Recruitment of the deep cervical flexor muscles during a postural-correction exercise performed in sitting

Deborah Falla, Shaun O’Leary, Amy Fagan, Gwendolen Jull

Division of Physiotherapy, The University of Queensland, Brisbane, Australia
Center for Sensory-Motor Interaction (SMI), Department of Health Science and Technology, Aalborg University, Aalborg, Denmark

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Abstract

Specific strategies to optimally facilitate postural muscles to retrain postural form are advocated in the clinical management of neck pain. The purpose of this study was to compare the activation of selected cervical, thoracic and lumbar muscles during independent and facilitated postural correction in sitting in 10 subjects with chronic neck pain. Deep cervical flexor (DCF) muscle activity was recorded with custom electrodes inserted via the nose and fixed by suction to the posterior mucosa of the oropharynx. Surface electrodes were placed over the thoracic erector spinae and lumbar multifidus muscles. Root-mean-square EMG amplitude was measured for each muscle across two conditions. In the first condition, subjects were instructed to spontaneously “sit up straight” from a slumped posture without any other guidance from the therapist. In the second condition the therapist provided specific manual and verbal facilitation to assist the patient to correct to an upright pelvic position with a neutral spinal lumbo-pelvic position. Activation of the DCF and lumbar multifidus muscles (P < 0.05) were significantly greater when the therapist facilitated postural correction compared to independent sitting correction. Specific postural-correction strategies result in better facilitation of key postural muscles compared to non-specific postural advice. The results of this study highlight the need for clinical skill and precision in postural training of patients with neck pain.

Keywords: Posture; Exercise; Neck pain; Electromyography

1. Introduction

The primary function of the cervical spine is to orientate the head against the opposing forces of gravity whilst permitting multi-directional movement. To accomplish this task the cervical spine must be mechanically stable, both in static and dynamic postures. In upright neutral postures, passive resistance to cervical spine motion is minimal (Oatis, 2004) and destabilizing gravitational forces are counteracted by moments of the anterior and posterior cervical muscles. In particular, the deep more segmental cervical muscles such as the deep cervical flexors (DCF), are important for the control and support of the cervical lordosis and maintenance of cervical spine postural form (Mayoux-Benhamou et al., 1994; Conley et al., 1995; Vasavada et al., 1998; Boyd Clark et al., 2001, 2002).

Our previous research has identified impaired activation of the DCF muscles, longus colli and longus capitis, in people with chronic neck pain (Falla et al., 2004a, b). These findings, in addition to evidence of altered control of functional working postures in persons with neck pain (Szeto et al., 2002), has directed the use of clinical posture-correction strategies as an early therapeutic exercise intervention in the management of neck pain (Jull et al., 2004). To retrain a neutral sitting posture patients are firstly taught to achieve a neutral
lumbo-pelvic sitting posture, followed by correction of thoracic and cervical postures with a subtle ‘sternal lift’ or ‘sternal drop’ as appropriate and a gentle ‘occipital lift’ manoeuvre to position the head in neutral. It has been proposed that frequent correction to an upright neutral postural position serves two functions (Jull et al., 2004). Firstly, that it may provide a regular reduction of adverse loads on the cervical joints induced by poor spinal, cervical and scapular postures. Secondly, it may train the deep postural stabilizing muscles of the spine in their functional postural supporting role. Patients are encouraged to perform this exercise repeatedly throughout the day, with the emphasis being on a change in postural habit (Jull et al., 2004). One early study on normal subjects using fine wire electrodes (Fountain et al., 1966) found that a neck straightening manoeuvre increased the activity in the longus colli muscle. However, since that time, there has been no further use of fine wire electrodes (presumably due to ethical safety reasons) or study of postural-correction techniques to determine whether or not clinical techniques of postural re-education can activate the DCF muscles. This is particularly relevant to patients with neck pain.

The purpose of this study was to investigate the activation of the DCF muscles, in conjunction with the lumbar multifidus and thoracic erector spinae muscles during the postural-correction sequence. More specifically, the primary aim of the study was to determine if specific re-education of sitting posture in neck pain patients is necessary to achieve recruitment particularly of the DCF muscles, or if simply instructing patients to spontaneously “sit up straight” would be equally effective. We hypothesized that the specific re-education of posture strategy would produce greater activation of the DCF muscles than simply an instruction for the patient to spontaneously sit up straight.

2. Methods

2.1. Subjects

Ten female subjects with a history of chronic neck pain participated in this study. Subjects were recruited via advertisements in local and university press. Participants were aged between 21 and 52 years (mean 39.8, SD 11.2 years) and had a history of neck pain greater than one year (mean 13.4, SD 11.7 years). The mean and SD for average intensity of pain (score out of 10) and perceived disability rated on the Neck Disability Index (score out of a 50) were 4.5 ± 2.3 and 10.5 ± 2.9, respectively. Subjects were excluded if they had either undergone spinal surgery, complained of any neurological signs, had participated in a neck or back exercise program in the past 12 months or were undergoing treatment at the time of testing. Ethical approval for the study was granted by the Institutional Medical Research Ethics Committee and all procedures were conducted according to the Declaration of Helsinki.

