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Differences in the activation and co-activation ratios of the four subdivisions of trapezius between genders following a computer typing task

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The aim of this study was to provide a description of gender differences of the activation patterns of the four subdivisions of the trapezius (clavicular, upper, middle, lower) following a 60 min computer work task. Surface EMG was collected from these subdivisions from 21 healthy subjects during bilateral arm elevation pre-/post- task. Subjects completed a standardized 60 min computer work task at a standard, ergonomic workstation. Normalized activation and activation ratios of each trapezius subdivision were compared between genders and condition with repeated measures ANOVAs. The interaction effect of Gender × Condition for upper trapezius% activation approached significance at $p = 0.051$with males demonstrating greater activation post-task. The main effect of Condition was statistically significant for% activation of middle and lower trapezius ($p < 0.05$), with both muscles demonstrating increase activation post-task. There was a statistically significant interaction effect of Gender × Condition for the Middle Trapezius/Upper Trapezius ratio and main effect of Condition for the Clavicular Trapezius/Upper Trapezius ratio, with a decreased ratio post-typing. Gender differences exist following 60 min of a low force computer typing task. Imbalances in muscle activation and activation ratios following computer work may affect total shoulder kinematics and should be further explored.

1. Introduction

Neck and shoulder pain are common work-related musculoskeletal disorders (WMSD), occurring with both manual labor and desk work. Risk factors for these conditions include: repetitive and/or sustained loading on the neck and upper extremities caused by maintaining static postures (Baker, Sussman, & Redfern, 2008; Wahlstrom, 2005) and non-neutral neck, shoulder, and elbow postures (Baker et al., 2008; Faucett & Rempel, 1994; Szeto, Straker, & Raine, 2002). Computer use specifically has been well-studied and is considered to be a risk factor for development of WMSD (Baker et al., 2008; Bruno Garza et al., 2012; Szeto et al., 2002; Waersted, Hanvold, & Veiersted, 2010). Computer work is common in modern society and has been associated with musculoskeletal complaints in the neck and upper extremity, especially in female workers (Jensen, Finsen, Søgaard, & Christensen, 2002; Waersted et al., 2010; Wahlstrom, 2005). Recent literature suggests

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that among computer work including mouse-work, keyboarding, and idle activities, keyboarding requires the greatest muscle effort by the trapezius muscle (Bruno Garza et al., 2012; Park & Yoo, 2013; Waersted et al., 2010). This increase in muscle effort by the trapezius may be a contributing factor to the development of trapezius myalgia and musculoskeletal discomfort in the neck/shoulder region.

Previously, it was believed that muscular contraction levels at 15% of maximum voluntary contraction (MVC) were acceptable within the work place. However, research has shown that musculoskeletal disorders of the shoulder are frequent in jobs with low force levels of 2–5%MVC, or even as low as 0.5–1% (de Looze, Bosch, & van Dieen, 2009; Jensen, Schibye, Sogaard, Simonsen, & Sjogaard, 1993). Typical office work activities, including typing, can range between 5–10%MVC (Ciccarelli, Straker, Mathiassen, & Pollock, 2013; Feng, Grooten, Wretenberg, & Arborelius, 1997; Fernstrom, Ericson, & Malker, 1994). Further, several studies have found that these low-intensity forces can cause muscle fatigue, including fatigue of the trapezius muscle (Bosch, de Looze, Kingma, Visser, & van Dieen, 2009; Kimura, Sato, Ochi, Hosoya, & Sadoyama, 2007). It has been postulated that fatigue is a precursor to shoulder pathology, with epidemiological reviews showing a strong correlation between work exposures (both high and low intensity) and shoulder pain/pathology (Bongers, Kremer, & ter Laak, 2002; Punnett & Gold, 2004). Additionally, musculoskeletal symptoms in the neck and shoulder region are positively associated with duration of computer work for females (Jensen et al., 2002).

