

Effect of the cervical flexion angle during smart phone use on muscle fatigue of the cervical erector spinae and upper trapezius

SANGYONG LEE, PhD, PT¹⁾, DAEHEE LEE, PhD, PT¹⁾, JUNGSEO PARK, PhD, PT¹⁾*

¹⁾ Department of Physical Therapy, Youngdong University: 12 Youngdong-eup, Youngdong-gun, Chungbuk 370-701, Republic of Korea

Abstract. [Purpose] The purpose of this study was to examine the influence of the cervical flexion angle when using a smart phone on muscle fatigue of the cervical erector spinae (CES) and upper trapezius (UT). [Subjects] This study recruited 12 healthy adults. [Methods] Each subject sat on a chair, with his/her back against the wall and held a smart phone with both hands. Fatigue of the neck and shoulder muscles at different cervical flexion angles (0°, 30°, and 50°) was measured by electromyography. The following muscles were assessed: the right upper trapezius (RtUT), left upper trapezius (LtUT), right cervical erector spinae (RtCES), and left cervical erector spinae (LtCES). A cervical range of motion instrument was attached to the subjects' heads to measure the cervical angle during the experiment. [Results] The RtUT and LtUT showed the highest muscle fatigue at a cervical flexion angle of 50° and the lowest fatigue at an angle of 30°. There was no significant difference in the muscle fatigue of the RtCES and LtCES at any of the cervical flexion angles. [Conclusion] UT muscle fatigue depends on the cervical flexion angle when using a smart phone.

Key words: Smart phone, Muscle fatigue, Cervical flexion angle

(This article was submitted Feb. 6, 2015, and was accepted Feb. 28, 2015)

INTRODUCTION

The numbers of smart phone users has increased dramatically. Poor posture while looking at the visual display terminals of smart phones for extended periods causes musculoskeletal problems¹⁾. Straker et al.²⁾ reported that the visual display terminal of a tablet PC, which has a smaller screen than that of a regular desktop computer, requires the user to bend his/her neck more, thereby increasing the activity of the shoulder muscles. The angle at which someone looks at a visual display terminal with a small screen is lower than that of a big screen. As a result, the person has to bend his/her neck a lot more. To keep the neck balanced, the extensor muscles are activated, thereby increasing the load placed on the cervical erector spinae (CES) and trapezius muscles³⁾. When someone constantly bends their head to look at a small screen, various problems, such as a forward-head posture or a slouched, turtle-like posture, can arise⁴⁾. A forward-head posture increases external flexion torque, placing a bigger load on the extensors and some parts of the connective tissues. In the long-term, poor posture can damage not only the neck bones and structures around the lumbar vertebra but

also the ligaments⁵⁾. Muscle activation and degeneration of ligaments caused by poor posture can also cause neck pain and impair proprioceptors in the muscles and ligaments⁶⁻⁸⁾. Using a smart phone while adopting a poor posture can cause various physical problems. The neck and shoulders are particularly vulnerable to pain due to smart phone use, with the muscles showing a high level of muscle fatigue, resulting in exhaustion and pain⁹⁾.

Many previous studies have focused on psychological problems, such as subjective symptoms of physical problems or stress¹⁰⁻¹²⁾. Few studies have focused on muscle fatigue according to the cervical flexion angle. Therefore, this study investigated the influence of the cervical flexion angle during smart phone use on muscle fatigue of the CES and upper trapezius (UT).

SUBJECTS AND METHODS

The study subjects were 12 healthy young adults (five male students and seven female students) in their 20s who were studying at Y University in Choongbuk. The average age, height, and weight of the subjects was 20.6±0.5 years, 165.9±8.1 cm, and 63.3±13.0 kg, respectively. The purpose and methods of the experiment were fully explained to all the subjects. They volunteered to participate in this study and signed an informed consent, following the ethical principles of the Declaration of Helsinki. This study excluded individuals with neck pain and those with congenital deformity, serious surgical or neurological disease, limb injury, or limb pain in the past 6 months.

*Corresponding author. Jungseo Park (E-mail: emotion526@nate.com)

We adjusted the stools that the subjects sat on, so that they would feel comfortable while they maintained their knee joints at 90° and rested their backs against the wall. To set the cervical flexion angle (0°, 30°, and 50°), a cervical range of motion (CROM; Performance Attainment Associates, USA) instrument was attached to their heads. The subjects started the experiment in a comfortable position while they held a smart phone with both hands and looked at the screen. When they started using the phone, they played a game. The measurer observed the subjects from the side to ensure that the subjects maintained the correct cervical flexion angle and guided them to maintain their posture. The subjects used a smart phone for 10 min.

