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Original Article

Influence of neck pain on cervical movement in the sagittal plane during smartphone use

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Abstract. [Purpose] Smartphone use reportedly changes posture. However, how neck posture is altered in smartphone users with neck pain is unknown. This study examined changes in the posture of young adults with and without mild neck pain (MNP) when using a smartphone. [Subjects] Thirteen control subjects and 14 subjects with MNP who used smartphones were recruited. [Methods] The upper cervical (UC) and lower cervical (LC) angles in the sagittal plane were measured using an ultrasound-based motion analysis system while the seated subjects used a smartphone for 5 min. [Results] During smartphone use, the MNP group exhibited greater UC and LC flexion angles than the control group. [Conclusion] These findings suggest that young adults with MNP are more careful and more frequently utilize a neutral neck posture than young adults without MNP when using a smartphone while sitting.

Key words: Smartphone, Cervical flexion, Young adult

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INTRODUCTION

Smartphones provide various conveniences, such as sending and receiving e-mail, accessing the internet, and engaging in entertainment[1)]. The number of smartphone users has increased dramatically in recent years because of these conveniences. However, the use of smartphones is reportedly associated with physical symptoms in some users[2)].

Some researchers have suggested that frequent smartphone use can lead to the use of a non-neutral neck posture or the development of musculoskeletal disorders[3, 4)]. Berolo, Wells, and Amick[4)] surveyed a Canadian university population and reported that the duration and frequency of use of mobile handheld devices were related to the prevalence of neck pain. A cause of neck disorders among smartphone users may be the ability to reposition the display of the mobile device, such as on a desk or below the shoulder[5)]. Many people may use smartphones with the head shifted forward and the smartphone placed near the waist or lap while in a sitting position[6)]. This flexed neck posture can increase the moment of the cervical spine and induce muscle strain in adjacent portions of the cervical spine[7)]. Although smartphone use is associated with causal factors of neck pain or musculoskeletal disease, fewer experimental studies have been performed on the effects of smartphone use than on the effects of visual display terminal (VDT) work.

Maintenance of a non-neutral neck posture, such as a flexed posture, is a well-known cause of neck pain[8)]. In a previous study, small forward shifts of the head in the sagittal plane increased the load on the supporting structures and activated the neck muscles[7)]. Harrison et al.[9)] found that the compressive load on the cervical discs in the neck-forward flexed position was 10 kg greater than that in the upright neck position. These biomechanical variations or the presence of neck pain can induce proprioceptive deficits in the cervical region. Szeto, Straker, and O'Sullivan[10)] reported that more symptomatic than asymptomatic individuals used a flexed neck position while using a VDT. Therefore, we postulated that smartphone users with neck pain might more frequently utilize a non-neutral neck posture than asymptomatic users.

Many previous studies have investigated the alterations in cervical movement patterns during computer use[11, 12)]. However, few experimental studies have addressed how smartphone use changes cervical movement patterns. Additionally, no study has reported the effect of mild neck pain (MNP) on smartphone use. Thus, this study compared alterations in the cervical spine posture of young adults with and without MNP during smartphone use. We hypothesized that the cervical spine of young adults with MNP would be more flexed than that of asymptomatic young adults during smartphone use.

SUBJECTS AND METHODS

For this study, 27 young adults (12 male, 15 female) who had used a smartphone for at least 1 year were recruited from the University of Gimhae, South Korea, by print me-

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dia advertisement. All subjects who were included in the study had experienced cervical symptoms during smartphone use within the last year. Individuals with a history of neck trauma or surgery or with a medical diagnosis of fibromyalgia, cervical radiculopathy, a systemic illness, or a connective tissue disorder were excluded from this study. All subjects were grouped into either the MNP group or the control group based on their Neck Disability Index (NDI) scores (>8 and ≤ 8). The NDI involves a 10-item questionnaire regarding the effects of neck pain and symptoms during a range of functional activities. Each subject was instructed to select one of six options concerning the severity of each item (0–5). The NDI score was calculated as the total score multiplied by two (score range = 0–100). A higher NDI score indicates greater neck disability. The intraclass correlation coefficient of the NDI scoring method in the Korean language version is reported to be excellent, at 0.90[6].

The Inje University Faculty of Health Science Human Ethics Committee granted approval for this study, and all subjects provided their written informed consent prior to participation.

Kinematic data of the upper cervical (UC) and lower cervical (LC) angles in the sagittal plane during smartphone use were collected using an ultrasound-based motion analysis system (CMS20; Zebris Medical GmbH, Isny, Germany). For measurement of the UC and LC flexion angles, four active single markers were attached, one each over the zygomatic bone, tragus, first thoracic spinous process, and sternum[13].

