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Original Article

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Change in Each Vertebral Segment During Smartphone Usage with Both Hands while in the Standing Position

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| Abstract |

Purpose: Continuous use of a smartphone increases the angle of forward bending of the user's cervical vertebrae, causing pain in the shoulders and back, including the thorax, lumbar region, and vertebrae. Although there are many studies on changes in the cervical spine due to smartphone usage, the changes in the shoulders, thoracolumbar spine, and pelvic have rarely been compared. The purpose of this study is to investigate the change in the spinal segments, shoulders, and pelvic when using a smartphone with both hands while in the standing position.

Methods: This study was conducted on 35 adults in their twenties. The selection criteria for the subjects were limited to those in a similar age group, thus excluding posture differences according to age, and to those who did not have specific diseases or pain in the spinal and musculoskeletal system for 12 months prior to the study. In this study, we used a 3D spinal diagnostic imaging system (Back Mapper, Frickenhausen) to compare the changing conditions in each vertebral segment before and during smartphone usage with both hands while in the standing position. Posture differences according to smartphone usage were compared using the paired t-test for the motion of each spinal segment.

Results: This study showed that the thoracic and lumbar angle increased posteriorly during smartphone usage ($p<0.05$). In addition, the anterior rotation angle of the shoulder bone significantly increased, but no significant difference occurred in the pelvic region.

Conclusion: Based on the results of this study, smartphone usage with both hands while in the standing position showed that the spine, as a whole, forms a kyphotic curve. Therefore, we propose to present a postural guideline for correct smartphone usage, considering the change in each vertebral segment.

Key Words: Smartphone posture, Thoracic angle, Lumbar angle, Scapular, Pelvic

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Ⅰ. Introduction

The use of handheld multimedia devices has been rapidly increasing worldwide. Smartphones are especially popular across all generations. Smartphones can be used to quickly acquire information and they attract great interest, making them an indispensable item for modern people (Madeleine et al., 2013; Waersted et al., 2010).

However, many problems such as posture imbalance and pain have been caused by long-term use of smartphones according to study of Schabrun et al. (2014) and Nurwulan et al. (2015). Prolonged smartphone usage is likely to cause symptoms such as neck and finger pain (Berolo et al., 2011), which are similar to the symptoms of a forward head posture, as the forward bending of the neck is common when using a smartphone (Gold et al., 2012). In a study by Lee et al. (2015), the angle of forward bending of the neck increased when using a smartphones, and the angle was most markedly increased while sitting and sending texts. We also observed that the use of smartphones not only increased the forward bending angle of the neck but also decreased the breathing volume. This suggests that incorrect alignment of the neck and back can narrow the thoracic volume and weaken the respiratory muscles, thereby affecting breathing ability (Lee et al., 2017). In addition, long-term use of the smartphone induces a low-level persistent muscle tone condition, which causes pain in the muscles because it is performed without muscle relaxation time, and the fixed contraction of the muscles translocates the bones connected to the muscle. This ultimately leads to posture imbalance (Jonsson, 1988).

Therefore, it is necessary to maintain a proper posture while using a smartphone because not only muscle but also spinal misalignment may affect the systemic imbalance of the body.

Previous studies have shown that the load on the cervical vertebrae increases by as much as six times while sending texts from smartphones. In addition, it has been reported that sustained forward bending of the neck may lead to neck degenerative diseases such as cervical disc herniation (Hansraj, 2014).

However, these findings are limited to studies of kinematics and related symptoms of the cervical spine. There is no accurate review of the changes in the overall spinal alignment such as that of the thoracolumbar spine or pelvis due to prolonged use of smartphone. The study by Park et al. (2017) observed the flexion and rotation angles of the spine according to the time of smartphone use by cam images. However, the angle of rotation was not analyzed according to the spine segment because of which there are difficulties in understanding the segmental spine motion.

Therefore, the purpose of this study is to observe the changes in each segment such as thoracic and lumbar areas, pelvis, and shoulder bones using 3D images of the coronal and sagittal cross sections while using a smartphone with both hands in standing position. We also intend to present basic data for establishing standards for smartphone usage posture in the future.