A Galaxy Note 3 (SM-N900S, Samsung Electronics Co., Ltd., Seoul, Korea) was used in this experiment. Electromyography (MP150, BIOPAC System Inc. Santa Barbara, CA, USA) was used to measure muscle fatigue. Surface electrodes were attached to the right upper trapezius (RtUT), left upper trapezius (LtUT), right cervical erector spinae (RtCES), and left cervical erector spinae (LtCES). The median frequency (MDF) was used to monitor muscle fatigue. In this study, the lower the MDF, the higher the muscle fatigue; the higher the MDF, the lower the muscle fatigue.

Repeated measures one-way ANOVA was performed to analyze the data of muscle fatigue of the neck and shoulder according to the cervical flexion angle. SPSS 12.0 for Windows was used for statistical analysis with a significance level of 0.05.

RESULTS

The muscle fatigue of the RtUT and LtUT were highest when the cervical flexion angle was 50° and lowest when it was 30°. There were no significant differences in the muscle fatigue of the RtCES and LtCES between any of the cervical flexion angles (Table 1).

DISCUSSION

If muscle fatigue is continuous due to long hours of maintaining a static posture while working, a muscle may not react to stimulation. Fatigue can also weaken the muscles, thereby destabilizing the neck and shoulder muscles. This study examined muscle fatigue of the neck and shoulder muscles according to the cervical flexion angle of healthy individuals using a smart phone.

Zhang et al.¹³⁾ reported that the CES and UT are the major muscles responsible for providing stability to the neck and shoulders. In an electromyographic study, Greig et al.³⁾ reported that the muscle activities of the CES and UT increased by more than 5% when using visual display terminals. In another electromyography study, Sjøgaard et al.¹⁴⁾ reported over 1 h of this level of activity on a visual display terminal can cause muscle activity. Thus, the use of visual display terminals is closely related to increased fatigue of the neck and arm muscles, and musculoskeletal problems.

Yoo¹⁵⁾ reported that the average cervical flexion angle was 38.5±6.02° when watching a Digital Multimedia Broadcasting (DMB) phone and that this cervical flexion posture increased the muscle activity of the UT and splenius capitis

Table 1. Comparison of the muscle fatigue of various muscles among different neck flexion angles unit (Hz)

	0°	30°	50°
RtUT*	-0.2±1.3	0.4±1.0	-3.5±5.6
LtUT*	-0.3±4.1	0.6±4.4	-5.4±5.9
RtCES	-0.1±4.2	-0.6±3.1	-3.5±5.0
LtCES	0.3±3.6	1.1±2.0	-2.3±5.0

RtUT: right upper trapezius, LtUT: left upper trapezius, RtCES: right cervical erector spinae, LtCES: left cervical erector spinae; *p<0.05. repeated measures ANOVA

muscle compared to a cervical neutral position. Yoo also reported that increased muscle activity by DMB phone users affected the musculoskeletal system and resulted in neck and shoulder pain. So and Yoo¹⁶⁾ reported that smart phone use decreased the experimental pressure threshold and the cervical range of motion, which, in turn, increased neck and shoulder fatigue and pain. Kim et al.¹⁷⁾ conducted a study of healthy adults (a smart phone-using group and a computer-using group). They reported that the experimental pressure threshold of the UT significantly decreased and that muscle fatigue occurred in both the computer and smart phone using groups. In a study by Um¹⁸⁾, 18.8% of subjects experienced pain due to musculoskeletal system-related diseases caused by smart phone use. In addition, those with “more usage” (SMS and data) and a longer “using time” experienced more physical abnormalities.

According to the results of this study, the muscle fatigue of the RtUT and LtUT were highest at a cervical flexion angle of 50° and lowest at an angle of 30°. RtCES and LtCES did not show significant differences in muscle fatigue. These findings confirm that the cervical flexion angle influences the muscle fatigue of RtUT and LtUT. Healthy cervical vertebrae have a forward convex C curve. However, during the use of portable electronic devices, the user inclines forward. This extends the muscle behind the neck too much, placing a substantial load and stress on the cervical vertebrae. This abnormal posture, together with the changes in the mechanism of contraction, places pressure on the facet joint and disks, causing headaches and neck pain. To reduce such fatigue of the neck muscles, the cervical flexion angle should be maintained at 30° rather than 50° or 0°.

