The relationship between smartphone use and subjective musculoskeletal symptoms and university students

HYO-JEONG KIM, DH, PhD1, JIN-SEOP KIM, PT, PhD2*

1) Department of Dental Hygiene, Andong Science College, Republic of Korea
2) Department of Physical Therapy, Sunmoon University: 70 Sunmoon-ro, 221 Beon-gil, Tangjeong-myeon, Asan-si, Chungnam 336-708, Republic of Korea

Abstract. [Purpose] The purpose of this study was to investigate the use of smartphones by university students in selected areas, their musculoskeletal symptoms, and the associated hazard ratio. [Subjects and Methods] This involved the completion of a self-administered questionnaire by dental hygiene students in Seoul, Gyeonggido, and Gyeongsangbukdo. The 292 completed copies of the questionnaire were then analyzed. [Results] The most painful body regions after the use of smartphones were found to be the shoulders and neck. In the musculoskeletal system, back pain was found to have a positive correlation with the size of the smartphone’s liquid crystal display (LCD) screen, and pain in legs and feet were found to have a negative correlation with the length of time that the smartphone was used. As a result, it was revealed that the use of a smartphone was correlated with musculoskeletal symptoms. [Conclusion] Therefore, in today’s environment, where the use of smartphones is on the rise, it is necessary to improve the ways that they are used and to develop a preventive program to alleviate the symptoms of musculoskeletal damage.

Key words: Smartphone, Musculoskeletal symptoms, Prevent

INTRODUCTION

Smartphone market penetration in the Republic of Korea has gradually increased from 23 million people owning a smartphone in 2012 to 33 million owning one in January 2013. The age group of smartphone users varies, ranging from students to workers to elderly people1). Since smartphone users search the Internet, chat with others, use social networking services (SNS), write documents, and perform other tasks while looking at their phone’s small monitor, their constant and repeated motions in a certain posture can cause musculoskeletal disorders2, 3). Furthermore, since smartphone users in their teens and twenties commonly use their smartphones more than the elderly do, they are vulnerable to having severe musculoskeletal disorders, the symptoms of which can include fatigue and pains in the upper extremities, such as the neck, shoulders, arms, wrists, back of the hand, and fingers, in addition to pain in the waist. The user’s static repeated motion reduces blood circulation, prevents nutrients from being supplied to muscles, and causes small amounts of fatigue and pain. The musculoskeletal disorders that often occur are caused by repeated motions and by the phone user’s minimal muscle tension caused by long hours of exposure. In addition, poor postures lead to fatigue, which can have negative effects, such as reduced physiological function, disruption of the autonomic nervous system, creation of problems in daily life, and affects on both the visual and the musculoskeletal systems, leading to headaches and stress4, 5). The musculoskeletal disorders related to smartphone use include muscle fatigue and loading of the for neck and shoulder muscles, due to the repeated motions of hands, wrists, and arms6–9). As a result, pain, stiffness, insensitivity to pain, and quivers in the neck, shoulders, and arms may appear. Shoulder-arm-neck syndrome is mainly found in people who do repetitive work for more than six months.

Most previous studies of musculoskeletal disorders have been based on students’ use of computers. There has been some research carried out on factors related to the visual display terminal (VDT) syndrome experienced by middle and high school students. However, these days, many students use smartphones for longer periods and more frequently than computers because they are small, easily portable, and accessible. Despite this, there has been little research on the relationship between their use, pain, and posture or on the effects that smartphone use has on the musculoskeletal structure of each body region.

SUBJECTS AND METHODS

In terms of the general characteristics of smartphone
users, their age, height, and weight were considered, along with the type of smartphone used, place and purpose of use (multiple answers), and the average length of time of computer use. The subjects were asked to write down their age, height, and weight. The type of smartphone used was identified, and the location of use was categorized as home, library, school, and others; the options for purpose of use were searching for data, writing documents, games, chatting, and others; the options for average daily use were less than one hour, over four hours, and at intervals of one hour.

The survey was carried out with dental hygiene students in Seoul, Gyeonggido, and Gyeongsangbukdo from March 1 to May 1, 2014. Three hundred questionnaires were completed, and those copies that were considered to contain answers that were untruthful or incorrect were excluded. As a result, 292 completed questionnaires were used for the data analysis. This enabled the general characteristics of the students and smartphones to be identified. To assess the university students’ subjective musculoskeletal symptoms, a table of such symptoms in the Guideline of Harmful Factors Survey for Musculoskeletal Disorders, presented by the Korean Occupational Safety and Health Agency, was consulted. In order to carry out the data analysis, SPSS (ver. 20.0) Statistics was used. Both the general characteristics of the subjects and the subjective musculoskeletal symptoms in relation to this were presented by cross-tabulation analysis. To identify the relationships between smartphone-related characteristics and subjective musculoskeletal symptoms, Pearson’s correlation coefficient was calculated. Logistic regression analysis was performed to analyze how smartphone-related characteristics affect subjective musculoskeletal symptoms. The IBM SPSS Statistics for Windows, Version 20.0, software (IBM Corp., Armonk, NY, USA) was applied for the analysis. A p-value <0.05 was based on a significance test.

