Original Article

Effects of Cervical Flexion on the Flexion-relaxation Ratio during Smartphone Use

HyeonHui Shin[1)], KyeongMi Kim[2)*]

[1)] *Department of Rehabilitation Science, Graduate School of Inje University, Republic of Korea*
[2)] *Department of Occupational Therapy, College of Biomedical Sciences and Engineering, Inje University: 197 Inje-ro, Gimhae-si, Gyeongsangnam-do 621-749, Republic of Korea*

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Abstract. [Purpose] The purpose of this study was to measure the cervical flexion-relaxation ratio (FRR) and intensity of neck pain and identify the differences according to postures adopted while using smartphones. [Subjects] Fifteen healthy adults with no neck pain, spinal trauma, or history cervical surgery participated in this study. [Methods] The activity of the cervical erector spinae muscle was recorded while performing a standardized cervical flexion-extension movement in three phases (flexion, sustained full flexion, extension). And neck pain intensity was recorded using a visual analog scale (VAS) with values between 0 and 10. Postures held while using a smartphone are distinguished between desk postures and lap postures. The FRR was calculated by dividing the maximal muscle activation during the extension phase by average activation during the complete flexion phase. [Results] No significant differences were found in the FRR between desk posture, lap posture, and baseline, though the intensity of the neck pain increased in the lap posture. [Conclusion] The FRR could be a significant criterion of neuromuscular impairment in chronic neck pain or lumbar pain patients, but it is impossible to distinguish neck pain that is caused by performing task for a short time. Prolonged lap posture might cause neck pain, so the use of smartphones for a long time in this posture should be avoided.
Key words: Smartphone, Cervical flexion-relaxation ratio, Electromyography

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INTRODUCTION

The use of smartphones to send or receive messages and to access the internet is on the rise[1)]. Although no epidemiological studies have been reported, case reports and laboratory studies indicate that the use of a mobile device may damage musculoskeletal health[2)]. Furthermore, because most mobile device tasks require users to look downwards or to hold their arms in front of them to view the screen, this could cause fatigue and pain in the neck and shoulders[3)]. Villanueva et al. identified the effects of screen height on the electromyographic activities of the neck and shoulder muscles in 10 healthy subjects[4)]. When the height was low, the neck was more flexed, and it produced significantly higher neck extensor muscle activities. Floyd and Silver first defined the flexion-relaxation phenomenon (FRP), and it refers to a reduced or sudden onset of myoelectric silence in the erector spinae muscles during full trunk flexion[5)]. A transfer of the extension movement from the active muscular structures to passive structures of the spinal column possibly explains this phenomenon[6)]. Some studies have reported the absence or delay of FRP during complete trunk flexion, which could be used to differentiate between healthy subjects and subjects with low back pain[6)]. The cervical FRP has been observed to be similar to that of the lumbar region[7)]. Recent studies have suggested that the flexion-relaxation ratio (FRR) may be an important marker of neuromuscular impairment[6, 8)]. Murphy et al. found that the cervical FRR is significantly lower in neck pain patients than in healthy subjects[9)]. Another study suggested that FRR could be used to identify the potential risks of neck discomfort in computer workers[10)]. However, no study has compared FRRs among postures employed during smartphone use. The purpose of this study was to measure the cervical FRR and neck pain intensity in healthy subjects, and to identify the differences according to the postures employed while using a smartphone.

SUBJECTS AND METHODS

Fifteen healthy adult subjects participated in this study. Subjects were excluded if, in the past year, they had experienced neck pain, spinal trauma, or cervical surgery. All subjects provided their informed consent after receiving a detailed explanation of the study. In addition, the Institutional Review Board of Inje University approved this study. The average age of the subjects was 26.07±5.73 (mean±SD) years, and their average height and weight were 173.2±10.05 cm and 69.33±13.01 kg, respectively. The muscle activity of the cervical erector spinae (CES) muscle

*Corresponding author. KyeongMi Kim (E-mail: kmik321@inje.ac.kr)