A limitation of this study was that it was conducted for a short period and was thus unable to determine the long-term effect of smart phone use. Future studies should extend the hours of smart phone use to compare trends over longer periods.

REFERENCES

- 1) Kang JH, Park RY, Lee SJ, et al.: The effect of the forward head posture on postural balance in long time computer based worker. *Ann Rehabil Med*, 2012, 36: 98–104. [Medline] [CrossRef]
- 2) Straker LM, Coleman J, Skoss R, et al.: A comparison of posture and muscle activity during tablet computer, desktop computer and paper use by young children. *Ergonomics*, 2008, 51: 540–555. [Medline] [CrossRef]
- 3) Greig AM, Straker LM, Briggs AM: Cervical erector spinae and upper trapezius muscle activity in children using different information technologies. *Physiotherapy*, 2005, 91: 119–126. [CrossRef]
- 4) Yoo SH: Effects of posture, break type and work-break schedule on fatigue

- during smartphone use. Hanyang University, Dissertation of master's degree, 2012.
- 5) Bonney RA, Corlett EN: Head posture and loading of the cervical spine. *Appl Ergon*, 2002, 33: 415–417. [[Medline](#)] [[CrossRef](#)]
 - 6) Dolan KJ, Green A: Lumbar spine reposition sense: the effect of a 'slouched' posture. *Man Ther*, 2006, 11: 202–207. [[Medline](#)] [[CrossRef](#)]
 - 7) Brumagne S, Lysens R, Swinnen S, et al.: Effect of paraspinal muscle vibration on position sense of the lumbosacral spine. *Spine*, 1999, 24: 1328–1331. [[Medline](#)] [[CrossRef](#)]
 - 8) McGill SM, Brown S: Creep response of the lumbar spine to prolonged full flexion. *Clin Biomech (Bristol, Avon)*, 1992, 7: 43–46. [[Medline](#)] [[CrossRef](#)]
 - 9) Szeto GP, Straker LM, O'Sullivan PB: Examining the low, high and range measures of muscle activity amplitudes in symptomatic and asymptomatic computer users performing typing and mousing tasks. *Eur J Appl Physiol*, 2009, 106: 243–251. [[Medline](#)] [[CrossRef](#)]
 - 10) Chang EK, Lee HK: A study on the factors influencing smartphone user satisfaction. *Journal of Consumption Culture*, 2010, 13: 129–145. [[CrossRef](#)]
 - 11) Park YM: A Study on Adult's Smart Phone Addition and Mental Health. Sangji University. Dissertation of master's degree, 2011.
 - 12) Kim BY: The Correlations Amoms Highschool students' Internet Game Addition, Smartphone Addition, the Lack of Sleep and Stress. Univirsity of Sahamyook, Dissertation of master's degree, 2012.
 - 13) Zhang FR, He LH, Wu SS, et al.: Quantify work load and muscle functional activation patterns in neck-shoulder muscles of female sewing machine operators using surface electromyogram. *Chin Med J (Engl)*, 2011, 124: 3731–3737. [[Medline](#)]
 - 14) Sjøgaard G, Kiens B, Jørgensen K, et al.: Intramuscular pressure, EMG and blood flow during low-level prolonged static contraction in man. *Acta Physiol Scand*, 1986, 128: 475–484. [[Medline](#)] [[CrossRef](#)]
 - 15) Yoo CU: Electromyographic activity of the neck and shoulder muscles while watching a DMB phone with the neck flexed. Yonsei university, Dissertation of master's degree, 2008.
 - 16) So YG, Yoo YG: Effects of smartphone use on muscle fatigue and pain and, cervical range of motion among subjects with and without neck muscle pain. *J Physical Therapy Korea*, 2014, 21: 28–37. [[CrossRef](#)]
 - 17) Kim GY, Ahn CS, Jeon HW, et al.: Effects of the use of smartphones on pain and muscle fatigue in the upper extremity. *J Phys Ther Sci*, 2012, 24: 1255–1258. [[CrossRef](#)]
 - 18) Um SH: An empirical study on relationship between physical symptoms and smartphone usage. Incheon Inha University, Dissertation of master's degree, 2013.