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Correlation between Muscular Fatigue and EMG Activity during the Prolonged Casual Computer Work

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Abstract An experimental study was conducted to investigate the effects of turtle neck syndrome, so called, on muscular fatigue and muscle activity. Six subjects (males) participated and performed the prolonged casual computer work in the study. EMG signals from six muscles of the dominant neck-back region were acquired and recorded for 10 seconds at the beginning and the end of three hours computer work. EMG was recorded from six muscles by using a computerized data recording and analysis system. Power spectrum function of EMG was calculated off-line by means of a signal processing software package. Power spectrum functions were smoothed with a moving average filter of 21 points and normalized with respect to the maximal value achieved during the trials. Muscle activity and median frequencies of Sternocleidomastoid(SCM) in turtle neck posture was approximately 51%, which were less than those in normal neck posture. SCM also showed the biggest decrease in median frequency. Results will provide the insight into the neck-back injury mechanism of turtle neck patients. Furthermore, they will be helpful in developing rehabilitation programs for restoring patients' neck-back functions.

Keywords: Turtle Neck Syndrome, Electromyography, Muscle Fatigue, Median Frequency

1. Introduction

Due to recent rapid computerization of industry and business, office workers are often seated at visual display terminals(VDTs) for more than 8 hours a day. Consequently, the number of people suffering from chronic fatigue in the neck-back region is also increasing due to continuous work of this type. It is generally believed that these symptoms originate and are exacerbated in accordance with the accumulation of muscle fatigue. This fatigue is accompanied by poor microcirculation due to continuous low-force contraction of the corresponding muscles when the same posture is maintained for a long period of time (Westgaard, 1988).

The characteristics of trapezius fatigue due to VDT work have been described in studies dealing with experimental fatigue and in current research on office workers (Larsson et al., 2000; Roman-Liu et al., 2004; Falla and Farina, 2005; Schulte et al, 2006). However, it remains unclear why and how serious chronic muscle fatigue is induced from transitory muscle fatigue. To date, muscle fatigue and its recovery over time have not yet been revealed enough in terms of both perceived and physiological muscle fatigue, though many studies have investigated both of perceived exertion and localized muscle fatigue (Mitsutoshi et al., 2007).

Particularly, so called, turtle neck syndrome is a serious health problem in VDT related syndromes. It affects the mobility of the neck-back region and adjacent muscles leading to functional disabilities. It is clinically important to increase our understanding of the effects of turtle

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neck syndrome on the relationship between the movements of the cervical spine and adjacent muscles.

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 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 are important for controlling and supporting of the cervical lordosis and maintaining of cervical spine postural form (Boyd et al., 2002; Vasavada et al., 1998).

The upper trapezius muscle has often been investigated by EMG during sustained fatiguing contractions in relation to neck pain (ÖBerg et al, 1992). The decrease of Median frequency of the EMG signal has proven to be an indicator of neuromuscular fatigue for the upper trapezius, as well as for other muscles (Basmajian and DeLuca, 1985; Moritani et al., 1986; Madeleine et al, 2002). Besides objectively measurable indicators, a subjective factor is also a conceptual part of fatigue (Simonson and Weiser, 1976). The perception of exertion has been used in many previous studies, especially in the research fields of medicine and sports physiology. The Median frequency, as an indicator of objective detectable fatigue, seems to be a sensitive measure for subjective sensation of fatigue. There are a few studies that compare changes in perceived exertion with changes in the EMG signal during fatiguing muscle contractions (Hummel et al, 2005).

In this study, we investigated the effects of turtle neck syndrome on muscular fatigue and muscle activity during the prolonged casual computer work. We also provided the quantitative data which correlation muscle fatigue and EMG activity in turtle neck syndrome patient..

2. Methods

Six male subjects participated in this study. The average values of the subjects' anthropometrical data were as follows: age (mean±SD) 28±2 yrs; height 168±7 cm; weight 67±11.0 kg (Table 1). The standard of judgment has not been accurate in turtle neck posture until now. In this study, we had an arbitrary decision using the radius curvature of cervical vertebrae about the standard of normal or turtle neck posture. The radius curvature of cervical vertebrae was 0.08 in normal neck posture and was 0 in a straight. Thus, in this study, we had decided that the range of turtle neck posture was from 0 to 0.027, the range of progressing to turtle neck posture was from 0.027 to 0.054, and the range of normal neck posture was from 0.054 to 0.080.

