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Original article

Does increased superficial neck flexor activity in the craniocervical flexion test reflect reduced deep flexor activity in people with neck pain?

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ABSTRACT

Background: The craniocervical flexion test assesses the deep cervical flexor muscles (longus capitis, longus colli). Ideally, electromyography (EMG) studies measure activity in both deep and superficial (sternocleidomastoid, anterior scalene) flexors during the test, but most studies confine recordings to superficial muscle activity as the technique to record the deep muscles is invasive. Higher activity of the superficial flexors has been interpreted as an indicator of reduced deep flexor activity in people with neck pain but how close the inverse relationship is during this test is unknown.
Methods: EMG was recorded from the sternocleidomastoid, anterior scalene and deep cervical flexor muscles to quantify their relationship during the craniocervical flexion test, from 32 women (age: 38.0 ± 11.6 yrs) with a history of chronic non-specific neck pain. The range of craniocervical flexion at each of the five test stages was also measured.
Results: A moderate negative correlation was identified ($r = -0.45$; $P < 0.01$) between the average normalized EMG amplitude of the deep cervical flexors and sternocleidomastoid across all stages of the craniocervical flexion test. There was a moderate although weaker and non-significant negative correlation between deep cervical flexors and anterior scalene activity ($r = -0.34$; $P = 0.053$).
Conclusions: The results affirm the interpretation that higher levels of activity of the superficial flexor muscles are an indicator of reduced deep cervical flexor activity in the craniocervical flexion test. Further studies of neuromuscular and movement strategies used by people with neck pain to compensate for poorer activation of the deep cervical flexors will inform best clinical assessment.
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1. Introduction

The craniocervical flexion test is a test which assesses the control of the deep cervical flexor muscles (longus capitis, longus colli) (Jull et al., 2008). Evaluation of test performance involves three components: assessment of the contractile capacity of the deep cervical flexors (ability to flex to five progressively inner range positions of craniocervical flexion), assessment of any increased compensatory activity of the superficial flexors (craniocervical flexion is not the anatomical action of the sternocleidomastoid or anterior scalene muscles) and assessment of the quality and range of head sagittal plane rotation which should proportionally increase with progressive stages of the test (Falla et al., 2003b; Jull et al., 2008). The content validity (Falla et al., 2003a) and reliability of the test have been established (Juul et al., 2013; Jørgensen et al., 2014).

In the research setting, surface electromyography (EMG) is used to quantify the activity of the deep and superficial neck flexors during the test. The longus capitis and longus colli are deep muscles and are unable to be accessed using conventional surface EMG electrodes. Consequently, a novel method is utilized which consists of bipolar electrodes housed within a nasopharyngeal catheter (Falla et al., 2003a). The catheter is inserted via the subject's nose and is suctioned onto the posterior oropharyngeal wall adjacent to the uvula to directly measure deep flexor muscle activity. This

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procedure is invasive and not suitable for studying large clinical populations. Hence most clinical laboratory studies of the craniocervical flexion test have confined EMG measurement to the readily accessible sternocleidomastoid and anterior scalene muscles (Zito et al., 2006; Jull et al., 2007; Johnston et al., 2008; Armijo-Olivo et al., 2011). The assumption is that excessive activation of the superficial flexors is compensatory as craniocervical flexion is not their anatomical action. In support of this assumption, Falla et al. (2004c) showed increased activity of the superficial flexors and lower activation of the deep cervical flexors in people with neck pain compared to pain-free individuals and Jull et al. (2009) demonstrated that an increase in deep flexor activity after training was associated with a decrease in activity of the superficial flexors. However how close the inverse relationship is between the superficial and deep muscles is unknown. The aim of this study was to explore this relationship, to vindicate or not the use of the clinical test method of measuring superficial flexors only.

2. Methods

2.1. Participants

Thirty two women (age, mean ± SD: 38.0 ± 11.6 yrs) with a history of chronic non-specific neck pain participated in this study. Patients were recruited by advertisements in the local press and were included if they were between the ages of 18 and 60 years, reported a history of neck pain of greater than 6 months duration, scored 5 points (Vernon, 1996) or greater out of a possible 50 points on the Neck Disability Index (NDI) (Vernon and Mior, 1991), and demonstrated positive findings on a physical examination of the cervical spine (altered joint motion and painful reactivity to palpation on manual examination of the spine (Jull et al., 1988)). Patients were excluded if they had undergone cervical spine surgery, presented with any neurological signs in the upper limb or had participated in a neck exercise program in the past 12 months.

