International Journal of Industrial Ergonomics 49 (2015) 53–59

Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

Neck and shoulder muscle activity among ophthalmologists during routine clinical examinations

Nathan B. Fethke [a,*], Mark C. Schall Jr. [b], Emily M. Determan [a], Anna S. Kitzmann [c]

[a] Department of Occupational and Environmental Health, College of Public Health, University of Iowa, Iowa City, IA 52242, USA
[b] Department of Industrial and Systems Engineering, Samuel Ginn College of Engineering, Auburn University, Auburn, AL 36849, USA
[c] Department of Ophthalmology, Mayo Clinic, Mayo Clinic Health System Fairmont, Fairmont, MN 56301, USA

ARTICLE INFO

Article history:
Received 7 January 2015
Received in revised form
19 March 2015
Accepted 3 June 2015
Available online 20 June 2015

Keywords:
Healthcare
Musculoskeletal
Workplace ergonomics
Shoulder

ABSTRACT

Muscular demands during common clinical ophthalmologic activities may contribute to the high prevalence of musculoskeletal health outcomes observed among ophthalmologists and other eye care physicians. Characterizations of the muscle activation patterns in the live ophthalmologic environment are lacking. This study was conducted to (i) characterize the frequencies and durations of common activities performed by ophthalmologists during routine clinical examinations, (ii) characterize neck and shoulder muscle activation patterns during the whole clinical work day, and (iii) explore differences in neck and shoulder muscle activation patterns between common clinical activities. Fifteen ophthalmologists performed routine patient examinations in an outpatient ophthalmology clinic while continuous surface electromyography measurements of the upper trapezius and anterior deltoid muscles were obtained. Results indicated that while computer use was the most frequently performed clinical activity, use of the indirect ophthalmoscope, followed by use of the slit lamp biomicroscope, required greater muscular demands than computer use or other clinical activities. Results provide evidence that the clinical activities of indirect ophthalmoscope and slit lamp biomicroscope use are appropriate for ergonomic intervention.

1. Introduction

Musculoskeletal health outcomes represent the second greatest cause of disability worldwide (Vos et al. 2013), and their impact on the health of the world population is only expected to increase (Murray et al. 2013). Neck and shoulder pain, in particular, is very common. Of the 291 conditions studied in the Global Burden of Disease 2010 Study, neck and shoulder pain ranked 4th highest in terms of disability, and 21st in terms of overall burden (Hoy et al. 2014).

Musculoskeletal pain is common among ophthalmologists and other eye care physicians (Chams et al. 2004; Chatterjee et al. 1994; Dhimitri et al. 2005; Kitzmann et al. 2012; Sivak-Callcott et al. 2011). In particular, pain and discomfort in the neck and shoulder region is reported more frequently by eye care physicians than peers in other medical specialties (Kitzmann et al. 2012). Consequences of this pain and physical discomfort include reduced working hours, regular pursuit of medical treatment, and job change (Long et al. 2012a, 2012b, 2014).

Positive associations have been observed between exposure to physical risk factors and musculoskeletal symptoms of the neck and shoulder among many occupational groups in the health care sector, including dentists and dental hygienists (Hayes et al. 2009, 2013; Occhionero et al. 2014), hospital physicians (Hengel et al. 2011), and surgeons (Gofrit et al. 2008; Nimbarte et al. 2013a, 2013b; Rambabu and Suneetha, 2014; Sivak-Callcott et al. 2011; Stomberg et al. 2010; Szeto et al. 2009). Similar to office workers and other occupational groups with work characterized by relatively low physical demands, the muscular demands resulting from sustained, non-neutral working postures may contribute to the development of musculoskeletal pain and associated health outcomes in health care workers (Hägg, 2000; Sjøgaard et al. 2000; Christensen and Knardahl, 2010; Richter et al. 2009; Caruso and Waters, 2008; Nimbarte et al. 2013a; Waters et al. 2006).

In a previous cross-sectional study, eye care physicians reported “working in awkward/cramped positions” and “working in the same position for long periods” as job factors contributing to musculoskeletal symptoms to a greater extent than family

* Corresponding author.
E-mail address: nathan-fethke@uiowa.edu (N.B. Fethke).

http://dx.doi.org/10.1016/j.ergon.2015.06.001
0169-8141/

medicine physicians (Kitzmann et al. 2012). More recently, Schall Jr et al. (2014) examined the effect of alternative designs of equipment frequently used in the clinical ophthalmologic environment (e.g., the slit lamp biomicroscope and the binocular indirect ophthalmoscope) on estimates of neck and shoulder muscular activation levels among ophthalmologists performing mock clinical examinations. Although results of Schall Jr et al. (2014) suggested that alternative examination equipment may reduce neck and shoulder muscular loading, a more complete understanding of the tasks performed and muscle activation patterns during the live clinical environment is needed to develop maximally effective strategies to mitigate MSD risk factors among ophthalmologists and other eye care physicians.

The objectives of this study, therefore, were to (i) characterize the frequencies and durations of common activities performed by ophthalmologists during routine clinical examinations, (ii) characterize neck and shoulder muscle activation patterns during the whole clinical work day, and (iii) explore differences in neck and shoulder muscle activation patterns between common clinical activities.