Each subject was seated on an adjustable-height chair without a backrest, with the knee and hip joints at 90° angles and the feet on the floor. The subject initially adopted a neutral cervical posture and held the smartphone in both hands while sitting. The neutral position was defined as a cervical posture without rotation, lateral bending, or excessive cervical lordosis in the sitting posture, but with slight lumbar lordosis and a relaxed thorax. Straker, Jones, and Miller[7] reported that the discomfort score was higher among workers performing VDT work in a flexed neck posture. In the present study, all subjects were instructed to maintain a neutral cervical posture during smartphone use. All subjects were instructed to maintain their preferred shoulder and arm postures with the exception of placing the arm and hand on the thigh during the experiment. The subjects freely used the messenger application or the internet on a Galaxy SII phone (SHW-M250S; Samsung Electronics Co. Ltd., Gumi, Korea) for 5 min. Each subject performed three test trials with a 3-min rest period between trials.

To analyze the cervical angle, the raw kinematic data was collected at a 10-Hz sampling rate and converted to ASCII files. Then, the flexion angles were analyzed using Microsoft Excel 2010 (Microsoft Corp., Redmond, WA, USA). A negative cervical angle was defined as cervical flexion. In each of the three trials, the flexion angle data points of 100, 200, and 300 s of smartphone use were used in the analysis. The mean of the three trial values was analyzed to determine the UC and LC flexion angles during smartphone use.

The cervical flexion angles were analyzed using 2 (groups) × 3 (time) analysis of variance with repeated measures of both factors. A Greenhouse-Geisser correction was used to adjust the degrees of freedom whenever an inequality of sphericity was rejected by Mauchly's test. Differences in the NDI score and anthropometric characteristics between the two groups were analyzed using the independent t-test. Statistical analyses were performed using SPSS version 20.0 for Windows (IBM Corp., Armonk, NY, USA). A p-value of ≤0.05 was regarded as indicative of statistical significance.

Table 1. Summary of the anthropometric characteristics and neck disability indices of the study participants

Characteristic	Control group (n = 13)	MNP group (n = 14)
Sex (n, male)	6	6
Age (years), mean ± SD	20.6 ± 1.6	20.6 ± 1.5
Height (cm), mean ± SD	167.3 ± 6.9	168.0 ± 8.0
Weight (kg), mean ± SD	60.7 ± 10.7	61.0 ± 12.4
Neck disability index (%), mean ± SD	3.3 ± 2.6	16.9 ± 7.1*

MNP, mild neck pain; SD, standard deviation. *Significant difference between the two groups, $p < 0.05$.

RESULTS

Twenty-seven subjects were recruited from among young adults who used a smartphone in Korea. The NDI score of the MNP group was significantly higher than that of the control group (Table 1). No significant differences in age, height, or weight were observed between the MNP and control groups.

Table 1 shows the mean UC and LC flexion angles of subjects with and without MNP at each measured time point during smartphone use. All angles showed a tendency to increase with time. During smartphone use, the cervical spine flexion angles were significantly higher in the MNP group than in the control group ($p < 0.05$). The UC of subjects with MNP exhibited greater flexion than that of subjects without MND ($p < 0.05$). The variations in the degrees of LC flexion in the MND group were significantly greater than those in the control group ($p < 0.05$). There were no significant differences in the UC and LC segments over time between the two groups (Table 2).

DISCUSSION

In the present study, the MNP group exhibited greater UC and LC flexion angles than the control group during smartphone use. We found differences in the position of the cervical spine during smartphone use between individuals with and without MNP. Young adults with MNP exhibited greater flexion of their cervical spines when using a smartphone than users without MNP. These findings indicate that young adults with MNP experience difficulty in maintaining a neutral neck posture during smartphone use. Possible explanations for the increased neck flexion angles in subjects with MNP include neck pain altering the motor control of the neck muscles[10]. Based on these findings, it

Table 2. Cervical spine angle of subjects with and without MNP according to time

Segment	Control group (n = 13)			MNP group (n = 14)		
	100 s	200 s	300 s	100 s	200 s	300 s
Upper cervical spine	2.68 ± 1.46	2.82 ± 2.21	3.20 ± 2.47	4.95 ± 3.01*	5.85 ± 3.02*	5.87 ± 3.63*
Lower cervical spine	3.99 ± 2.57	5.14 ± 2.55	5.84 ± 2.93	8.19 ± 5.05*	9.20 ± 3.86*	9.95 ± 4.22*

MNP, mild neck pain, mean ± SD.
*Significant difference between the two groups, $p < 0.05$.

appears that induction factors of neck pain occurred in control subjects during consistent use of the smartphone. Thus, we believe that cognition of posture and maintenance of a neutral neck posture are important for subjects both with and without neck pain.

Our findings demonstrated differences in the cervical flexion angles with time during smartphone use. The cervical flexion angles were influenced in the UC and LC regions by the passage of time during smartphone use. Possible explanations for the effect of time on the cervical angle include the subjects maintaining a static sitting posture during smartphone use. The results obtained by Lee et al.[14] support our findings. They reported that cervical angles showed gradual increase of flexion with time in asymptomatic subjects during VDT work.

Whether subtle changes in these angles have a clinical meaning is debatable. However, some studies have suggested that subtle but significant differences in these angles might correct postural malalignment associated with musculoskeletal disorders[15, 16]. Considering the findings of these previous studies, we suggest that the significant changes in the cervical flexion angles observed in the present study might reduce mechanical stress on the cervical spine, even though the differences in the angles were subtle.

