Available online at www.sciencedirect.com
ScienceDirect
Journal of Electromyography and Kinesiology 17 (2007) 35–40
JOURNAL OF ELECTROMYOGRAPHY AND KINESIOLOGY
www.elsevier.com/locate/jelekin

Muscle specificity in tests of cervical flexor muscle performance

Shaun O'Leary *, Deborah Falla, Gwendolen Jull, Bill Vicenzino

Division of Physiotherapy, The University of Queensland, Brisbane, Qld. 4072, Australia

Received 28 December 2004; received in revised form 24 August 2005; accepted 27 October 2005

Abstract

The deep cervical flexor (DCF) muscles are considered to be of substantial clinical importance in the management of neck pain. While conventional cervical flexion (CF) dynamometry methods have been used frequently to assess the capacity of the cervical flexor muscles, it has been suggested that cranio-cervical flexion (CCF) methods may provide a more specific test of DCF muscle performance. This study compared the activation of the deep and superficial cervical flexor muscles between tests of isometric cranio-cervical flexion (CCF) and conventional cervical flexion (CF) dynamometry. Normalised root-mean-square values were recorded for the deep cervical flexor (DCF), sternocleidomastoid (SCM), anterior scalene (AS), and sternohyoid (SH) muscles during isometric CCF and CF tests at maximal voluntary contraction (MVC), 50% MVC, and 20% MVC in ten healthy volunteers. The results demonstrated significantly greater electromyography (EMG) amplitude for the SCM ($P < .001$–$.002$) and AS ($P < .001$–$.001$) muscles in the CF test conditions (MVC, 20%MVC, and 50%MVC) compared to CCF test conditions. Moreover, the SH muscle demonstrated significantly greater EMG amplitude during CF compared to CCF but only in the 50% MVC and 20% MVC conditions ($P = .007$ and .02 respectively). These results demonstrate that dynamometry tests of CF result in greater activity of the superficial cervical flexor muscles compared to tests of CCF. As a result, CCF dynamometry may provide a more specific method to assess and retrain DCF muscle performance, compared to conventional CF in which superficial muscle activity may mask impaired performance of the DCF muscles.

Keywords: Dynamometry; Cervical spine; Muscle testing

1. Introduction

Impaired cervical flexor muscle performance has been shown to be a factor in painful neck disorders [1–11], and in accordance, assessment and retraining of their performance is advocated in clinical practice [12–14]. There are two basic methods that have been described in research and clinical literature to assess and retrain the cervical flexor muscles. The first method is conventional cervical flexion (CF) where the subjects head and neck are flexed together on the thorax [1–7,15–27]. The second method involves cranio-cervical flexion (CCF) where the head is flexed on the cervical spine [10,11,13,28,29]. Cranio-cervical flexion has been advocated as the method of choice to assess and retrain the contractile performance of the deep cervical flexor (DCF) muscles (*longus capitis* and *longus colli*) [13]. This recommendation is based on structural anatomical grounds in that the CCF method emphasises upper cervical flexion in association with a mild flattening effect of the cervical lordosis, an anatomical action of the deep *longus capitis* and *longus colli* muscles [30–34]. In contrast, superficial cervical flexor muscles such as the sternocleidomastoid (SCM) and the anterior scalene (AS) muscles are not prime movers of CCF [31,34], and structurally are more suited to assist in flexing the lower cervical spine on the thorax [31] as would be required for the CF method.

In clinical practice muscle tests and exercise are applied to target the function of specific muscle groups. In recent years evidence has accumulated of impairment in DCF muscle function in neck pain sufferers [9,10,28,35] supporting the use of CCF muscle test methods, as opposed to conventional CF methods, in the clinical management of neck pain [13]. While it would appear that the predictions of muscle

* Corresponding author. Tel.: +61 7 3365 4587; fax: +61 7 3365 2775.
E-mail address: s.oleary@shrs.uq.edu.au (S. O'Leary).

1050-6411/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jelekin.2005.10.006

activation with the CCF and CF methods are accurately based on structural anatomical grounds, no investigations have been performed to compare the activation of the deep and superficial muscles between these different tests of cervical flexor muscle performance. In order to test this hypothesis, the purpose of this study was to compare myoelectric signals from the deep and the superficial cervical flexor muscles between isometric dynamometry tests of CCF and CF. It is anticipated that this study will provide preliminary data that may assist in the appropriate application of the CCF and CF methods as muscle tests and therapeutic exercise methods in the management of cervical spine disorders.

