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The effects of using a single display screen versus dual screens on neck-shoulder muscle activity during computer tasks

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ABSTRACT

The present study compared the effects of using one versus two display screens on cervical muscle activity of computer users. Healthy pain-free university students were recruited (11 males and 11 females), and surface electromyography in bilateral cervical erector spinae and upper trapezius (UT) muscles was measured. Each subject performed standardized text editing tasks for 15 min using a single screen and dual screens in a randomized order. In the dual screen condition, the primary screen was placed directly in front while the secondary screen was angled to the right of the user. Significant reductions of the 50th and 90th percentile amplitudes, representative of dynamic muscle loading, were found in the right UT muscle for dual screen condition. The 10th percentile muscle activity was similar in all muscles in the two conditions. These results suggest that viewing dual screens may be associated with different postural muscle activity compared to single screen.

Relevance to industry: Use of two display screens is now a very common practice in the office setting. The results of this study will provide information about how the viewing of two screens will affect the muscle activity in the neck region.

1. Introduction

Computers play an essential role in people's daily lives all over the world. Although the physical demands of computer work are relatively low in terms of physiological exertion, there have been increasing reports of adverse health effects as a result of prolonged computer use. Various studies have reported a high prevalence of work-related musculoskeletal disorders (WMSD) among computer users (Tittiranonda et al., 1999; Buckle and Devereux, 2002; Gerr et al., 2004; Andersen et al., 2011). The computer workstation setting has been reported to contribute to physical risk factors which may ultimately contribute to musculoskeletal disorders. Static neck and upper limb posture associated with prolonged viewing of a display screen has been identified as one of the major risk factors for WMSD (Bergqvist et al., 1995; Gerr et al., 2004; Szeto et al., 2005a). Static neck posture is often associated with higher levels of postural muscle activity, and this has been demonstrated to be a common feature among symptomatic office workers with chronic neck and upper limb pain (Szeto et al., 2005a, 2009).

In the ergonomic literature regarding computer display screen location, the commonly adopted recommendation is to place the display screen directly in front of the user, and the top of the screen should be at eye level and at a suitable distance (range: 40–70 cm) from the eyes (Grandjean et al., 1983; Psihogios et al., 2001). To understand how the display screen position affects the users physically, past research has focused on examining what the optimal height of the display screen should be. There have been arguments about whether the display screen should be placed at a higher or lower position and how this may affect both the visual comfort and the muscle load in the neck region of the user (Mon-Williams et al., 1999; Burgess-Limerick et al., 2000; Sommerich et al., 2001; Seghers et al., 2003; Fostervold et al., 2006; Straker et al., 2008; Kothiyal and Bjornerem, 2009). It has been proposed that a downward gaze angle of about 15° is more appropriate for visual comfort (Jaschinshi-Kruza et al., 1998; Mon-Williams et al., 1999; Sommerich et al., 2001). However, from the biomechanical perspective, a lower screen position is associated with an increase in the cervical muscle activity required to maintain the head position against gravitational pull (Turville et al., 1998; Seghers et al., 2003). Straker et al. (2008) reviewed all of the currently available research studies at the time, on the effects of display screen height on cervical muscle activity, and all the studies they reviewed involved examining single screens and comparing different screen heights in the sagittal plane. A recent study compared three screen positions – front-on, angled left, and angled right – and found that neck muscle activity is lowest when a screen is viewed from a direct front-on position (Szeto and Sham, 2008).

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The past research has mainly examined the issue of display screen setting using only one screen. In the modern day office, it is very common for computer users to use two or even three screens at the same time. In recent years, many offices workers have adopted the practice of using two display screens simultaneously as they find this more convenient for processing a large amount of information or viewing more than one document at a time. The use of dual screens may also lead to less printing of hard copies of documents for concurrent viewing, which is beneficial for the environment. As this practice becomes more and more common, it is important to examine how it affects the postural muscle loading of intensive computer users.

Usually, an office worker has a primary screen placed in the centre and another screen placed on the side, either on the left or right, for occasional use only. Another arrangement that is commonly adopted is to have two screens placed side by side and used simultaneously all the time. Either way, the viewing of two screens may affect the neck-shoulder muscles differently compared to using one screen only. Nimbarte et al. (2013) examined the head-neck posture and neck muscle activity when healthy university students performed reading and typing tasks with dual screens. In that study, the dual screens were placed side by side in a straight line and the person positioned in midline in between the two screens. It was reported that the nature of the task had an important influence on the extent of head-neck movements and the muscle activity involved in performing the tasks. The authors also suggested that more different arrangements of the display screens in relation to the keyboard and mouse positions should be explored. In the present study the effects of one specific dual screen setting was investigated, with the primary screen placed in the centre and a second screen placed on one side. The results from the present study will reveal how the neck muscles would change when subjects performed text-editing tasks using a single screen versus a dual screen arrangement. This may provide useful information on the potential effects in terms of musculoskeletal loading in computer users resulting from the use of dual screens.