Trapezius myalgia is a common WMSD often observed in female office workers (Goudy & McLean, 2006; Sjors, Larsson, Dahlman, Falkmer, & Gerdle, 2009). In this condition, pain is reported in the upper trapezius fibers, not in the middle or lower trapezius (Larsson, Bodegard, Henriksson, & Oberg, 1990). Most existing studies that explore muscle activation following work tasks only include these standard three anatomical subdivisions of the trapezius muscle – the upper, middle and lower trapezius (Chopp, Fischer, & Dickerson, 2011; Kim, Ahn, Jeon, & Lee, 2012; Kimura et al., 2007; Ludewig & Cook, 2000; Szucs, Navalgund, & Borstad, 2009). However, previous research has demonstrated that the upper trapezius is not uniformly activated and that the upper trapezius can be further divided into two functional portions: the clavicular and upper trapezius, each of which can be independently activated from the other (Falla & Farina, 2008; Holtermann et al., 2009; Jensen & Westgaard, 1995; Jensen & Westgaard, 1997). Previous studies have demonstrated differences in co-activation ratios of the upper trapezius and serratus anterior following a fatiguing task or exercise and in clinical populations (Cools, Declercq, Cambier, Mahieu, & Witvrouw, 2007; Michener, Sharma, Cools, & Timmons, 2016; Szucs et al., 2009), though a recent study by Larsen and colleagues did not find significant differences in co-activation ratios in persons with subacromial impingement syndrome (Larsen, Sogaard, Chreiteh, Holtermann, & Juul-Kristensen, 2013). As the two subdivisions of the upper trapezius insert onto different bony segments of the shoulder – the clavicular trapezius onto the clavicle and the upper trapezius onto the scapula – altered co-activation between these two subdivisions may affect scapula and clavicle kinematics differently (Michener et al., 2016; Park & Yoo, 2013; Szucs et al., 2009; Zanca, Oliveira, Ansanello, Barros, & Mattiello, 2014). Therefore, in order to develop a complete picture of work-related changes in trapezius muscle activation, it is necessary to capture the muscle activation of the clavicular subdivision of trapezius in studies of muscle activation and computer work.

Female workers who use computers for prolonged periods of the work day report musculoskeletal symptoms twice as frequently as their male counterparts (Jensen et al., 2002). Differences have been observed in trapezius activation following work or exercise tasks between genders, (Borstad, Szucs, & Navalgund, 2009; Nussbaum, 2001; Nussbaum, Clark, Lanza, & Rice, 2001), though a more recent study demonstrated that gender differences may be task and extremity specific (Senefeld, Yoon, Bement, & Hunter, 2013). Some reports have found no differences between gender following a fatiguing activity (Hunter, Critchlow, Shin, & Enoka, 2004; Hunter & Enoka, 2001). Whether muscle activation changes manifest differentially between genders at low-intensity forces or within the clavicular trapezius is not currently known. Given that there is a higher prevalence of musculoskeletal disorders in females (Jensen et al., 2002; Nordander et al., 2008), gender differences of muscle activation patterns should be explored as a risk factor for pathology.

The purpose of this study was to explore the effects of a constant 60 min keyboarding task on the activation and co-activation ratios of the four subdivisions of trapezius. In order to better understand work-related changes in muscle activation and associated shoulder disorders, it is necessary to describe how low-intensity forces impact each of the four subdivisions of the trapezius. Additionally, the effects of gender on muscle activation following typing were examined. We hypothesized that normalized activation and co-activation ratios between the four parts of trapezius would differ following a 60 min computer work task and that these changes would be different between genders.

2. Methods

2.1. Subjects

Subjects were recruited from the University's student population. Exclusion criteria included history of or current shoulder injury or disorder, acute shoulder pain, metal implant, and body mass index $\geqslant$25. All potential participants underwent a physical screening to determine eligibility. The screening included an assessment of upper extremity (UE) range of motion, strength, and tests for underlying shoulder pathology. Based on a power analysis using previous EMG data acquired by the primary investigator to account for error, 20–23 subjects were required to find statistically significant differences at a power of 0.80. Twenty-one subjects completed this study (average age (SD): 21.2 ± 0.92; 10 females, 11 males). This study was approved by the institution's IRB, and all subjects provided informed consent prior to starting data collection.