



Original Article

Effects of the cervical flexion angle during smartphone use on muscle fatigue and pain in the cervical erector spinae and upper trapezius in normal adults in their 20s

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Abstract. [Purpose] The purpose of this study was to examine the effects of the cervical flexion angle on muscle fatigue and pain in the cervical erector spinae and upper trapezius in normal adults in their 20s. [Subjects and Methods] The study's subjects were 14 normal adults. After sitting on a chair with their back against the wall, they held a smartphone with both hands for 10 minutes and fatigue and pain in the neck and shoulder muscles were measured at different cervical flexion angles (0°, 30°, and 50°). Electromyography was performed to analyze the muscle fatigue of the right upper trapezius, left upper trapezius, right cervical erector spinae, and left cervical erector spinae, and a Commander™ Algometer was used to measure pain. The cervical range of motion was used as an instrument to compare and analyze the cervical flexion angles. [Results] The study's results showed statistically significant differences in the muscle fatigue and pain of the right upper trapezius and left upper trapezius depending on the cervical flexion angle and a post-hoc test showed statistically significant lower levels of muscle fatigue and pain at 50° than at 0° or 30°. No statistically significant differences were found between the right cervical erector spinae and left cervical erector spinae. [Conclusion] The cervical flexion angle during smartphone use may influence the muscle fatigue and pain of the upper trapezius.

Key words: Smartphone, Muscle fatigue, Pain

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INTRODUCTION

With the growing penetration of smartphones, the time spent using them has also rapidly increased. Using visual display terminals such as smartphones for a long time can cause neck and back pain¹⁾. A study by Traker et al.²⁾ reported that the use of a tablet computer, which is a small screen visual display terminal, resulted in larger cervical flexion than the use of a general desktop computer and increased the activity of the muscles around the shoulder. Taking this posture consistently for a long period of time may not only cause pain in the neck and back, but also impair the proprioceptive sense³⁾. Ultimately, when using a smartphone in a wrong posture, it can cause various problems in the body, and in particular, abnormalities around the neck. The neck and shoulder are the regions that feel pain easily during smartphone use and show high levels of muscle fatigue, which leads to fatigue and pain⁴⁾. Previous research has included studies on upper extremity muscle activity, pain during smartphone use⁵⁾, and the amount of time spent using smartphones⁶⁾. However, studies on muscle fatigue and pain according to the neck flexion angle are limited. Therefore, the purpose of this study was to investigate the effects of the cervical flexion angle during smartphone use on the muscle fatigue and pain of the cervical erector spinae and upper trapezius in normal adults.

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Table 1. Comparison of muscle fatigue and pain according to cervical flexion angle

	Muscle	0°	30°	50°
Fatigue (Hz)	RtUT**	42.5 ± 13.9	32.0 ± 15.7	26.3 ± 11.4
	LtUT**	38.2 ± 16.5	26.7 ± 13.1	18.7 ± 10.1
	RtCES	31.4 ± 15.6	31.2 ± 15.9	24.4 ± 11.6
	LtCES	31.9 ± 14.9	29.7 ± 10.5	28.3 ± 13.2
Pain (Lb)	RtUT*	15.9 ± 2.9	15.6 ± 1.8	14.7 ± 2.8
	LtUT**	16.6 ± 2.9	16.5 ± 2.4	15.1 ± 3.2
	RtCES	12.5 ± 2.9	12.0 ± 3.1	11.7 ± 2.6
	LtCES	13.1 ± 2.5	12.8 ± 3.3	11.9 ± 2.6

RtUT: right upper trapezius; LtUT: left upper trapezius; RtCES: right cervical erector spinae; LtCES: left cervical erector spinae, *p<0.05, **p<0.01

SUBJECTS AND METHODS

The subjects were 14 healthy young adults (eight men and six women) enrolled in Chungbuk U1 University. Their mean age was 22.1 ± 1.6 years, mean height was 167.6 ± 8.7 cm, and mean weight was 63.9 ± 10.9 kg. The exclusion criteria were those who had experienced pain or trauma in the neck during the past six months, had congenital deformities in their extremities, or had severe surgical or neurological disorders. Ethical approval for the study was granted by the U1 University institutional review board. All subjects read and signed consent forms in accordance with the ethical standards of the Declaration of Helsinki. All subjects who participated in the experiment adjusted the chair's height so that they felt comfortable while maintaining a knee joint flexion of 90° and sat on the chair without a backrest so that their back was against the wall. They wore the cervical range of motion instrument (CROM; Performance Attainment Associates, USA) on their head to adjust the cervical flexion angle (0° , 30° , and 50°). They performed a default posture to view the screen comfortably holding a smartphone (iPhone 6s/A1688, Apple Inc., CA, USA) with both hands, and then played a game on the smartphone. The measurer instructed the subjects to maintain their posture while observing them from the side to help maintain the cervical flexion angles, and the time spent using the smartphone was set at 10 minutes.

