-5)</th>
<th>Severity (0-10)</th>
<th>Y/N</th>
<th>NPRS ‡ (0-10)</th>
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<td>35 10 26</td>
<td>60 26 18 16</td>
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<td>2</td>
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<td>24 4 44</td>
<td>40 18 12 10</td>
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<td>3</td>
<td>2</td>
<td>5</td>
<td>Yes</td>
<td>Yes (5)</td>
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<td>2</td>
<td>Yes</td>
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<td>24</td>
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<td>32 6 26</td>
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<td>2</td>
<td>3</td>
<td>Unsure</td>
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<td>26 3 18</td>
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<td>Yes (Unilateral, side shift)</td>
<td>2</td>
<td>24</td>
<td>3</td>
<td>Yes</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Mean / %

| 50 | 8.5 | 2.4 | 9.5 | 16.3 | 8.4 | 7.3 | 3.5 | 2.1 | 10.4 | 2.2 | 2.1 | 1.5 |

* As recommended by Eyres et al. ‡, a separate score for the RPQ-3 (headaches, dizziness, nausea) is provided (and the RPQ-13 can be calculated).

† Headache days in the past week

‡ NPRS=Numeric Pain Rating Scale: calculated as the average of the current, best and worst neck pain in the last 24 hours on a scale 0-10 for each.
### TABLE 3. Physical examination and analysis (n=20)

<table>
<thead>
<tr>
<th>ID</th>
<th>AROM loss of ≥10 degrees in rotation/side flexion</th>
<th>Flexion rotation test</th>
<th>Segmental levels with moderate-severe pain (≥4/10)</th>
<th>Suboccipital tenderness</th>
<th>Paraspinal tenderness</th>
<th>Headache provoked by physical examination</th>
<th>Other relevant findings</th>
<th>Analysis*</th>
<th>Neck considered contributing to current symptoms*</th>
<th>Neck treatment recommended*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Right rotation</td>
<td>Positive</td>
<td>C2/3 right</td>
<td>Nil</td>
<td>Right</td>
<td>No</td>
<td>Pain cervicothoracic junction</td>
<td>C2/3 dysfunction; possible cervicogenic headache</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>No</td>
<td>Negative</td>
<td>C0-2 bilateral</td>
<td>Right</td>
<td>Right</td>
<td>No</td>
<td>Nil of note</td>
<td>Possible cervicogenic headache</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>No</td>
<td>Negative</td>
<td>C0-4 left, C1-4 right</td>
<td>Left</td>
<td>Left</td>
<td>No</td>
<td>Pain C6/7 left (8/10)</td>
<td>Lower cervical neck pain</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>4</td>
<td>No</td>
<td>Negative</td>
<td>C0-2 right</td>
<td>Nil</td>
<td>Nil</td>
<td>Yes</td>
<td>Upper cervical flexion reproduced headache</td>
<td>Possible cervicogenic headache and dizziness</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>No</td>
<td>Positive</td>
<td>Nil (mild only)</td>
<td>Bilateral</td>
<td>Right</td>
<td>No</td>
<td>Tight upper trapezius</td>
<td>Neck injury</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>No</td>
<td>Negative</td>
<td>C0-3 right</td>
<td>Right</td>
<td>Right</td>
<td>Yes</td>
<td>SCM tender bilateral</td>
<td>Possible cervicogenic headache and dizziness</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>No</td>
<td>Positive</td>
<td>C1/2 right</td>
<td>Nil</td>
<td>Nil</td>
<td>No</td>
<td>Nil of note</td>
<td>Possible cervicogenic headache and dizziness. Chronic neck issue related to several concussions / whiplash</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Right rotation</td>
<td>Negative</td>
<td>C1-3 right</td>
<td>Nil</td>
<td>Nil</td>
<td>Yes</td>
<td>SCM tenderness right &gt; left</td>
<td>Possible cervicogenic headache and dizziness. Neck injury</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>9</td>
<td>No</td>
<td>Positive</td>
<td>Nil (mild only)</td>
<td>Left</td>
<td>Left</td>
<td>No</td>
<td>Paraspinal / suboccipital muscle tightness</td>
<td>Neck injury - left neck pain and severe spasm</td>
<td>Yes</td>
<td>Yes</td>
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<td>Left rotation, Right side flexion</td>
<td>Negative</td>
<td>C3/4 bilateral, C1-3 right</td>
<td>Nil</td>
<td>Nil</td>
<td>No</td>
<td>Pain left C5/6, cervicothoracic junction</td>
<td>Lower cervical injury left side</td>
<td>Yes</td>
<td>Yes</td>
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<td>Right side flexion</td>
<td>Negative</td>
<td>C0-4 right</td>
<td>Right</td>
<td>Right</td>
<td>No</td>
<td>Nil of note</td>
<td>Neck injury - right upper cervical. Headache not reproduced</td>
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<td>Yes</td>
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<td>12</td>
<td>No</td>
<td>Negative</td>
<td>C0-2 and C3/4 bilateral, C2/3 right</td>
<td>Nil</td>
<td>Right</td>
<td>No</td>
<td>Stiffness &amp; pain T2/3 - familiar to her pain day to day</td>
<td>Main problem upper thoracic spine pain/stiffness</td>
<td>Yes†</td>
<td>Yes†</td>
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<td>13</td>
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<td>Positive</td>
<td>C0-4 left</td>
<td>Nil</td>
<td>Nil</td>
<td>Yes</td>
<td>Right upper cervical side bend tighter than left</td>
<td>Possible cervicogenic headache</td>
<td>Yes</td>
<td>Yes</td>
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<td>C0-2 right</td>
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<td>Yes</td>
<td>Nil of note</td>
<td>Possible cervicogenic headache</td>
<td>Yes</td>
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<td>C0-2 bilateral</td>
<td>Bilateral</td>
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<td>Tender trapezius bilateral</td>
<td>Possible cervicogenic headache and neck injury</td>
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<td>17</td>
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<td>Nil (mild only)</td>
<td>Nil</td>
<td>Nil</td>
<td>No</td>
<td>Upper cervical flexion &amp; right side bend tight</td>
<td>No acute neck injury or cervicogenic headache. Has chronic thoracic spine pain, will continue current treatment for this injury</td>
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<td>Negative</td>
<td>C0/1 bilateral</td>
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<td>Nil</td>
<td>Yes</td>
<td>Reduced left rotation C1/2 &amp; right upper cervical side bend</td>
<td>Underlying chronic neck stiffness, no worse as a result of this injury</td>
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<td>No</td>
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<tr>
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<td>C1/2 right</td>
<td>Right</td>
<td>Nil</td>
<td>No</td>
<td>Tender right trapezius. Note fracture right clavicle concurrent with concussion</td>
<td>Possible cervicogenic headache and dizziness. Upper cervical dysfunction C1-3</td>
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<td>Yes</td>
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<tr>
<td>20</td>
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<td>Positive</td>
<td>C0-4 bilateral</td>
<td>Bilateral</td>
<td>Nil</td>
<td>No</td>
<td>SCM tender bilateral</td>
<td>Possible cervicogenic headache and dizziness. C0-2 dysfunction</td>
<td>Yes</td>
<td>Yes</td>
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</tbody>
</table>