2.2. Electromyography

EMG recordings of the DCF muscles were made unilaterally using bipolar electrodes (Falla et al., 2003). Measurements were made on the side of greatest pain for consistency between subjects. If subjects had bilateral neck pain, the more symptomatic side was tested. The apparatus consisted of silver wire electrode contacts (dimensions: 2 mm × 0.6 mm, inter-electrode distance: 10 mm) attached to a suction catheter in vertical alignment (size 10FG), with a heat sealed distal end, which were inserted via the nose to the posterior oropharyngeal wall. The DCF muscles are situated posterior to the oropharyngeal wall providing an ideal location to make recordings via the mucosal wall without requiring intramuscular recording techniques (Falla et al., 2003). Placement of the electrodes ensured correct orientation along the fibres of the DCF muscles, approximately 1 cm lateral to the midline at the level of the uvula (approximately the level of the C2-3 inter-vertebral disc) which is the level of the muscle belly of longus capitis and at which the upper portion of the longus colli muscle has its greatest cross-sectional area (Lang, 1993). Location of the electrode was confirmed by inspection through the mouth. 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 anaesthetized with three metered doses of Xylocaine® spray (Astra Pharmaceuticals) administered via the nostril and three metered doses to the posterior oropharyngeal wall on the same side, via the mouth.

Myoelectric signals were detected from the thoracic erector spinae and lumbar multifidus ipsilateral to the DCF electrode using surface electrodes (20 mm Ag/Ag Cl disc electrodes, inter-electrode distance = 20 mm, Grass Telefactor, Astro-Med, Inc.) following careful skin preparation. Electrodes for the lumbar multifidus muscles were positioned immediately adjacent to the spinous process of the fifth lumbar vertebrae (Ng et al., 2003). Electrodes for the thoracic erector spinae were positioned approximately 5 cm lateral to the spinous process of the tenth thoracic vertebrae such that the electrodes overlaid the thoracic portion of the longissimus thoracis muscle.

A ground reference was placed over the upper thoracic spine. EMG data were amplified (Gain = 1000), band pass filtered between 20 Hz–1 kHz and sampled at 2 kHz. Data were sampled with Spike software (Cambridge Electronic Design, Cambridge, UK) and converted into a format suitable for signal
processing with Matlab software (The MathWorks, Inc. Natick, MA, USA).

2.3. Procedure

Participants were asked to sit in a comfortable position on the treatment couch such that their feet were flat on the floor and their buttocks were fully supported on the couch. The couch was set to a height so that with the feet flat on the floor, the participant’s thighs were inclined slightly downwards from the horizontal so that the hips were approximately in 100° of flexion. This starting position was adopted so that hypomobility in the posterior hip structures in some patients would not prevent them from comfortably anteriorly rotating the pelvis at the hip joints required to achieve a neutral lumbar spine posture.

Participants were first asked to sit in this position in a slouched posture as they felt comfortable, and to focus on a marker on the wall directly in front of them. Participants were then asked to “sit up straight the best way they knew how” and to “maintain this position” for a 10 s duration during which EMG recordings were made. Following this, participants were instructed to slouch again and were then taught, with verbal and manual guidance, the corrected neutral postural position sequence by the therapist. Participants were instructed on three main elements. They were firstly asked to gently roll their pelvis forward such that they were sitting on top of their ischial tuberosities with resumption of the lumbar lordosis. Secondly, they were instructed that their thorax should move slightly upwards and forwards to follow the motion of the pelvis to encourage a slight sternal lift without excessive thoraco-lumbar extension. Lastly, the participant was asked to gently and minimally lift their occiput to position their head from any upper cervical extension position to a more neutral position. During this training period participants were given the appropriate manual facilitation by the musculoskeletal physiotherapist at the lumbo-pelvic region, the sternum, or the occiput as required by the individual to achieve the desired positions. This postural-correction sequence was practiced twice. Participants were then instructed to slouch again, and then to actively correct their posture into the upright neutral position with the verbal and manual facilitation provided by the therapist. The participant was then asked to maintain this corrected position for 10 s as EMG signals were acquired. No subject reported any pain with the postural correction procedures.

2.4. Data analysis and statistics

To obtain a measure of EMG signal amplitude, maximum root mean square (RMS) was calculated over 1 s epochs for each muscle using Matlab software (The MathWorks, Inc. Natick, MA, USA). Reporting the data as absolute EMG amplitude precludes a between-muscle comparison for the two different conditions due to the various factors which influence EMG such as amplitude electrode location, thickness of the subcutaneous tissues and distribution of motor unit conduction velocities (Farina et al., 2004). For this reason, Wilcoxon signed-ranks tests were conducted to assess for change in RMS values across the two conditions for each muscle. Statistical analyses were performed using SPSS 10.0 for Windows. A value of \( P < 0.05 \) was used as an indicator of statistical significance.