Ethical approval for the study was granted by the Institutional Ethics Committee and the procedures were conducted according to the Declaration of Helsinki. Participants provided written informed consent. Data collected from this sample has been partially previously reported (Falla et al., 2011) albeit with a focus on the relation to patient self-reports of pain intensity.

2.2. Pain and disability

The average intensity of current neck pain was measured on a 10 cm Numerical Rating Scale (NRS) anchored with “no pain” and “the worst possible pain imaginable”. The NDI was used to assess neck pain-related disability (10 items) (Vernon and Mior, 1991); each item is scored from 0 to 5, and the total score out of 50 points is summated.

2.3. Electromyography

EMG was recorded from the deep cervical flexor muscles unilaterally on the side of greatest pain, which was the right side for 7 of the 32 patients. The apparatus consisted of bipolar silver wire electrode contacts (2 mm × 0.6 mm, 10-mm inter-electrode distance) attached to a suction catheter (size 10FG), with a heat sealed distal end, which was inserted via the nose to the posterior oropharyngeal wall with the patient in supine (Falla et al., 2003a, 2006). The validity and reliability of this technique has been established previously (Falla et al., 2006). The electrode was positioned ~1 cm lateral to the midline at the level of the uvula and the location was confirmed by inspection through the mouth. The electrode contacts were fixed to the mucosal wall with a suction pressure of 30 mmHg via a portal between the two contacts. Before insertion, the nose and pharynx were anaesthetized with three metred doses of 2% Xylocaine® spray (lidocaine, Astra Pharmaceuticals, Sweden) administered via the nostril and to the posterior oropharyngeal wall, via the mouth.

Surface EMG signals were recorded from the sternal head of sternocleidomastoid and the anterior scalene muscles bilaterally using Ag/AgCl electrodes (Grass Telefactor, Astro-Med Inc.) following skin preparation and guidelines for electrode placement (Falla et al., 2002). The reference electrode was placed on the upper thoracic spine. EMG data were amplified (Gain = 1000), band-pass filtered between 20 Hz and 1 kHz and sampled at 2 kHz. Data were sampled with Spike software using a micro1401 data acquisition system (Cambridge Electronic Design, Cambridge, UK) and converted into a format suitable for signal processing with Matlab (MathWorks, Inc. MA, USA).

2.4. Procedure

Subjects were comfortably positioned in supine, with their knees bent, their head and neck in a mid-position. They were instructed to perform a craniocervical flexion action. The task consisted of five incremental movements of increasing craniocervical flexion range of motion (Jull et al., 2008). Performance was guided by visual feedback from an air-filled pressure sensor (Stabilizer™, Chattanooga Group Inc. USA) placed sub-occipitally behind the subject's neck and inflated to a baseline pressure of 20 mmHg. During the task, subjects were required to perform gentle nodding motions of craniocervical flexion that progressed in range to increase the pressure by five incremental levels, with each increment representing 2 mmHg (Jull et al., 2008). Participants practised targeting the five test levels (22–30 mmHg; increments of 2 mmHg) in two practice trials before the electrodes were applied. EMG data were then collected for 10 s during a standardized manoeuvre for EMG normalization purposes. The task involved cervical and craniocervical flexion to lift and hold the head just clear of the bed (reference voluntary contraction). Subjects then performed the five incremental stages (22–30 mmHg) of the craniocervical task to the best of their abilities, maintaining the pressure steady on each target for 10 s. EMG data collection for all muscles commenced when the subject reached the pressure target. A 30 s rest was given between stages.

Craniocervical flexion range of motion was recorded for each test stage using a digital imaging method as previously described (Falla et al., 2003b). Briefly, anatomical markers were positioned on the tragus of the ear, the mental protuberance of the mandible and the lateral aspect of the neck − 7 cm inferior to the mastoid process. A digital camera was positioned on a tripod horizontally parallel to the subject's head/neck region at a distance of 80 cm. An initial photograph was taken of the subject in the starting neutral position, followed by a photograph at the full range of active craniocervical flexion available in this position. Subsequent photos were taken when the subject reached each level of the craniocervical flexion test.

2.5. Data analysis

The EMG signal amplitude was estimated as the root mean square (RMS) value computed over intervals of 1 s during each 10-s contraction. The values of RMS were expressed as a percentage of the maximum RMS value during the reference voluntary contraction (head lift) and then were further averaged across the five stages of the task. Since the RMS values of the sternocleidomastoid and anterior scalene were comparable between sides, the average across both sides was taken for further analysis.

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