



Original article

Endurance and fatigue characteristics of the neck flexor and extensor muscles during isometric tests in patients with postural neck pain

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ABSTRACT

Sustained postural loading of the cervical spine during work or recreational tasks may contribute to the development of neck pain. The aim of this study was to compare neck muscle endurance and fatigue characteristics during sub-maximal isometric endurance tests in patients with postural neck pain, with asymptomatic subjects. Thirteen female patients with postural neck pain and 12 asymptomatic female control subjects completed timed sub-maximal muscle endurance tests for the neck flexor and extensor muscles. Muscle fatigue, defined as the time-dependent decrease in median frequency electromyography (EMG), was examined using surface EMG analysis during the tests. The median extensor test holding time was lower but not significantly different in the neck pain group (165 s) than the control group (228 s) ($p = 0.17$). There was no difference between groups in the flexor test holding time (neck pain = 36 s, controls = 38 s) ($p = 0.96$). The neck pain group was characterised by greater variability in neck flexor ($p = 0.03$) and extensor ($p = 0.006$) muscle endurance. For both tests, the rate of decrease in median frequency EMG was highly variable within and between groups with no significant difference between groups for the flexor or extensor test ($p = 0.05$ – 0.82). Patients with postural neck pain did not have significant impairment of neck muscle endurance or accelerated fatigue compared to control subjects. However, the greater variability in these indices of muscle function may reflect patient-specific changes in muscle function associated with neck pain disorder.

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1. Introduction

Sustained postural loading during occupational and recreational tasks is increasingly being recognised as an important aetiological factor for mechanical neck and upper back pain (Eltayeb et al., 2009). The prevalence of neck and shoulder girdle pain related to office-based activities may be as high as 47%, so the identification of related impairments of function is important to the prevention and treatment of this disorder (Côté et al., 2008). One factor which may be an important determinant of postural control and magnitude of spinal loading, is the level of muscle activity associated with the posture. Sitting tasks are typically associated with low levels of muscle activity that need to be maintained over long periods of time, although the level of activity may vary during a monotonous task (McLean, 2005; Mork and Westgaard, 2006). Consequently, the impairments of muscle function which appear most relevant to postural neck pain are likely to be endurance and fatigue.

Changes in muscle strength in individuals with neck pain have been widely documented (Cagnie et al., 2007), but impairments of muscle endurance are not as well defined. In subjects with non-specific neck pain, a decrease in neck extensor muscle endurance has been described, which was greater in individuals who had sought treatment than in those who had not (Lee et al., 2005). Similarly, a decrease in neck flexor and extensor endurance has been reported in patients with non-specific neck pain, and following anterior cervical fusion, compared to asymptomatic subjects (Peolsson and Kjellman, 2007). Using a global neck flexion test, patients with non-specific neck pain were found to have reduced endurance compared to asymptomatic subjects (Harris et al., 2005). Similarly, Jull et al. (2004) described a decrease in the endurance of the deep flexor muscles in patients with whiplash injuries and idiopathic neck pain using the craniocervical flexion test. Although these studies have been able to identify impairments of muscle endurance in the patients with neck pain, muscle endurance has not been specifically examined in individuals with neck pain associated with sustained postural loading tasks.

Sitting postures are typically associated with levels of muscle activation of between 2 and 6% Maximum Voluntary Contraction

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(MVC) with activity being present in deep and superficial muscles (McLean, 2005). Despite these low levels of muscle activity it has been suggested that postural neck pain may be associated with accelerated fatigue of the contracting muscles (Sommerich et al., 2000). Evaluation of muscle fatigue during functional tasks or muscle endurance tests can be achieved by monitoring the temporal changes in the electromyographic (EMG) activity of the muscles during the task performance (Mannion and Dolan, 1994). The decline in the median frequency (MF) of the EMG power spectrum is considered a sensitive marker of muscle fatigue during voluntary contractions, and an objective method of monitoring fatigue during isometric muscle performance tests (Solomonow et al., 1990; Arnall et al., 2002). Accelerated fatigue during sub-maximal isometric neck flexor tests has been reported in patients with non-specific neck pain, and in adolescents with tension headache compared to pain-free subjects (Falla et al., 2003; Oksanen et al., 2007). Patients with symptomatic cervical spine degeneration have also been shown to fatigue more rapidly than asymptomatic control subjects during sustained isometric contraction of the neck flexor and extensor muscles (Gogia and Sabbahi, 1994). However, the between group difference in fatigue was only evident at levels of muscle activation greater than 50% maximum. Similarly, individuals with neck pain related to computer work have been shown to demonstrate fatigue responses which are similar to, or less pronounced, than control subjects during isometric contractions of the upper trapezius muscle of between 10 and 25% of maximum (Goudy and McLean, 2006; Kallenberg et al., 2007).