3. Results

As demonstrated in Figs. 1 and 2, when patients with neck pain were specifically facilitated into an upright neutral posture, the EMG amplitude of the DCF \( (P < 0.05) \) and lumbar multifidus \( (P < 0.05) \) muscles were significantly greater compared to the condition of un-facilitated spontaneous upright sitting. No difference in EMG amplitude for the thoracic erector spinae muscles \( (P > 0.05) \) between the two test conditions was recorded.

4. Discussion

Retraining of neutral sitting postures is considered an important component of the rehabilitation of patients with neck pain. It has been hypothesized that specific correction of spinal postural form performed regularly throughout the day may assist training of the deep cervical stabilizing muscles in their functional postural supporting role (Jull et al., 2004). In favour of this hypothesis, the results of this study demonstrate greater activation of the DCF muscles with specific correction of spinal posture compared to independent erect sitting in patients with chronic neck pain. This finding highlights the need for clinical skill and precision in the
postural rehabilitation for patients with neck pain to achieve optimal benefits of this self-help exercise strategy.

4.1. Muscle activation associated with corrected sitting posture

Historically clinicians have instructed and encouraged patients to move out of slumped postures and to sit and stand in neutral spinal postures with the understanding that this minimizes mechanical load on the musculoskeletal system and may facilitate recruitment of the deep stabilizing muscles of the spine. Despite the absence of a definitive indicator or measure of neutral spine posture, clinically, a neutral sitting spine posture is encouraged by facilitating the formation of the normal lumbar and cervical lordoses, and a thoracic kyphosis, to a position in which all regions are neither flexed or extended, a position that is subjectively judged by the therapist for an individual patient.

The findings of this study are in accordance with those of Fountain et al. (1966). In particular, the results indicate that the longus capitis/collis can be facilitated with a specific clinical postural manoeuvre in neck pain patients. Additionally, the findings in the trunk muscles agree with those of O’Sullivan and colleagues (2002) who described activation of the lumbar multifidus, thoracic erector spinae and the internal oblique muscles with assumption of an erect neutral sitting posture compared to slouch sitting. We concur with O’Sullivan et al.’s (2002) suggestions that instructing patients with low back pain to adopt an erect posture will facilitate key lumbo-pelvic stabilizing muscles, resulting in a more effective load sharing within the muscle system, reducing focal end range stress on the sensitized passive structures. The important extension of knowledge from this current study was the finding of significantly greater activation of the DCF with adoption of a neutral lumbo-pelvic, cervical and cranio-cervical posture in patients with neck pain.

A common clinical observation of patients with neck pain, when asked to assume an upright sitting posture, is a movement strategy which appears to be initiated with and dominated by thoracolumbar extension rather than with the formation of a lumbar lordosis, with ‘over activation’ of the thoracolumbar extensors. When subjects were merely instructed to “sit up straight the best way they knew how” in this study, there was significantly less lumbar multifidus and DCF muscle activation compared to facilitation of the ‘ideal’ neutral postural position. However, there was no difference in the activation levels of the thoracic erector spinae muscles between the two sitting conditions. Thus, it appears that the patients do not use lesser thoracolumbar extensor activity in assuming a neutral lumbo-pelvic position, rather there is a pattern of synergistic use of both the lumbar multifidus and thoracolumbar erector spinae. It is possible that the difference between the contributions of the lumbar and thoracic extensors may have been identified if other parameters of the EMG signal were analysed. For example, an investigation of the muscle recruitment order may have demonstrated different onset of muscle activation with the facilitated sitting posture compared to independent erect sitting. Further research is warranted to clarify this.

4.2. Clinical implications

The benefit of regular correction to an upright neutral posture has not been investigated in isolation in people with neck pain. However, there is evidence which indicates that specific postural re-education exercise as described in this study, in the context of an active muscle stabilization program is effective in the management of patients with chronic neck pain and headache (Jull et al., 2002). Specific postural re-education exercise which is initiated with the formation of a neutral lumbo-pelvic posture should therefore be viewed at this time as a component of rehabilitation which provides a simple means for the patient to recruit the deep postural muscles of the cervical spine in a functional way regularly throughout the day. Further research investigating the benefits and mechanisms of specific
postural-correction exercise alone both on patient symptoms and on postural form is warranted.

4.3. Study considerations

It must be acknowledged that in this study we measured muscle EMG activity during sitting posture-correction tasks, which involved manual and verbal facilitation provided by the therapist. Additional research is necessary to confirm that the exercise is effective in recruiting the postural muscles when facilitation is either withdrawn by the therapist or is self-applied by the patient. This study was conducted on a group of female volunteers. Additional research is warranted to identify whether similar results would be obtained in male participants. Moreover, in future studies the use of concurrent movement analysis together with examination of the cervical extensor and axio-scapular muscles may provide a more complete picture about the biomechanical loadings of the spine.

5. Conclusion

Postural re-education is recommended practice for the management of patients with cervical spine dysfunction. The results of this study demonstrate that re-education of sitting posture to an upright neutral spinal position promotes activation of the DCF muscles. Whilst further research is necessary to appreciate the benefits of this exercise on patient symptoms and postural form, the results highlight the need for clinical skill and precision in the postural rehabilitation for patients with neck pain to achieve optimal effects of this self-help exercise strategy.

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References


