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Exposure to a workday environment results in an increase in anterior tilting of the scapula in dental hygienists with greater employment experience

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ABSTRACT

Background: Dental hygienists suffer a high incidence of shoulder pathology that seems to increase with job longevity. It has been hypothesized that occupational injuries could be due to local muscle fatigue caused by repetitive low level work and awkward and constrained working postures. In the laboratory, scapular kinematics can be temporarily altered using fatiguing protocols. It is unknown whether or not workday fatigue causes changes to scapular kinematics. The aim of this study was to examine if changes in scapular tilt and rotation occurs after a workday in dental hygienists.
Methods: The pre and post workday scapular kinematics were recorded from dental hygienists using an electromagnetic tracking system. All data were recorded within the place of employment of the dental hygienist.
Results: Following the workday, there was significantly more scapular anterior tilt in dental hygienists ($P<0.05$); however, no changes were found for upward or internal rotation. Greater kinematic differences were found for hygienists with greater job longevity.
Interpretation: The increase in scapular anterior tilting could be due to post workday fatigue. Anterior tilting of the scapula may have an influence on the development of subacromial impingement syndrome. Hygienists with greater duration of work experience may be at greater risk for developing shoulder injuries as they have more anterior tilting of the scapula post workday.

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1. Introduction

Dental hygienists have a high incidence of shoulder related pain and pathology, which may be associated with the demands of the workplace environment and/or work-related tasks. Repetitive arm motions, especially above 60° and 90° of humeral elevation, are highly associated with the development of shoulder pathology (Svendsen et al. 2004b). In dental hygienists, elevated and repetitive arm motions are common (Akesson et al. 1999). Studies have also shown an association between prolonged elevated arm positions and the development of work-related disorders (Ohlsson et al., 1994; Svendsen et al. 2004a). In 2007, the United States Department of Labor reported that in the private industry over 335,000 musculoskeletal injuries occurred resulting in approximately 3 million missed days of work. For dental hygienists, between 11% and 68% of work-related injuries occur in the upper extremities (Akesson et al. 1999; Bernard, 1997). Although not all manual labor-intensive careers are the same, many result in similar musculoskeletal disorders (MSDs) of the upper extremity, such as carpal tunnel syndrome, shoulder impingement syndrome and neck pain (Akesson et al. 1999). In other occupations such as house painters, machinists and car mechanics, an association between arm abduction exposure and shoulder injuries has been made (Svendsen et al. 2004a)

Dental hygienists are exposed to workday fatigue since their job often requires low level static loads on the shoulder as well as awkward and constrained postures of the trunk (Akesson et al. 1999; Marklin and Cherney 2005). Greenfield et al. conducted a study comparing patients with overuse shoulder injuries to healthy controls. Results from their study suggest an association between prolonged forward head position and overuse shoulder injuries (Greenfield et al. 1995). It has been reported that dental hygienists spend 66% of their working time in a seated position with their neck flexed at 60° and with their trunk flexed to 30° or higher (Marklin and Cherney 2005). Additionally, hygienists maintain an elevated and abducted shoulder position for at least half of the time working with each patient (Marklin and Cherney 2005). A flexed trunk posture has been associated with altered scapular kinematics and decreased muscle force, particularly with the arm in an elevated position (Kebaetse et al. 1999).

In healthy populations, upper extremity fatiguing protocols result in altered scapular kinematics (Borstad et al., 2009b; Ebaugh et al., 2006a, b; McQuade et al. 1998; Tsai et al. 2003). Multiple studies show that with a decrease in muscle performance, a reduction in

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scapular posterior tilting occurs; however, these studies found variable effects of scapular upward and internal rotation (Borstad et al., 2009b; Ebaugh et al., 2006a, b; McQuade and Smidt, 1995; McQuade et al. 1998; Tsai et al. 2003). Weakness, and/or fatigue of the serratus anterior and the trapezius muscles may be responsible for a reduction in posterior tilting of the scapula and may be associated with degeneration of the rotator cuff (Borstad et al., 2009b). These muscles, when functioning properly, are believed to help maintain adequate space between the acromion process and the head of the humerus (Endo et al. 2001).While the direct effects of fatigue have been studied in the laboratory using various fatiguing protocols, the relationship between repetitive arm motions in the workplace and altered scapular kinematics remains unstudied. This would lead to great insights for understanding occupational shoulder injury risk and prevention.

Upper extremity MSDs in the workplace have been correlated with job longevity, where greater duration of work exposure yields a higher occurrence of injury (Akesson et al. 1999; Anton et al. 2002; Ohlsson et al., 1994). In a five-year longitudinal study, Akesson et al. found that the cumulative exposure to occupational demands in dental hygiene increased the risk of shoulder injury development (Akesson et al. 1999). Additionally, all dental hygienists who had left the profession during the five-year study had symptoms of upper extremity disorders. Anton et al. composed a survey of 109 practicing dental hygienists and the survey indicated that hygienists practicing for more than 22 years had significantly more symptoms of carpal tunnel syndrome as well as other upper extremity MSDs. Moreover, hygienists with less than 12 years of work experience had no pain-related complaints or symptoms of MSDs.