was recorded with an MP150WSW (BIOPAC System Inc., Santa Barbara, CA, USA), the analog signal was converted to a digital signal, and the data was processed using the AcqKnowledge 4.1 software. A sampling rate of 1,000 Hz was used, and the data was band-pass filtered between 10 and 500 Hz. The electrode pairs were placed approximately 2 cm from the spinous process over the belly of the muscle at the level of C4. A ground electrode was placed over C7. Subjects were required to sit erect in a straight-backed chair with their hips and knees at 90°, feet positioned shoulder width apart, and with their arms relaxed by their sides, while viewing a point at eye level. To measure the FRR, subjects were asked to perform a standardized cervical flexion-extension movement in three phases: phase I, full cervical flexion to last for 5 s; phase II, sustained cervical full flexion for 5 s; and phase III, cervical extension with return to the starting position for 5 s. While measuring the FRR, to prevent the effects of speed on FRP and to provide standardized test times, the speed was regulated by the beat of a digital metronome. Two practice trials were performed by the subjects. Each subject performed three trials of the three phases at 60-s intervals. The FRR was calculated by dividing the maximum muscle activity during the 5 s of phase III by the average activation during phase II. The mean of the three trials performed was used to calculate the FRR. After the initial measurements for FRR (baseline I), a smartphone, Galaxy S3 (SHV-E210S, Samsung Electronics Co., Ltd.) smartphone, size 136.6×70.6×9.0 mm (length×breadth×thickness), weight of 138.5 g, was given to the participants, and they used the applications of their choice for 15 minutes. The postures adopted while using the smartphone were distinguished between desk posture and lap posture, and the testing sequence of the settings was randomized. In the desk posture, participants viewed a point on a smartphone screen with the neck in a neutral position. Then, subjects were asked to use both hands to hold the smartphone, keeping their elbows on the desk. In the lap posture, subjects were instructed to use both hands to hold the smartphone in the lap while performing neck flexion. While performing the task in the lap posture, the cervical range of motion (ROM) was measured using a cervical ROM instrument (Performance Attainment Associates, St. Paul, MN, USA). After using the smartphone for 15 minutes in the desk posture or lap posture, measurements for FRR were performed in the same manner as the baseline measurement, and a break time of 30 min was provided. Then, measurements for the FRR of the second baseline (baseline II) were conducted, and the subjects used the smartphone for 15 minutes in the next posture and the measurements for FRR were repeated. Before making EMG measurements, neck pain intensity was recorded using a visual analog scale (VAS) with values between 0 (no pain) and 10 (the worst imaginable pain). SPSS 21.0 (IBM Corporation, Armonk, NY, USA) was used for statistical analysis. The FRR was compared using a one-factor repeated measures analysis of variance (ANOVA). Post hoc analysis was performed using the Bonferroni correction, and statistical significance was accepted for values of $\alpha<0.05$.

RESULTS

No significant differences were found in the FRRs among desk posture, lap posture, and baseline. The FRR for the desk posture was 1.89±0.61 on the right and 2.15±0.92 on the left, 2.14±0.80 and 2.42±1.18 for the lap posture, 2.16±0.64 and 2.36±0.80 for baseline I, and 2.07±0.71 and 2.30±1.13 for baseline II, respectively. The cervical ROM of neck flexion in the lap posture was 44±4.31°. Before measuring baseline I, the results of the VAS were 0. However, after using the smartphone in a desk posture and a lap posture, the mean values of VAS were 1.7 and 5.2, respectively.

DISCUSSION

This study measured cervical FRRs and the intensity of neck pain to identify differences elicited by the various postures employed while using the smartphone. There was a difference in neck pain intensity, according to the different postures, but no significant differences in cervical FRRs were found. However, chronic low-back pain patients demonstrate the absence of or delayed lumbar FRR during forward flexion compared to healthy adults[6, 8, 11]. Murphy et al. found that the FRR of neck pain patients was significantly lower than that of asymptomatic subjects in a control group[9]. In these studies, chronic neck pain or low back pain patients had higher muscle activities in forward flexion than subjects in the control group, so FRR was low. The reduced FRR could be the result of altered neural reflexes that make the CES muscles more active during sustained full cervical flexion (phase II) to protect the spine from secondary injury. In addition, the absence of FRR in low-back pain patients is due to an imbalance between neural discharges to the muscles from pathologic structures, and this dysfunction in the reflex arc is expressed as continuous paraspinal activity to protect the spinal structures[12]. However, the participants in this study were healthy adults with no neck pain and no pathological conditions surrounding the neck muscles and structures. Also, after using smartphones in a lap posture, muscle activity did not change in phase II. Thus, the FRR may be a significant criterion of neuromuscular impairment and function in chronic neck pain or lumbar pain patients[9]; however, it may not be possible to distinguish neck pain that is caused by performing tasks for a short time. The FRRs observed in the present study were lower than those in the low back musculature (12–15) noted in the study by Watson et al[13]. The reason for this is that the CES muscle has a lower anatomic cross-sectional area than the lumbar extensors.

The VAS values after using a smartphone in the lap posture were higher than those of the desk posture. This means that pain is more severe in a lap posture. Greig et al. reported that CES and upper trapezius muscle activities were higher with a laptop set-up than with a desktop set-up[14]. Lee et al. found that the activities of the trapezius and erector spinae muscles increased when viewing a lower screen height[15]. This would cause fatigue, as the load of the muscles around the neck is increased. Thus, persistent neck flexion while using a smartphone or laptop computer may cause structural damage in the tissues around the cervical vertebra which may elicit a risk of neck pain[3, 16]. There-

fore, using a smartphone in a desk posture with a neutral neck position might reduce the incidence of neck pain. In addition, using smartphones for a long time in one posture should be avoided as it often results in stretching of the neck and shoulders.

This study had some limitations. First, because measurements for the calculation of FRR were taken after using smartphones for 15 minutes, we could not identify the effects of prolonged smartphone use in specific postures. Second, in the lap posture, the angles of neck flexion were not identical, among the subject, whose movements were not controlled. Therefore, future studies, will be required to compare FRRs among postures with prolonged use of smartphones.

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