Table 1 Anthropometrical data of the subjects

	Age	Height	Mass	The radius curvature of cervical vertebrae
Group 1	26	168 cm	67 kg	0.075
	26	170 cm	65 kg	0.070
	28	170 cm	70 kg	0.070
Group 2	27	169 cm	70 kg	0.015
	28	168 cm	66 kg	0.010
	28	170 cm	68 kg	0.020

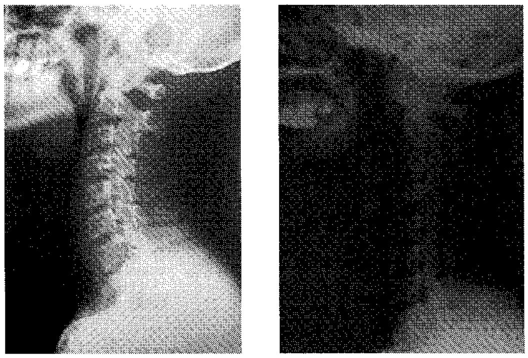


Fig. 1 Normal neck posture and turtle neck posture

They were divided into two different groups: group 1 - three normal subjects who were in good health with no history of neck or back pain within the last 12 months, group 2 - three subjects in turtle neck syndrome (Fig. 1). There were no significant differences among the two groups of subjects regarding age, weight and height. Subjects were excluded if they had inflammatory joint disease, fracture/dislocation of the vertebral column, history of spinal surgery, neurological signs or unable to perform trunk movements due to unbearable pain. Subjects were informed about the experimental procedure and any potential risks prior to the attainment of written consent. Subjects were asked to perform a prolonged casual computer work for three hours as shown in Fig. 2. Each subject sat on a chair watching the computer monitor and rest hands on the desk. The seat height was adjusted for each subject before the experiment to maintain the upper arm in an upright position and the lower arm horizontal. EMG signals from six muscles of the dominant neck-back region were acquired (Oatis, 2004) and recorded for 10 seconds at the beginning and the end of the three-hour computer work. The selected six muscles were as follows: thoracolumbar paraspinal(TP), sternocleidomastoid(SCM), upper trapezius(UT), middle trapezius(MT), infraspinatus(IS), latissimus dorsi (LAT). The EMG data were acquired simultaneously from six muscles, using an eight-channel portable system of EMG amplifiers connected in parallel (MyoSystem 1400, Noraxon USA, Inc.). After

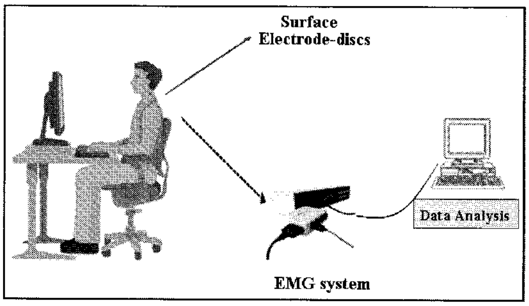


Fig. 2 Experimental setup

having and scrubbing the skin with alcohol, disposable Ag/AgCl surface electrodediscs with a diameter of 9 mm (Noraxon Dual Electrodes) were attached to the subject's skin at locations recommended by Perotto and Delagi (1996). For each muscle, two electrodes were placed at a distance of 20 mm in the direction of the muscle fibers. A reference electrode, shared by the six measurement channels, was placed on the bony part of the lateral aspect of the knee joint. Cables and interfaces were shielded to eliminate interferences. EMG was recorded from six muscles of the dominant neck-back region using a computerized data recording and analysis system. EMG signals were pre-amplified by factors in the range of 1000–4000 (depending on the subject) and captured by a 12-bit A/D board (PLC 818, Scientific Solution Lab, USA) at a sampling rate of 1 kHz. The evolution of the power spectrum function of each six muscles of interest was calculated off-line by means of a signal processing software package. Signal envelopes were calculated using a digital band, 10-200 Hz band pass filter, 60 Hz band stop filter and six-order Butterworth 7–11 Hz filter (Winter, 1995) to evaluate the activity time frames of the EMG bursts and to locate the mid-time values of their duration. And then those were smoothed with a 'moving average' filter of 21 points and normalized with respect to the maximal value achieved during trials.