2. Methods

2.1. Subjects

Ten volunteers (5 females, 5 males) with no history of neck pain and a mean age of 31.6 ± 10.8 years (range 20–55 years) participated in the study. Participants were excluded if they had suffered neck pain over the previous year, had a history of orthopaedic disorders affecting the neck or neurological disorders, or if they had specifically trained their neck or shoulder girdle muscles over the previous six months. Subjects were also screened for contraindications and precautions for the use of Xylocaine® spray local anaesthetic[1] [36] and for the use of nasopharyngeal suctioning technique [37] which were a part of the EMG technique for measuring activity of the DCF muscles [8,9,38]. After receiving verbal and written information each subject signed a consent form containing information about the nature of the study. Ethical approval for the study was granted by the Institutional Medical Research Ethics Committee. All studies were conducted in accordance with the declaration of Helsinki.

3. Instrumentation and measurements

3.1. Electromyography

Myoelectric signals were detected from the right DCF muscles using custom made bipolar electrodes [38]. The apparatus consisted of silver wire electrode contacts (dimensions: $2\,\mathrm{mm} \times 0.6\,\mathrm{mm}$, inter-electrode distance: 10 mm) inbuilt into a suction catheter (size 10FG), with a heat sealed distal end. The bipolar electrode was inserted via the nose to the posterior oropharyngeal wall at approximately the level of the C2/3 intervertebral disc. The *longus capitis* and *longus colli* (superior portion) muscles are situated posterior to the oropharyngeal wall at this vertebral level providing an ideal location to make recordings via the mucosal wall without requiring intramuscular recording techniques [9,38]. Once this position was achieved, the electrode contacts were fixed to the mucosal wall with a suction pressure of 30 mmHg via a portal between the two contacts. Prior to insertion, the nose and pharynx were anaesthetised with three metered doses of Xylocaine® spray[1] administered via the nostril and three metered doses to the posterior oropharyngeal wall on the same side, via the mouth. Each electrode catheter was individually packed and sterilized using standard gas sterilization procedures.

Recordings of EMG activity for the SCM, AS and sternohyoid (SH) muscles were detected using surface electrodes (Grass Telefactor[2]). Following careful skin preparation, surface electrodes were positioned over the lower one third of the right SCM (20 mm Ag/Ag Cl disc electrodes) and AS (11 mm Ag/Ag Cl disc electrodes) muscles [39] and over the right SH muscle (11 mm Ag/Ag Cl disc electrodes) midway between its inferior attachment at the manubrium and clavicle, and its superior attachment onto the body of the hyoid bone [31]. This location was chosen to minimise cross-talk signals from the SCM muscle that overlies the inferior portion of the SH muscle. Recordings were made from the SH muscle as it is the most superficial of all the infrahyoid muscles and thus the most amenable to surface EMG detection. Recordings from the suprahyoid muscles were not possible as the positioning of the electrodes would have interfered with the positioning of the resistance arm during the CCF dynamometry method. The ground electrode was placed on the upper thoracic spine. EMG data were amplified (Gain = 1000), band pass filtered between 20 Hz–1 kHz and sampled at 2 kHz (NeuroLog[3]). Data were sampled with Spike software[4] and converted into a format suitable for signal processing with Matlab software[5].

3.2. Dynamometry equipment

Isometric CCF was performed in the supine position with a CCF dynamometer (Fig. 1A) that has demonstrated reliability in the measurement of isometric cranio-cervical flexor torque [29]. With this dynamometer, cranio-cervical flexion is resisted at the under-surface of the mandible by the dynamometer resistance arm producing torque at the dynamometer axis that in turn is aligned to the axis of rotation of the subjects' 0/C1 motion segment. Torque is measured with a load cell (TBS Series[6]) connected to an amplifier (PM4-SG-240-5E-A[7]) and a personal computer installed with a custom written program (LabView 6i Virtual Instruments[8]) that is calibrated to convert voltage

[1] Astra Pharmaceuticals®, 50 Otis St, Westborough, MA 01581.

[2] Astro-Med Inc, 600 East Greenwich Avenue, West Warwick, Rhode Island, 02893, USA.

[3] Digitimer Ltd, Welwyn Garden City, Hertfordshire, AL73BE, England.

[4] Cambridge Electronic Design, Cambridge, UK.

[5] The Marks Works Inc, 3 Apple Hill Dr, Natick, MA 01760-2098.

[6] Transducer Techniques, 42480 Rio Nedo, Temecula, CA 92590.

[7] Davidson Measurement Pty. Ltd., 1-3 Lakewood Boulevard, Braeside, VIC, 3195 Australia.

[8] National Instruments Corp, 11500 N Mopac Expressway, Austin, TX 78759.