2. Methods

2.1. Subjects

Twenty-two healthy university students, 11 males and 11 females, were recruited by convenience sampling. The study design involved only one subject group, and each subject had to perform two standardized tasks. Within-subject comparisons were conducted on the effects of the performed tasks on cervical muscle activity. To ensure that the subjects could complete the computer tasks, one of the inclusion criteria for subject recruitment was a regular pattern of computer usage for at least 2 years (minimum 1 h/day). Those who had a history of neck, shoulder, or back pain or a trauma to these regions in the past 6 months were excluded. All subjects were asked to complete a Northwick Park neck pain questionnaire (Leak and Cooper, 1994) in order to assess their current neck pain condition, and those with a score of >6 were excluded. The subjects' demographic characteristics are summarized in Table 1. All subjects provided informed consent, and the study was approved by the Hong Kong Polytechnic University Human Ethics Committee.

2.2. Surface electromyography

The primary dependent variables for this study were the amplitude metrics of electromyographic activity in four muscles: the right and left upper trapezius (UT) and the left and right cervical erector spinae (CES). The Noraxon Telemyo System (Noraxon, USA Inc., USA) with a sampling frequency of 1000 Hz and a bandwidth of 10–500 Hz was used to record the surface electromyography (EMG) of these four muscles. The electrode placement area was cleaned using sand paper and swabbed with alcohol, and hair was shaved if necessary. Skin impedance was measured by a Noraxon impedance meter, and a value less than 10 kΩ was considered acceptable. Bipolar silver–silver chloride electrodes (3 M Infant Red Dot™, 15 mm in diameter, 3 M Hong Kong Ltd., Hong Kong) were placed on the skin surface of the bilateral CES and UT areas with a 2 cm inter-electrode distance. For the CES muscle, electrodes were placed at about 1 cm lateral to the spinous processes of C4 and C5 bilaterally. For the UT muscle, electrodes were placed on the midpoint between the spinous process of C7 and the tip of the acromion. A ground electrode was placed on the spinous process of C7. Prior to starting the experimental trials, each subject was required to perform three trials of maximum voluntary contractions (MVC) of the CES and UT muscles to normalise the EMG signals. To test the MVC of the CES muscles, the subject had to perform a resisted neck extension against a loadcell positioned at the occiput with maximal effort. The subject was in a sitting position with back supported, and each contraction lasted for 5 s. To test the MVC of the UT muscles, the subject had to perform resisted shoulder elevation against a shoulder strap (connected to a loadcell fixed to the floor) using maximal effort. In the CES muscle test, both muscles were tested simultaneously whereas in the UT muscle test, the two sides were tested separately. The Noraxon system comes with a function to detect the maximum EMG signal for each muscle in a series of MVC contractions. Then the EMG data files collected during the text-editing tasks can be normalised to these "MVC" values for each muscle.

2.3. Experimental procedures

Each subject performed two computer tasks at a standardized workstation. A desktop computer with a 15″ LCD display screen (Samsung SyncMaster 151 s) was used as the primary screen, while a second screen (17″) angled laterally at 15° on the right hand side for the dual screen task (see Fig. 1).

A swivel chair with adjustable seat height and a backrest was provided. The keyboard was placed on an adjustable slide-out tray without wrist support. All subjects were advised to adjust the chair

Table 1
Demographic characteristics of subjects ($n = 22$).

Variable	All	Male ($n = 11$)	Female ($n = 11$)	Difference between groups
Age in yrs: mean (sd)	20.41 (.85)	20.55 (1.04)	20.27 (.65)	$t = -.741$, $p = .467$
Height in cm: mean (sd)	165.21 (8.34)	171.82 (3.87)	158.59 (5.89)	$t = -6.223$, $p = .000$*
Weight in kg: mean (sd)	55.73 (9.39)	61.71 (9.15)	49.75 (4.76)	$t = -3.847$, $p = .001$*
BMI: mean (sd)	20.34 (2.38)	20.88 (2.81)	19.80 (1.84)	$t = -1.072$, $p = .297$
NDI Score: mean (sd)	2.00 (1.88)	2.36 (1.63)	1.64 (2.11)	$t = -.905$, $p = 0376$
Handedness	Right = 22	–	–	–

*p significant at <.05.