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Spinal kinematics during smartphone texting – A comparison between young adults with and without chronic neck-shoulder pain

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ABSTRACT

To advance our understanding about the association between smartphone use and chronic neck-shoulder pain, the objective of this study was to compare spinal kinematics between different text-entry methods in smartphone users with and without chronic neck-shoulder pain. Symptomatic (n = 19) and healthy participants (n = 18) were recruited and they performed three tasks: texting on a smartphone with one hand, with two hands, and typing on a desktop computer. Three-dimensional kinematics were examined in the cervical, thoracic and lumbar regions for each task. This study suggests that altered kinematics may be associated with pain since significantly increased angles of cervical right side flexion during smartphone texting and greater postural changes in cervical rotation were found during all text-entry tasks in the symptomatic group. Two-handed texting was associated with increased cervical flexion while one-handed texting was correlated with an asymmetric neck posture, indicating both text-entry methods are not favorable in terms of spinal postures.

1. Introduction

Mobile information technology (IT) devices such as computers and smartphones are making a tremendous impact on people's lifestyle as well as their health. Musculoskeletal disorders are widely reported among computer users (Waersted et al., 2010; Madeleine et al., 2013) in the past decades. Recently, musculoskeletal symptoms among smartphone users have gained increasing attentions. Musculoskeletal complaints in the neck region have the highest prevalence rate compared with other body parts among handheld device users, ranging from 17.3% to 67.8% in different countries, including China, Canada, South Korean, and India (Xie et al., 2017). The prevalence of chronic neck-shoulder pain has increased significantly among the 20- to 34-year-old population in the past two decades (Hagen et al., 2011). The growing use of computers and handheld devices such as mobile phones among the young population has been proposed to be “the most probable explanation” for the rise in the prevalence of neck-shoulder pain (Hagen et al., 2011). To understand the relationship between computer use and neck-shoulder pain, motor control patterns such as muscle activation and kinematics of the neck and the shoulder girdle during computer use have been extensively investigated in many previous studies which involved case-control study design (Szeto et al., 2005, 2009; Johnston et al., 2008a). However, the findings in these studies may not be applicable to that involved in using mobile devices as these devices are much smaller, lighter and the touchscreen involves different input methods altogether. Hence, there is a need to study how the use of smartphones affects the users in general and in particular users with and without chronic neck-shoulder pain.

With the goal to provide evidence for developing ergonomic recommendations for smartphone users, studies have emerged recently to examine physical exposures of smartphone users. When interacting with mobile handheld devices, users have been observed to display neck flexion angles of 20° or more (Kietrys et al., 2015; Lee et al., 2015; Ning et al., 2015). Gravitational demands on the neck muscles are reported to be 3–5 times higher when holding a handheld device with a flexed head and neck posture than with a seated neutral posture (Vasavada et al., 2015). Smartphone users adopt the largest head and neck flexion angle during texting compared with that during other mobile phone activities (Lee et al., 2015; Ning et al., 2015). This indicates that cervical flexion during smartphone use is a common habit which may or may not be a contributing factor to chronic neck-shoulder pain. Gustafsson (2012) compared between the most common text-entry methods, two-handed texting and one-handed texting, on the motor control of thumbs, recommending two-handed texting to reduce the risk of musculoskeletal disorders. Yet, effects of these text-entry methods on other parts of bodies have not been reported, making it

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difficult to provide evidence for the development of ergonomic recommendations to prevent neck-shoulder pain. Moreover, mobile phone texting has been found to be significantly associated with neck pain (Berolo et al., 2011; Hegazy et al., 2016). Of note, pain assessment is based on subjective reports from the participants. Still, there is a lack of objective evidence on postural or motor deviations in mobile device users who have developed symptoms.

Recently, some studies have found symptomatic subjects presenting with greater head or neck flexion angles than healthy individuals during smartphone texting (Gustafsson et al., 2011; Kim, 2015). However, these studies only focused on the cervical postures instead of the entire spine during smartphone use. It is essential to understand the kinematics of adjacent spinal segments because some studies reported that the head/neck posture and cervicothoracic muscle activity could be affected by thoracolumbar postures during sitting (Caneiro et al., 2010; Falla et al., 2007; O'Sullivan et al., 2006). Further, the thoracic flexion angle rather than the craniovertebral angle has been suggested to be a better predictor for neck-shoulder pain (Lau et al., 2010). Tsang et al. (2013a, 2013b) have found a high degree of movement coordination between the cervical and thoracic spines, which is more potent in healthy individuals compared with individuals suffering from chronic neck pain. Considering that the kinematics of cervical, thoracic and lumbar spines affect each other, it appears important to examine the kinematics of the whole spine during smartphone texting tasks. This is further substantiated by a recent study showing that symptomatic individuals were characterized by reduced coordination among proximal and distal muscles during smartphone texting (Madeleine et al., 2016). Therefore, studying the kinematics of the entire spine provides further insight into its potential role in the associations between smartphone use and chronic neck-shoulder pain.