Ⅱ. Methods

1. Subjects

This study was conducted on 35 healthy men and women in their twenties. The selection criteria of the subjects were limited to similar age groups to exclude posture differences according to age, and to those who did not have specific diseases or pain in the spinal and musculoskeletal system for the past 12 months. The subjects were asked to fill out a consent form after voluntarily listening to the purpose and procedure of this

study. This study was a comparative study of one group before and after. The procedure of this study was approved by the Institutional Review Board (Kaya IRB-214) at Kaya University.

2. Research procedure

One person came to the laboratory to blind the subjects. After hearing the researcher's explanation, the subjects took off the top clothes in the dressing room. Subjects were asked to look at the wall at the Back Mapper (Back Mapper, Frickenhausen, Germany) measurement point. The eye gaze was performed at the eye level. Both hands of the subject were placed down naturally and stood on Back Mapper for three minute. At this time, the gap between the two feet was kept as wide as the shoulder width. While the subject was standing naturally, the posture image of the subject was measured 3 minutes later from standing on the back mapper. Then, subjects were asked to watch the video for 3 minutes while holding the smartphone with both hands in a 90 degree bend of the elbow in the same position as before. At this time, the head was bent slightly forward to watch the smartphone, and the gaze was fixed on the smartphone. The researchers measured the posture image at three minutes later from standing on the back mapper as before. According to the gender of the subjects, same-sex researchers were allowed to shoot 3D images of the spine.

3. Measurement of vertebral curvature

Back Mapper was used to measure the anterior, posterior, and lateral displacements, and the rotation of each segment of the vertebrae. The shoulder tilt means to the degree of tilt to the left and right about the vertical line. The thoracic angle is the kyphotic curve of the thoracic vertebra, and the lumbar angle is the lordotic curve of the lumbar vertebra. Scapular rotation, which represented upward ratation of scapular. Pelvic torsion, which represented anterior tilting of pelvic. And, pelvic ratation is a rotation of pelvic on the transverse plane. The subjects stood on the Back Mapper with their shoes and tops removed and faced the wall. The researchers measured the motion of the vertebrae by laser irradiation from a distance of approximately 2 meter. In addition, in order to measure the spinal motion when using a smartphone, the subject used the smartphone with both bands in a relaxed posture under the same condition as before. The place of measurement was isolated with a curtain so that the subject's psychological condition did not affect the posture.

4. Statistical analysis

Statistical analyses were performed using a commercially available software package, SPSS version 18.0. The general characteristics of the subjects were analyzed using descriptive statistics. Furthermore, posture differences according to smartphone use were compared using paired t-test for the motion of each spinal segment.

Ⅲ. Results

1. General characteristics of subjects

The general characteristics of the subjects are shown in below (Table1).

Table 1. General characteristics of subjects (n=35)

Variable	Mean±SD
Age (years)	22.88±1.45
Height (cm)	166.22±4.68
Weight (kg)	61.11±8.34
Sex (male/female)	9/26

Table 2. Spinal changes in each segment (unit: °)

Variable	Mean±SD		95% CI	p
	Pre	Post		
Shoulder left tilt	29.62±7.81	26.40±6.69	(0.00, 6.45)	0.05
Shoulder right tilt	32.28±6.89	30.14±6.53	(-0.59, 4.87)	0.12
Thoracic angle	11.65±2.87	14.57±2.72	(-3.93, -1.89)	0.00*
Scapular rotation	2.54±2.55	3.78±3.15	(-1.58, 0.09)	0.04*
Lumbar angle	10.00±2.95	10.85±3.21	(-1.62, -0.08)	0.03*
Pelvic torsion	-1.60±5.52	-0.82±4.42	(-2.29, 0.74)	0.31
Pelvic rotation	1.62±2.67	1.82±2.91	(-0.93, 0.53)	0.58

*: $\alpha<0.05$, Shoulder left tilt: shoulder left tilt against the vertical line, Shoulder right tilt: shoulder right tilt against the vertical line, Thoracic angle: kyphotic angle of thoracic spine, Scapular rotation: scapular upward rotation, Lumbar angle: lordotic angle of lumbar spine, Pelvic torsion: pelvic anterior tilt, Pelvic rotation: pelvic rotation on a horizontal plane

2. Spinal changes in each segment

The results of this study showed that the thoracic angle was significantly increased posteriorly. Scapular rotation was significant in the anterior direction and the lumbar angle of the lumbar spine was significantly increased in the posterior direction. In the frontal plane, scapular movement did not differ significantly from side to side. There was no significant difference in pelvic rotation between the two postures in the transverse plane (Table2).

