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Original article

Cranio-cervical flexor muscle impairment at maximal, moderate, and low loads is a feature of neck pain

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Abstract

Impairment of the cranio-cervical flexor (CCF) muscles is a feature of painful cervical spine disorders. The aim of this study was to investigate if CCF muscle impairment is present over a range of contraction intensities (maximal, moderate, low) in neck pain sufferers compared to individuals with no history of neck pain. Isometric CCF muscle strength (isometric maximal voluntary contraction (MVC)), and endurance at moderate (50% of MVC), and low (20% of MVC) loads was compared in 46 participants with neck pain (Neck Disability Index (NDI): mean ± SD; 22.8 ± 5.2) and 47 control participants (NDI: 2.6 ± 2.6). Compared to the control group, the neck pain group had a significant deficit (15.9%, $P = 0.037$) in their MVC peak torque recordings, as well as a significantly reduced capacity to sustain isometric CCF muscle contractions to task failure at 20% of MVC (35% deficit, $P = 0.03$) and 50% of MVC (27% deficit, $P = 0.002$). Neck pain participants also demonstrated poorer accuracy in maintaining their MVC_{20} contraction at the nominated isometric CCF torque amplitude ($P = 0.02$), compared to control participants. It would appear that impairment in isometric CCF muscle performance exists over a range of contraction intensities in neck pain sufferers, which may benefit from specific therapeutic intervention.

Keywords: Cranio-cervical flexor muscles; Neck pain; Dynamometry

1. Introduction

Cranio-cervical flexor (CCF) muscle impairment is a feature of painful cervical spine disorders (Watson and Trott, 1993; Falla et al., 2004a, b; Jull et al., 2004b), and their rehabilitation is effective in reducing the symptoms of cervicogenic headache (Jull et al., 2002). In accordance, specific assessment and rehabilitation of their performance is an accepted practice in the clinical management of neck pain and cervicogenic headache (Jull et al., 2002, 2004a). Specific assessment of these muscles is warranted because, compared to other cervical flexor muscles, the attachment of the CCF muscles (primarily the longus capitis and rectus capitis anterior muscles) to the head, affords them functional autonomy in orientation and stability of the specialized upper cervical motion segments (Vasavada et al., 1998; Moore and Dalley, 1999; Kettler et al., 2002). Theoretically, deficits in the contractile capacity of the CCF muscles would destabilize the cranio-cervical region with a tendency for it to extend and as such, poor performance of these muscles has been implicated in abnormal head on neck posture (Janda, 1988; Jull, 1988; Watson and Trott, 1993; Grimmer and Trott, 1998).

While tests of isometric cervical flexor muscle performance using various dynamometry methods have been widely described (Jordan et al., 1999; Peolsson et al., 2001; Chiu and Lo, 2002; Garces et al., 2002; Seng et al., 2002; Gabriel et al., 2004; Ylinen et al., 2004), specific measurements of isometric CCF muscle performance are less common (Watson and Trott, 1993; Jull et al., 2004a; O'Leary et al., 2005b). Watson and Trott

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(1993) using an isometric dynamometry method showed deficits in CCF muscle maximal strength and endurance in cervicogenic headache sufferers compared to control participants. Deficits in low load CCF muscle performance have also been shown in neck pain sufferers compared to control participants when performing the cranio-cervical flexion test (Jull et al., 2004b). The cranio-cervical flexion test method utilizes a pneumatic pressure sensor placed behind the upper cervical spine to monitor the capacity of the CCF muscles to flatten the cervical lordosis. Larger pressure shortfalls (Jull et al., 1999, 2004b; Jull, 2000), and altered coordination of the CCF muscles within the cervical flexor synergy, characterized by reduced activity of primary CCF muscles (longus capitis) that coincided with elevated activity of superficial muscles that are not primary CCF muscles (sternocleidomatoid, anterior scalenes) (Falla et al., 2004b), have been demonstrated in participants with neck pain when compared to control participants. Such findings of CCF muscle impairment at low load have underpinned strategies for their rehabilitation (Jull et al., 2002, 2004a).

The purpose of this study was to investigate isometric CCF muscle performance at maximal (maximal voluntary contraction—MVC), moderate (50% of MVC), and low (20% of MVC) contraction intensities in neck pain sufferers compared to control participants using a cranio-cervical flexion dynamometry method (O'Leary et al., 2005b). The aim of these isometric tests was to challenge the CCF muscles over a spectrum of contraction intensities as would be required for cranio-cervical postural function. The hypothesis was that participants with neck pain would demonstrate poorer performance over the spectrum of contraction intensities (maximal, moderate, low) compared to control participants with no history of neck pain.

2. Methods

2.1. Participants

Ninety-three female volunteers participated in this study including 46 participants with a history of neck pain (age 37.0 ± 10.1 years, weight 64.0 ± 10.6 kg, height 166.2 ± 6.7 cm), and 47 control participants with no history of neck pain (age 27.8 ± 7.7 years, weight 62.6 ± 9.3 kg, height 167.5 ± 6.1 cm). Groups were similar in their height and weight characteristics but there was a significant difference in age ($P < 0.0001$) with the neck pain group being older. Females only were included in this comparative cohort study so as to eliminate a potential confounding factor of gender to strength measures (Jordan et al., 1999; Kumar et al., 2001; Portero and Genries, 2003).

All participants were recruited via electronic and written advertising within the university and general community. Participants with neck pain were included if they reported neck pain of greater than 3 months duration of either a traumatic or non-traumatic origin, scored greater than 10/100 on the Neck Disability Index (NDI) (NDI 22.8 ± 5.2) (Vernon, 1996), and demonstrated positive findings on a physical examination of the cervical spine such as altered joint motion, and painful reactivity to palpation (Jull, 1994). Control participants were included if they reported no history of neck pain for which they had sought treatment, scored less than 10 on the NDI (NDI 2.6 ± 2.6), and had no positive findings on a physical examination of the cervical spine.

Participants in either group were excluded if they had specifically trained their neck or shoulder girdle muscles in the preceding 6 months, had neck pain from non-musculoskeletal causes, neurological signs, or any medical disorder contraindicating physical exercise. After receiving verbal and written information each participant signed a consent form. This study was ethically approved by the University's Medical Research Ethics Committee and was in accordance with the declaration of Helsinki.

2.2. Instrumentation and measurement procedure

CCF muscle performance was measured in supine using a cranio-cervical flexion dynamometer (Fig. 1) that has been shown to have good test–retest measurement reliability (ICC 0.7–0.92) (O'Leary, 2005). The dynamometer measures isometric CCF muscle torque about the axis of rotation (AOR) of the C0/1 motion segment that lies in close proximity to the anterior mastoid process (Harms-Ringdahl et al., 1986; White and Panjabi, 1990; vanMameran et al., 1992). Due the occlusion of the anterior mastoid process from direct vision by the ear, the axis of the dynamometer was aligned to the concha of the ear as this best approximated the anterior mastoid process (O'Leary et al., 2005b).

The CCF effort was resisted at the under-surface of the mandible by the dynamometer resistance arm producing a torque at the dynamometer axis that was measured in Newton meters (N m). Any tendency for the participant to push their head into or lift it off the supporting surface, thought to be a possible strategy to enhance CCF muscle torque (O'Leary et al., 2005a), was monitored with a force platform (Watson and Trott, 1993; O'Leary, 2005). All measurements of CCF muscle torque were recorded in an anthropometric neutral cranio-cervical flexion/extension position (Montagu, 1960; Norton and Olds, 1996), with the participant's knees and hips positioned in 45° and the arms folded