2. Methods

2.1. Study sample and setting

A convenience sample of 15 faculty, fellow and resident ophthalmologists was recruited from the University of Iowa Hospitals and Clinics (UIHC) Department of Ophthalmology, representing a variety of ophthalmology specialties (e.g., cornea, glaucoma and retina). Participants reported no history of physician-diagnosed musculoskeletal health outcomes in the neck and/or shoulder region and no episodes of neck and/or shoulder pain within 14 days prior to participation. All study procedures were approved by the University of Iowa Institutional Review Board.

2.2. Data collection procedures

Data were collected as participants performed routine patient examinations in outpatient ophthalmology clinics affiliated with the UIHC (located at the main hospital, the Veteran's Affairs Hospital, and the UIHC Iowa River Landing outpatient facility). Examination rooms at each location were similar in physical square footage and contained essentially identical examination equipment, furniture (for both patients and the clinicians) and computer hardware.

Each participant was observed across two full working days while performing routine outpatient clinical activities. Common clinical activities included 1) examining a patient using a slit lamp biomicroscope, 2) examining a patient with an indirect ophthalmoscope, 3) “documentation”, such as using a computer or completing paperwork, and 4) other activities. Examples of other activities included (but were not limited to) applying eye drops, using a cotton swab to apply medicine, using a tonopen, completing a vision examination with a Snellen chart, using a phoropter, answering a phone call, and speaking with a nurse or attending physician. A research assistant shadowed each participant and, using a tablet computer, recorded the time (to the nearest second) at which specific clinical activities began and ended. The tablet computer was then used to export the activity time records to ASCII text files.

2.3. Surface electromyography instrumentation and procedures

For each participant and observation day, continuous surface electromyography (EMG) recordings were obtained bilaterally from the upper trapezius and anterior deltoid muscles. Preamplified EMG electrodes (model DE2.3, Delsys Inc., Boston, MA, USA; bandwidth 20–450 Hz) were positioned according to published guidelines (Criswell, 2010), and a reference electrode was attached to the skin over the non-dominant clavicle. The electrodes were connected to a portable EMG instrumentation amplifier and data logger (Myomonitor IV®, Delsys Inc., Boston, MA), and the raw EMG signals were sampled at 1000 Hz and stored on a compact flash memory card. The raw EMG recordings were then transferred to a desktop computer workstation for signal processing and analysis.

All EMG signal processing and analysis was performed using custom LabVIEW (version 2013, National Instruments, Inc., Austin, TX, USA) and Matlab (r2013b, The Math Works, Inc., Natick, MA, USA) programs. First, unprocessed EMG recordings were visually scanned for obvious transient artifacts which were removed and replaced with the mean voltage of the entire recording period. Then, the mean voltage value of the unprocessed EMG files was subtracted to remove DC offset and the power spectral density of each EMG recording was examined to identify possible sources of interference with the EMG signals (e.g., 60 Hz or electrocardiogram). If present, interference was attenuated using standard filtering methods (Drake and Callaghan, 2006; Redfern et al. 1993). Finally, each raw EMG recording was converted to instantaneous root-mean-square (RMS) amplitude using a 100-sample moving window with a 50-sample overlap.

For each muscle group, the RMS EMG amplitudes recorded during working activities were expressed as a percentage of the RMS EMG amplitude observed during submaximal, isometric reference contractions (%RVE). For the upper trapezius, reference contractions were obtained while the participant held a 2 kg weight in each hand with the upper arms elevated to 90° in the scapular plane, elbows fully extended and forearms pronated (Mathiassen et al. 1995). For the anterior deltoid, participants held a 2 kg weight in each hand with the upper arms flexed forward to 90° of elevation and the elbows fully extended (Cook et al. 2004; Yoo et al. 2010; Rota et al. 2013). Three repetitions of each reference contraction were performed, with a 1-min rest between repetitions. Participants maintained each reference contraction for 15 s and the mean RMS amplitude of the middle 10 s was calculated. For each muscle separately, the average of the mean RMS EMG amplitudes of the three reference contractions was used as the RVE activation level. For each muscle, baseline noise was defined as the lowest RMS EMG amplitude observed during the full-shift EMG recording and subtracted from all other RMS EMG amplitude values in a power sense (Thorn et al. 2007).

2.4. Measurements

2.4.1. Clinical activities

The number of examinations performed during any observation day ranged from 8 to 43. For observations days during which more than 8 examinations were performed, we randomly-selected 8 examinations for analysis. For the 8 examinations selected for each participant on each observation day and using the activity time records, we then tabulated the frequency and duration of the clinical activities described above.

2.4.2. Surface EMG

For each participant and observation day and using the activity time records, we computed EMG summary measures (i) across each full-shift recording, (ii) across each of the 8 patient examinations selected for analysis within each shift, and (iii) for each clinical activity observed within each of these 8 examinations. For each muscle separately, EMG summary measures included the mean RMS amplitude (in %RVE), the 10th and 90th percentiles of the