3. Results

Muscular activities in two postures are shown in Table 2. After 3 hours, muscle activities are increased by 25±2.1 % to 35±3.2 % in normal neck posture. On the other side, muscle activities are increased by 17±1.7 % to 27±1.8 % in turtle neck posture. Especially muscle activity of SCM is increased by 17±1.7 % in a turtle neck posture whereas it is increased by 35±3.2 % in normal neck posture. Median frequencies of selected muscles for turtle and normal neck postures are shown in Table 3. After 3 hours, median frequencies are decreased by 16±2.7 % to 22±2.3 % in normal neck posture. On the other side, median frequencies are decreased by 26±2.7 % to 38±3.2 % in turtle neck posture. Especially median frequencies of SCM are decreased by 38±3.2 % in a turtle neck posture whereas it is decreased by 16±2.7 % in normal neck posture.

4. Discussion

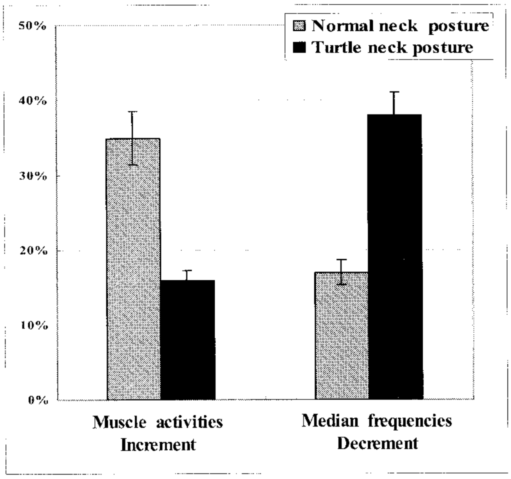
In turtle neck posture the increment of muscle activity was smaller and the muscle fatigue was developed more rapidly (Fig. 3). This result was considered as the fact that neck-back muscles kept on being strained and contracting excessively for the purpose of stabilizing the head. Especially SCM showed the biggest change. This result was attributed to the unique anatomical role of SCM as a head-neck flexor and rotator. Consequently, we can conjecture that the prolonged computer work in turtle neck posture would develop more severe stiffness and fatigue on muscles from unbalanced muscle contraction due to the structural instability of head-neck musculo-skeletal system. The chronic appearance of this symptom with abnormal muscular development can cause severe muscle pain. Also there is higher probability of the herniation of cervical vertebral disc. In the future study, we will investigate the correlation

Table 2 Muscle activities increment of the selected muscles

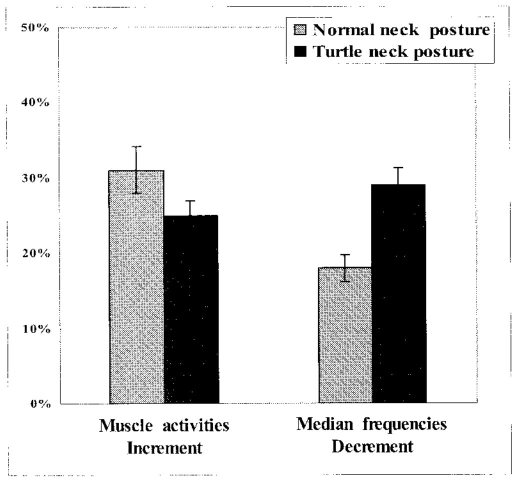
Posture / Muscle	normal neck posture	turtle neck posture
Thoracolumbar Paraspinal	31±2.1 %	27±1.8 %
Sternocleidomastoid	35±3.2 %	17±1.7 %
Upper Trapezius	25±2.5 %	24±2.3 %
Middle Trapezius	31±2.9 %	27±1.8 %
Infraspinatus	29±2.5 %	25±2.1 %
Latissimus dorsi	31±2.3 %	25±2.5 %

Table 3 Median frequencies decrement of the selected muscles

Posture / Muscle	normal neck posture	turtle neck posture
Thoracolumbar Paraspinal	17±2.2 %	26±2.7 %
Sternocleidomastoid	16±2.7 %	38±3.2 %
Upper Trapezius	22±2.3 %	30±2.2 %
Middle Trapezius	18±2.0 %	30±2.2 %
Infraspinatus	20±2.3 %	25±2.6 %
Latissimus dorsi	18±2.2 %	29±2.3 %



(a)



(b)

Fig. 3 Correlation between muscular fatigue and muscle activity of SCM (a) and LAT (b) between the mechanisms of cervical vertebral column and neck muscles by using computer simulation and kinematic analysis for turtle neck posture.

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