The present study uses biomechanical measures of shoulder motion (scapular kinematics), to investigate the effect of dental hygiene work. We hypothesize that scapular kinematics will be altered at the end of a workday in dental hygienists. Additionally, we hypothesize that hygienists with more years of work experience will demonstrate greater changes in scapular kinematics than less experienced hygienists.

2. Methods

2.1. Subjects

Thirty-four female dental hygienists with a mean age of 44 years (24–58 years), mean work experience of 17 years (2–38 years), mean height of 1.7 m, and mean mass of 70 kg participated in the study. On average, dental hygienists worked for 9 hours and treated 7 patients per day. A disability of the arm, shoulder and hand (DASH) work module questionnaire was given to all subjects (Kitis et al. 2009). The mean DASH score for dental hygienists was 9.5 out of 100 (SD 13.5). Groups based on experience were created to reflect findings from the literature, which demonstrated that hygienists with greater than 20 years of work experience have a higher occurrence of upper extremity disorders (Anton et al. 2002) (Table 2). Inclusion criteria required that subjects worked as dental hygienists for at least a year. Additionally, subjects were required to be currently working a minimum of 20 hours per week. No subjects were excluded from the study for shoulder related conditions although shoulder health history was obtained at the time of data collection. Prior to data collection all subjects signed written consent forms, which were approved by the University of Oregon's Institutional Review Board (IRB).

Data were collected before and after a typical workday for dental hygienists. Data were collected within the place of employment of the subject in order to minimize travel time and time between the end of a workday and kinematic measurements. Subjects arrived for data collection approximately one hour before their first patient arrived and were asked to stay one additional hour after their last patient left at the end of the day.

2.2. Instrumentation

The Polhemus Fastrak (Colchester, VT, USA) was used for collecting 3-D *in-vivo* kinematics of the shoulder complex at the workplace of the dental hygienists. The Polhemus unit consists of a transmitter, three receivers and a digitizer, all wired to a system electronics unit, which determines the relative orientation and position of the sensors in space. The transmitter served as a global reference frame and was fixed to a rigid plastic base and oriented such that the coordinate axes aligned with the cardinal planes of the human body. The digitizer sensor was used to identify anatomical landmarks with respect to the global reference frame. After digitization, the arbitrary coordinate systems defined by the Polhemus were converted to anatomically appropriate coordinate systems based on the recommendations of the International Society of Biomechanics Committee for Standardization and Terminology (Wu et al. 2005).

2.3. Set up and digitization

For digitization, subjects were asked to stand in a neutral position with their arms relaxed by their sides. Placement of sensors (receivers) was determined using methods previously validated (Karduna et al. 2001). Between sessions, all sensors were removed and repositioned for the second session. Placements of sensors were recorded using permanent marker. In addition, the sensors typically left an outline on the skin (from pressure) which helped determine sensor repositioning. All subjects were re-digitized during the second session and a new three-dimensional calibration matrix was created. The three receivers were placed on different body segments of the dominant side using double sided adhesive tape. The first receiver was placed on the thorax on the manubrium of the sternum at approximately the level of T3. The second receiver was positioned on the humerus by mounting it to an orthoplast device positioned on the proximal humerus with elastic straps. The final receiver was positioned over the scapula after mounting it on a custom scapular tracking device machined from plastic (Karduna et al. 2001). This tracker was attached to the scapular spine and posterior-lateral acromion with Velcro. The transmitter was then positioned approximately 30 cm behind the subject and was elevated to the height of their scapula using a non-metallic tripod. Anatomical landmarks were then digitized using the Polhemus stylus, for the thorax T8, xiphoid process, C7 and jugular notch. For the scapula the root of the scapular spine, inferior angle and posterior lateral boarder (acromial angle) of the scapula were digitized. For the humeral matrix, the medial and lateral epicondyles were digitized and the center of the humeral head was calculated. To calculate the center of the humeral head, the humerus was manipulated in small circular arcs within the mid-range of motion of the humerus. The center of the humeral head was defined by the point that moved the least with respect to the scapula through a least squares algorithm during humeral calibration (Karduna et al. 2001).

2.4. Experimental procedure

On the day prior to the data collection, subjects signed an informed consent form and completed a shoulder health history questionnaire (DASH). All other data, including total arm elevation exposure were collected before and after a typical workday for dental hygienists. The electromagnetic tracking device system was transported to each dental office to collect data within the workspace environment of the subjects. A metallic interference protocol was developed to ensure that each workspace was suitable for data collection and would not interfere with the electromagnetic tracking system. Prior to