The MP150 instrument (BIOPAC System Inc., Santa Barbara, CA, USA) was used for electromyography to measure the fatigue of the muscles, and 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). Median frequency (MDF) was used to measure muscle fatigue. Given that if muscles become tired, the process of repolarization after the electrical depolarization of muscles cells (i.e., the recovery process) is delayed, it was regarded that a lower MDF indicated a higher level of muscle fatigue and a higher MDF indicated a lower level of muscle fatigue. A Commander™ Algometer (J-TECH Medical, OH, USA) was used to measure tenderness on pressure. Here, a lower numerical value indicated a higher degree of pain.

A one-way repeated measure analysis of variance (ANOVA) was conducted to examine the fatigue and pain of the neck and shoulder muscles according to the cervical flexion angles, and the Bonferroni post-hoc test was employed. SPSS 12.0 for Windows was used for statistical processing and the statistical significance level was set at $\alpha=0.05$.

RESULTS

There were statistically significant differences in the muscle fatigue and pain of the RtUT and LtUT according to the cervical flexion angles and the post-hoc test showed lower levels of fatigue and pain at 50° than at 0° or 30° ($p<0.05$). No statistically significant differences were found between the RtCES and LtCES ($p>0.05$) (Table 1).

DISCUSSION

Yoo⁷⁾ reported that the mean flexion angle of the neck bone while subjects viewed a digital multimedia broadcasting (DMB) phone in a flexed neck posture was $38.5 \pm 6.02^\circ$, and flexed neck posture may increase the muscle activity of the upper trapezius and splenius capitis more than neutral neck posture. An increase in muscle activity can become the cause of pain in the musculoskeletal system of the neck and shoulder in DMB phone viewers.

In this study, the muscle fatigue and pain of the RtUT and LtUT were statistically significantly lower at a cervical flexion angle of 50° than at 0° or 30° . With regard to the reason for statistically significant declines at a cervical flexion angle of 50° , Kim et al.¹⁾ argued that a downward gaze showed higher muscle activity in the upper trapezius compared to an upward gaze and an eye-level gaze, suggesting that gaze by itself could generate high muscle activity and a downward gaze easily leads to fatigue. In addition, Leon⁸⁾ classified the upper trapezius as a motor muscle and defined it as a fast contracting fiber. When compared to slow muscle fibers, fast muscle fibers cause fatigue when a static posture is maintained for a long time, which

may have statistically significantly decreased the MDF of the upper trapezius as the cervical flexion angle increased.

In the present study, the measurement of tenderness at a cervical flexion angle of 50° showed a statistically significant decline in the upper trapezius. This may have been because muscle pain occurred due to the continuous isometric contraction of the trapezius at a flexion angle of 50°. Kim et al.¹⁾ reported that a decline in eye gaze resulted in a corresponding increase in cervical flexion and influenced the upper trapezius, and a further increase in cervical flexion led the weight of the head to move further forward and the activity of the upper trapezius, a leading cervical extensor, increased to withstand the movement. When the head is forward or bowed, the muscular tissues that perform cervical extension in the back of the neck are isometrically contracted, thereby creating a force against gravity. This prevents cervical flexion or forward head movement, and the long-term isometric contraction of the muscles in the back of the neck, which are involved in cervical extension, such as the upper trapezius and semispinalis capitis, can cause pain by stimulating trigger points⁹⁾.

REFERENCES

- 1) Kim YG, Kang MY, Kim JW, et al.: Influence of the duration of smartphone usage on flexion angles of the cervical and lumbar spine and on reposition error in the cervical spine. *Physical Therapy Korea*, 2013, 20: 10–17. [[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) Dolan KJ, Green A: Lumbar spine reposition sense: the effect of a ‘slouched’ posture. *Man Ther*, 2006, 11: 202–207. [[Medline](#)] [[CrossRef](#)]
- 4) 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](#)]
- 5) Lee M, Hong Y, Lee S, et al.: The effects of smartphone use on upper extremity muscle activity and pain threshold. *J Phys Ther Sci*, 2015, 27: 1743–1745. [[Medline](#)] [[CrossRef](#)]
- 6) Kim SY, Koo SJ: Effect of duration of smartphone use on muscle fatigue and pain caused by forward head posture in adults. *J Phys Ther Sci*, 2016, 28: 1669–1672. [[Medline](#)] [[CrossRef](#)]
- 7) 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.
- 8) Chaitow L: *Muscle energy techniques with CD*, 2e. Daihak Publishing, 2005, pp 56–57.
- 9) Muscolino JE: *Kinesiology*, 2e. Elsevier Korea L.L. 2011, C: 650.