The aim of the present study was to investigate the spinal kinematics of the cervical, thoracic and lumbar regions during smartphone texting and determine whether there would be differences (i) between users with and without neck-shoulder pain, (ii) across bilateral (two-handed) smartphone texting, unilateral (one-handed) smartphone texting, and two-handed computer typing. We hypothesized that users with chronic neck-shoulder pain compared with pain-free users would show increased cervical and thoracic spine flexion angles as well as more static postures, based on previous research on desktop computer users (Szeto et al., 2005). The second hypothesis was that users of both groups would display different kinematics patterns across the three text-entry tasks in agreement with recent studies reporting differences in muscle activation (Madeleine et al., 2016; Xie et al., 2016). The research findings can contribute towards developing recommendations about correcting postures for using these electronic devices which become very important in many peoples' daily lives in modern society.

2. Methods

2.1. Participants

Participants were recruited through poster advertisements in the local universities. Eligible smartphone users were right hand dominant, had a minimum of six months' experience in smartphone operation, spent 2 h or more daily on smartphones, as well as achieved minimum smartphone texting and computer typing speed of 15 and 30 words per minute, respectively. These inclusion criteria served to make sure that participants shared similar smartphone texting and computer typing skills, as motor changes could be affected by skills of performing a task (Madeleine and Madsen, 2009). All participants were allocated into Case Group and Control Group based on past pain history, and scores of neck disability index (NDI) and disability of arm, shoulder and hand (DASH). Cases were identified as those persons who declared non-specific pain in the neck and/or shoulder girdles for more than 3 months in the past year, and still suffered pain a week before and at the current time of the study. Furthermore, their NDI scores were higher than 8 (Johnston et al., 2008b) or DASH scores (Hunsaker et al., 2002) were higher than 10.1. Others were allocated into Control Group. Smartphone users from both groups were excluded if they demonstrated history of surgical intervention or traumatic injuries or other medical conditions that negatively affected the spine and upper limbs, orthopedic and neurological disorders, sensory deficits, and chronic disorders that influenced the musculoskeletal system, for instance, rheumatoid arthritis, osteoarthritis and other connective tissue diseases. The exclusion criteria served to exclude users with traumatic injuries related neck-shoulder pain and systematic diseases since non-specific neck-shoulder pain is defined as pain without histories of traumatic injuries and any specific systematic diseases being detected as the underlying cause of the disorder (Borghouts et al., 1998).

In total, 38 participants (20 in Case Group and 18 in Control Group) took part in the study. The data from one participant in the Case Group was discarded due to errors in securing the motion sensors and resulting in inaccurate data. The participant was observed to have cervical flexion during the experiment, but the sensor recorded it as cervical extension. Therefore, only data from 19 participants (Male = 8, Female = 11) in Case Group and 18 (Male = 7, Female = 11) in Control Group were used for statistical analysis in terms of spinal kinematics. Case Group and Control Group shared similar demographic characteristics and patterns in using various electronic devices (Table 1). In Case Group, all participants had neck pain, most of them had shoulder pain while some of them had additional pain in the upper back, wrists and thumbs (Table 2). Furthermore, Case Group showed significantly higher disability than Control Group (Table 2).

Table 1
Demographic characteristics [mean (SD)] of participants in Case and Control Group.

	Case (n = 19)	Control (n = 18)
Age (years)	24.4 (3.1)	23.2 (3.3)
Height (cm)	168.5 (7.6)	165.9 (11.8)
Body mass (kg)	63.2 (12.6)	59.5 (9.6)
Wear glasses (proportion)	Yes = 40% No = 60%	Yes = 30% No = 70%
Smartphone usage (years) [mode (range)]	Mode= > 3 (0-6 Month- > 3 years)	Mode= > 3 (0-6 Month- > 3 years)
Total time on smartphones (hrs/day)	4.5 (1.5)	3.9 (1.6)
Total time on tablet use (hrs/day)	1.2 (1.3)	0.6 (0.8)
Total time on computer use (hrs/day)	4.9 (2.2)	4.3 (2.3)
Phone input methods [proportion]	Right thumb = 63% Both thumbs = 37%	Right thumb = 55.6% Both thumbs = 44.4%

Note: hrs = hours.