A strength of this study was that the characteristics of the cervical posture of subjects with MNP during smartphone use were considered, and that this study demonstrated that subjects with MNP cannot maintain a neutral cervical posture as well as control subjects can. However, this study had several limitations. First, we did not measure the flexion angle of the lumbar spine during smartphone use. We speculate that lumbar flexion might induce cervical flexion because the lumbar spine is connected in a chain-like manner to the cervical spine[17]. However, this study focused on the posture of the cervical spine in subjects with MNP during smartphone use. Changes in lumbar flexion combined with cervical flexion when using a smartphone in a seated position should be assessed in future studies. Second, we did not analyze cervical muscle activity. Electromyography should be performed to examine the muscle activity of the cervical erector spinae in relation to the duration of smartphone use. Third, we compared only young adults with and without MNP. Further research is needed to identify alterations in cervical flexion angles depending on the grade of neck pain during smartphone use.

In conclusion, our findings indicate that individuals with MNP adopt a posture of greater neck flexion than individuals without MNP when using a smartphone. Our findings suggest that young adults with MNP must be aware of their posture and modify their non-neutral cervical alignment when using a smartphone. To reduce the risk of developing severe neck pain, clinicians should instruct smartphone users to maintain a correct neck posture.

REFERENCES

1) Perera C: The evolution of E-Health—mobile technology and mHealth. JMTM, 2012, 1: 1–2.
2) Korpinen LH, Pääkkönen RJ: Self-report of physical symptoms associated with using mobile phones and other electrical devices. Bioelectromagnetics, 2009, 30: 431–437. [Medline] [CrossRef]
3) Bababekova Y, Rosenfield M, Hue JE, et al.: Font size and viewing distance of handheld smart phones. Optom Vis Sci, 2011, 88: 795–797. [Medline] [CrossRef]
4) Berolo S, Wells RP, Amick BC 3rd: Musculoskeletal symptoms among mobile hand-held device users and their relationship to device use: a preliminary study in a Canadian university population. Appl Ergon, 2011, 42: 371–378. [Medline] [CrossRef]
5) Young JG, Trudeau M, Odell D, et al.: Touch-screen tablet user configurations and case-supported tilt affect head and neck flexion angles. Work, 2012, 41: 81–91. [Medline]
6) Lee H, Nicholson LL, Adams RD, et al.: Development and psychometric testing of Korean language versions of 4 neck pain and disability questionnaires. Spine, 2006, 31: 1841–1845. [Medline] [CrossRef]
7) Straker L, Jones KJ, Miller J: A comparison of the postures assumed when using laptop computers and desktop computers. Appl Ergon, 1997, 28: 263–268. [Medline] [CrossRef]
8) Johnston V, Souvlis T, Jimmieson NL, et al.: Associations between individual and workplace risk factors for self-reported neck pain and disability among female office workers. Appl Ergon, 2008, 39: 171–182. [Medline] [CrossRef]
9) Harrison DD, Harrison SO, Croft AC, et al.: Sitting biomechanics part I: review of the literature. J Manipulative Physiol Ther, 1999, 22: 594–609. [Medline] [CrossRef]
10) Szeto GP, Straker LM, O'Sullivan PB: A comparison of symptomatic and asymptomatic office workers performing monotonous keyboard work—2: neck and shoulder kinematics. Man Ther, 2005, 10: 281–291. [Medline] [CrossRef]
11) Yoo WG: Comparison of upper cervical flexion and cervical flexion angle of computer workers with upper trapezius and levator scapular pain. J Phys Ther Sci, 2014, 26: 269–270. [Medline] [CrossRef]
12) Yoo WG: Changes in pressure pain threshold of the upper trapezius, levator scapular and rhomboid muscles during continuous computer work. J Phys Ther Sci, 2013, 25: 1021–1022. [Medline] [CrossRef]
13) Kuo YL, Tully EA, Galea MP: Video based measurement of sagittal range of spinal motion in young and older adults. Man Ther, 2009, 14: 618–622. [Medline] [CrossRef]
14) Lee JH, Park SY, Yoo WG: Changes in craniocervical and trunk flexion angles and gluteal pressure during VDT work with continuous cross-legged sitting. J Occup Health, 2011, 53: 350–355. [Medline] [CrossRef]
15) Greig AM, Bennell KL, Briggs AM, et al.: Postural taping decreases thoracic kyphosis but does not influence trunk muscle electromyographic activity or balance in women with osteoporosis. Man Ther, 2008, 13: 249–257. [Medline] [CrossRef]
16) Horton SJ, Johnson GM, Skinner MA: Changes in head and neck posture using an office chair with and without lumbar roll support. Spine, 2010, 35: E542–E548. [Medline]
17) Page P, Frank CC, Lardner R: Assessment and treatment of muscle imbalance: the Janda approach. Champaign: Human Kinetics, 2009.