* Represents the clinical opinion of the assessing physical therapist. Note “Neck considered contributing to current symptoms” refers to symptoms arising from the clients most recent concussion injury.
† Note that although involving the upper thoracic spine this case was managed similarly to a neck injury, by the same provider and within the concussion service. To reflect this situation, the case has been recorded as: Neck considered contributing to current symptoms; Neck treatment recommended.
### TABLE 4. Treatment information, including co-morbidities and overlap in treatment (n=11)

<table>
<thead>
<tr>
<th>Treatment type (more than one could apply)</th>
<th>n=11</th>
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<tr>
<td>Manual therapy</td>
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<tr>
<td>Soft-tissue techniques</td>
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<tr>
<td>Specific exercises (e.g. posture, control)</td>
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</table>

Mean number of sessions: 4.45 (1.1), Range 3-6
Mean time span of treatment in weeks: 3.2 (2.3), Range 1-9
Neck treatment considered beneficial?* 11 (100%)

Co-morbidities identified
- Vestibular / functional balance: 11 (100%)
- Oculomotor: 6
- Mental health: 1
- Other musculoskeletal (e.g. fracture): 1

Other treatment received
- Vestibulo-ocular rehabilitation: 11 (100%)
- Psychology: 0
- Other musculoskeletal treatment: 1
- Occupational therapy: 5

Overlap in neck and vestibulo-ocular treatment
- No overlap: 3 (Case IDs 1, 2, 6)
- Single session: 2 (Case IDs 8, 10)
- Two sessions: 3 (Case IDs 3, 4, 9)
- Three or more sessions: 3 (Case IDs 5, 7, 11)

*Data retrieved from the multidisciplinary concussion service summary.*

*As reported by the treating physical therapist.*
39 potential participants seen by the concussion service providers over recruitment period

27 participants eligible

22 consenting participants completed initial neck assessment

20 participants included in initial assessment analysis

18 participants neck treatment recommended

12 participants received treatment with study physical therapists

11 participants with full pre and post-treatment data available for analysis

1 DNA entire service, 2 saw physical therapist of their own choice (non-study), 9 ineligible

1 declined to participate, 4 missed

2 participants excluded: 1 due to incomplete assessment data; 1 as considered by multidisciplinary team not to have sustained a concussion

2 participants neck treatment not recommended

6 participants received neck treatment elsewhere (out of town, or had a preferred physical therapist)

1 participant did not complete final assessment (left town)
Figure 2. Frequency of segmental findings from the occiput to C4 (C0-4). These data represent findings on the left or right side (n=20), and only include moderate-severe pain scores of four or more.
**FIGURE 3.** Individual headache data pre vs. post neck treatment (n=11). Participants one, two and six had no overlap with other treatment.