Ⅳ. Discussion

In this study, we measured the difference in the displacement of the vertebral segment according to the use of smartphone with both hands by 3D spinal diagnostic imaging system. The posterior dislocation angle of the thoracic and lumbar spine was significantly increased in the sagittal plane. In addition, we observed that the slope change of the scapula was significantly increased anteriorly in the cross section.

Studies of Han et al. (2016) have shown that increase in the forward bending angle of the neck with prolonged use of smartphones causes a forward head posture, which not only causes pain in the neck and shoulder area but also leads to upper crossed syndrome in the upper limb, leading to decreased breathing ability. In the present study, it was believed that the use of smartphones with both hands increased the angle of kyphosis in the thoracic spine by inducing forward bending of the neck, as the incidence of kyphosis in the thoracic spine was found to increase proportionally with the increase in the forward bending angle of the neck (Quek et al., 2013). The increase in the kyphotic curvature of the thoracic spine caused the scapula to rotate laterally along the rib cage (Deepika et al., 2017), which is similar to the posture of a typical round shoulder. There are individual differences in the posture of using a smartphone, such as one hand or two hands. Therefore, in this study, the elbow of subjects were flexed 90 degrees by holding the smartphone with both hands to offset the individual characteristics. As a result, anterior rotation of scapular is thought to be increased. Therefore, the prolonged use of smartphone will result in forward head posture and round shoulder. Strubhar et al. (2015) said that when the smartphone is used, the LOG tilts sideways and the posture stability is broken. However, in this study, there was no significant change in the tilt of the spine in the coronal plane.

In addition, this study found that the use of smartphones

increased the backward displacement of the lumbar spine, which could be attributed to the increase in the body sway. Cognition at standstill focuses on standing, but while using a smartphone, the focus is on the smartphone because of which the body sway gets bigger. When using a smartphone, the forward bending of the neck moves the center of pressure forward. To compensate for this, lordosis decreases in the lumbar spine, and then kyphosis increases in the thoracic spine to maintain the line of gravity. The increase in kyphosis in the thoracic vertebrae with forward bending of the cervical vertebrae is one of the prominent features of those with lower back pain (Christie et al., 1995). Therefore, the prolonged use of smartphone with both hands in the wrong posture may cause back and neck pain.

In previous studies, the forward bending of the neck showed little correlation with the parameters in the thoracic, lumbar, and pelvic areas (Lee et al., 2016; McClendon et al., 2016; Sugrue et al., 2013). In addition, although the flexion and extension of the cervical region were observed, thoracic and lumbar spine and the overall alignment of the vertebrae were not disturbed. Based on previous studies, it is believed that there should be no significant difference in the angular change of the thoracolumbar spine in this study, but the results of this study showed a misalignment of the thoracolumbar spine when bending the neck forward. Therefore, further studies are needed to clarify the mechanism behind this finding.

Although studies on kinematics and pain in the neck due to the use of smartphones are well known, few studies have found direct changes in the thoracolumbar and pelvis regions. Therefore, this study has significant implications for changes in the thoracolumbar spine and pelvis following smartphone use. This should be considered while creating a guideline for correct smartphone usage posture.

Ⅴ. Conclusion

This study examined changes in each vertebral segment when using smartphones. The use of smart phones increased the kyphosis of the thoracic spine and the anterior rotation of the scapular. In the lumbar spine, lumbar spine angles increased, indicating a compensatory action to avoid to get out center of gravity. I hope these research results will be used to create guidelines for the right smartphone usage posture in the future.

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