In summary, there are indications that muscle endurance and fatigue are factors that may characterise postural neck pain syndromes. One aspect missing from the literature is the differentiation between endurance performance (holding time) and the specific muscle fatigue rates reflected in activation patterns of the neck muscles. Although impairments of muscle endurance may be due to de-conditioning and consequently would be expected to be associated with accelerated fatigue (Stokes et al., 1989), cessation of the endurance task may be related to other behavioural factors such as pain or fear of pain. Recent literature has been equivocal on this relationship. For example, in patients with shoulder and upper back pain, impairments of muscle endurance compared to control subjects have been identified in the absence of differences in EMG characteristics associated with muscle fatigue (Hansson et al., 1992). More recently, a moderate negative correlation has been reported between neck flexor muscle endurance and the rate of decline in EMG median frequency in adolescents with tension headache, and asymptomatic subjects (Oksanen et al., 2007). Therefore, further evaluation of neck muscle endurance (holding time), and the related fatigue responses, is required in patients with postural neck pain to better understand the nature of the impairments of muscle function in this patient group. The objective of this study was to use standardised clinical tests to examine the performance of sub-maximal isometric endurance of the neck flexor and extensor muscles in individuals with postural neck pain, compared to pain-free control subjects. A second objective was to compare the EMG fatigue characteristics between the two groups, to determine whether individuals with postural neck pain show evidence of accelerated fatigue during the muscle endurance tests.

2. Methods

Thirteen women with postural neck pain were recruited from a university physical therapy clinic. The control group consisted of 12 asymptomatic women who were recruited from the university population. Subjects in both groups were either full-time university students or university staff who were primarily employed in office-based occupations. The mean age of the symptomatic subjects was

28.9 years (SD = 12.6), and the mean age of the control subjects was 26.1 years (SD = 5.3). The mean duration of neck pain in the symptomatic group was 51 (SD = 16) months.

Inclusion criteria for the postural neck pain group were neck pain that was primarily aggravated by functional activities which required sustained postures and relieved by postural modification, no pain-related restriction of cervical mobility and a symptom duration of more than three months. Subjects were excluded if they had pain or medical conditions affecting cervical mobility, arm pain or pain associated with movement of the upper limb, upper limb neurological symptoms or if they were receiving any form of physical treatment for neck pain. Subjects in the control group had to be symptom free with no history of spinal or shoulder pain in the past 12 months.

All participants completed a 100 mm pain intensity visual analogue scale (VAS), with reference to their average pain intensity during the main pain provocative activity, over the last week. The neck pain and disability scale (NPAD) was used to measure the level of neck pain-related disability (Wheeler et al., 1999). The range of possible scores for the NPAD scale is 0–100, where a zero score indicates no disability. All subjects signed an informed consent document following a detailed explanation of the study procedures. Approval for the study was provided by the institutional Human Research Ethics Committee (Approval No. PT0116).

The surface EMG data were recorded using a Bortec AMT-8 Octopus amplifier (Bortec Biomedical, Calgary, Canada) and transferred directly to a data acquisition computer for storage and analysis. Circular bipolar Ag/AgCl self-adhesive electrodes were placed over the required muscles with the patient lying in supine for the sternocleidomastoid (SCM) muscles, and prone for the erector spinae muscles. Electrodes were placed bilaterally 2 cm from the mid-line on the cervical erector spinae (at the level of C5), and over the thoracic erector spinae at the level of T4. The SCM electrodes were placed bilaterally so that the lowest part of the electrode was above the midpoint of the muscle belly as described by Oksanen et al. (2007). A common earth electrode was placed on the right clavicle. The inter-electrode distance was 15 mm. To reduce the inter-electrode resistance, the skin was shaved as required and cleaned with 60% alcohol.

All data processing was performed using a dedicated Labview (National Instruments, USA) software programme. The raw data was filtered using a 4th order zero lag Butterworth filter (20–1000 Hz). The first and last 2 s of data were truncated for all endurance task tests and all data were visually inspected for artifacts (heart rate and movement). Linear envelopes were created by full-wave rectification followed by low pass filtering at 8 Hz (4th order Butterworth filter). These were used to document changes in amplitude over time and were amplitude normalised to the mean of the initial 5 s. For group ensemble averaging, data was time normalised into epochs of 4% (25 data points) of the duration of the task. This was achieved using a cubic spline fit model. Changes in amplitude between groups were also compared within an absolute time frame. Therefore, data was truncated to a set time and then normalised to 25 data points. The threshold for this cut off was determined according to the group distributions and differences.

Frequency analysis was conducted on the truncated data where the median frequency (MF) of the power spectrum was derived from windows of 6 s duration. The start of the window was set at 3 s intervals so the windows were overlapping. The power density spectrum (PDS) was achieved by running a fast Fourier transfer (FFT) analysis (Hamming window, DC offset, 6000 data points, 3000 point moving window). The median frequency change was determined as the absolute change in Hz, relative to the first 9 s. The MF slope was determined using a linear best fit analysis where the slope was expressed as $\text{Hz} \cdot \text{min}^{-1}$ (Allison and Fujiwara, 2002).

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