![Headache data graphs](image)

**FIGURE 4.** Individual dizziness data pre vs. post neck treatment (n=11). Participants one, two and six had no overlap with other treatment.

![Dizziness data graphs](image)
FIGURE 5. Individual neck pain data pre vs. post neck treatment (n=11). Participants one, two and six had no overlap with other treatment.
Standard concussion neck assessment - INITIAL

Name: _____________________________________ Date: __________________
Physiotherapist: _____________________________

Subjective

Brief current history: _______________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Brief past history: _________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Main current problems: ____________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Headaches: Yes / No

Description: ________________________________________________________________
Provoked by neck movements or positions? Yes / No / Don’t know
Location: Unilateral without side-shift Unilateral with side-shift Bilateral
Notes: ________________________________________________________________
Frequency: _____ headache days in the past week
Duration: _____ minutes / hours (typically)
Severity: _____ / 10 (typically)

Dizziness: Yes / No

Description: ________________________________________________________________
Provoked by neck movements or positions? Yes / No / Don’t know
Frequency: _____ per day / week / month (circle) Constant
Duration: _____ seconds / minutes (typically)
Severity: _____ / 10 (typically)

Neck pain: Yes / No

Description: ________________________________________________________________
Constancy: Constant / Intermittent
Severity: _____ / 10 current _____/10 best last 24h _____/10 worst last 24h

Other relevant issues: (describe):
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Physical examination

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<th>Range of movement</th>
<th>CROM measure (degrees)</th>
<th>Notes</th>
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<td></td>
<td></td>
</tr>
<tr>
<td>Extension</td>
<td></td>
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<tr>
<td>Retraction</td>
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<td>Side flexion</td>
<td>L:</td>
<td>R:</td>
</tr>
<tr>
<td>Rotation</td>
<td>L:</td>
<td>R:</td>
</tr>
<tr>
<td>Flexion-rotation test</td>
<td>L:</td>
<td>R:</td>
</tr>
</tbody>
</table>

Note: The flexion-rotation test is positive when the visually estimated range is reduced >10° from the anticipated normal range (44° +/- 8°) (Hall et al. 2010).

Kennedy et al. 2019. School of Physiotherapy, University of Otago
# Standard concussion neck assessment - INITIAL

<table>
<thead>
<tr>
<th>Name: _______________________________</th>
<th>Date: ____________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiotherapist: _____________________</td>
<td>____________________________</td>
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</tbody>
</table>

## VBI screen

<table>
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<th>Clinical judgement</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Subjective</td>
<td>Positive / Negative</td>
</tr>
<tr>
<td>Physical examination</td>
<td>Positive / Negative</td>
</tr>
</tbody>
</table>

## Ligament testing

<table>
<thead>
<tr>
<th>Clinical judgement</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alar ligaments</td>
<td>Positive / Negative</td>
</tr>
<tr>
<td>Transverse ligament</td>
<td>Positive / Negative</td>
</tr>
</tbody>
</table>

## Segmental exam

<table>
<thead>
<tr>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain (NPRS)</td>
<td>Restriction (7-pt scale)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>C0/1</td>
<td></td>
</tr>
<tr>
<td>C1/2</td>
<td></td>
</tr>
<tr>
<td>C2/3</td>
<td></td>
</tr>
<tr>
<td>C3/4</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Restriction on 7-point scale hyper-mobile (1, 2, 3), normal (4), hypo-mobile (5, 6, 7).*

## Neurological exam

<table>
<thead>
<tr>
<th>Clinical judgement</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicated?</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Upper motor signs</td>
<td>Positive / Negative</td>
</tr>
<tr>
<td>Sensation</td>
<td>Positive / Negative</td>
</tr>
<tr>
<td>Motor</td>
<td>Positive / Negative</td>
</tr>
<tr>
<td>Reflex</td>
<td>Positive / Negative</td>
</tr>
</tbody>
</table>

## Muscle tenderness: Sub-occipital

<table>
<thead>
<tr>
<th>Left / Right</th>
<th>Para-spinal</th>
<th>Left / Right</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other: ________________________________

## Other relevant findings: (e.g. lower cervical spine, thoracic spine)

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

## Headache provoked during physical examination?

Yes / No  
If so, due to? ________________________________

## Dizziness provoked during physical examination?

Yes / No  
If so, due to? ________________________________

## Brief summary / analysis:

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

## Overall consider neck contributing to symptoms?

Yes / No  
If yes, evidence of (circle):  
  - Cervicogenic headache  
  - Cervicogenic dizziness  
  - Neck injury  
  Other: ____________________________________________

## Recommend further neck treatment?

Yes / No  
If yes, estimated treatment required is _____ hours over period of _____ weeks

## Comments:

________________________________________________________________________________________
________________________________________________________________________________________

Signature: ________________________________

Kennedy et al. 2019. School of Physiotherapy, University of Otago