### RESULTS

The general characteristics of the subjects are presented in Table 1. The complaint rate of their subjective musculoskeletal symptoms is presented in Table 2. The group of subjects with a height of less than 162 cm had a higher complaint rate in the arms, hands, legs, and feet than the group of subjects with a height of more than 163 cm. The complaint rate in the eyes, neck, shoulders, fingers, and waist, but a lower pain in the hands, 29.8% felt pain in their waist, and 9.6% felt pain in their legs and feet. It can therefore be seen that neck pain and shoulder pain were the symptom most commonly experienced. The correlations between the subjective musculoskeletal symptoms and the smartphone-related characteristics are presented in Table 4. Pain in the waist region had a positive correlation with the size of the LCD screen (p<0.05). Pain in the legs and feet had a negative correlation with the period of smartphone use (p<0.05). As the size of the LCD screen increased, the probability of

### Table 1. General characteristics of the study subjects (n=292)

| Characteristics | Categories | n   | %   |
|-----------------|------------|-----|-----|
| Height (cm)     | M±SD       | 161.5±4.90 |
| Weight (kg)     | M±SD       | 52.8±7.40  |
| Age (years)     | M±SD       | 21.42±1.57 |
| Smartphone LCD size (inch) | Less than 5 inches | 143 | 49.0 |
|                 | More than 5 inches | 149 | 51.0 |
| Smartphone (places in use) | Home | 282 | 58.4 |
|                 | Library    | 35  | 7.2 |
|                 | Classroom  | 83  | 17.2|
|                 | Cafeteria  | 55  | 11.4|
|                 | Others (subway and public transportation) | 28 | 5.8 |
| Smartphone (postures in use) | Sitting | 201 | 40.0 |
|                 | Lying on the back | 175 | 34.9 |
|                 | Standing    | 53  | 10.6|
|                 | Lying on the face | 64 | 12.7 |
|                 | Others      | 9   | 1.8 |
| Smartphone (purposes of use) | Searching | 190 | 38.2 |
|                 | Playing game | 62 | 12.5 |
|                 | Chatting    | 211 | 42.5|
|                 | Writing documents | 15 | 3.0 |
|                 | Others      | 19  | 3.8 |
| Smartphone (smartphone-use hours) | Less than 1 hour | 5 | 1.7 |
|                 | 1–2 hours   | 28  | 9.6 |
|                 | 2–3 hours   | 73  | 25.0|
|                 | 3–4 hours   | 63  | 21.6|
|                 | More than 4 hours | 123 | 42.1 |

### Table 2. Subjective musculoskeletal symptoms by body regions (n=292)

| Categories     | NO | %   | YES | %   |
|----------------|----|-----|-----|-----|
| Eyes           | 169| 57.9| 123 | 42.1|
| Neck           | 129| 44.2| 163 | 55.8|
| Shoulder       | 132| 45.2| 160 | 54.8|
| Arms           | 236| 80.8| 56  | 19.2|
| Hands          | 236| 80.8| 56  | 19.2|
| Wrists         | 213| 72.9| 79  | 27.1|
| Fingers        | 234| 80.1| 58  | 19.9|
| Waist          | 205| 70.2| 87  | 29.8|
| Legs and feet  | 264| 90.4| 28  | 9.6 |


Table 2. Complaint rates of musculoskeletal subjective symptoms according to study subjects’ general characteristics (n=292)

| Characteristics | Categories | Eyes | Neck | Shoulder | Arms | Hands | Wrists | Fingers | Waist | Legs and feet |
|-----------------|------------|------|------|----------|------|-------|--------|---------|-------|--------------|
| Height (cm)     | ≤162 cm    | 66 (53.7) | 96 (58.9) | 92 (57.1) | 26 (46.4) | 25 (44.6) | 42 (53.2) | 30 (51.7) | 50 (57.5) | 12 (42.9) |
|                 | >162 cm    | 57 (46.3) | 67 (41.1) | 69 (42.9) | 30 (53.6) | 31 (55.4) | 37 (46.8) | 28 (48.3) | 37 (42.5) | 16 (57.1) |
| Weight (cm)     | ≤50 kg     | 48 (39.0) | 68 (41.7) | 75 (46.6) | 21 (37.5) | 24 (42.9) | 34 (43.0) | 26 (44.8) | 37 (42.5) | 12 (42.9) |
|                 | >50 kg     | 75 (61.0) | 79 (58.3) | 86 (53.4) | 35 (62.5) | 32 (57.1) | 45 (57.0) | 32 (55.2) | 50 (57.5) | 16 (57.1) |
| Smartphone LCD size (inch) | Less than 5 inches | 59 (48.0) | 83 (50.9) | 78 (48.4) | 25 (44.6) | 27 (48.2) | 35 (44.3) | 29 (50.0) | 34 (39.1) | 17 (60.7) |
|                 | More than 5 inches | 64 (52.0) | 80 (49.1) | 83 (51.6) | 31 (55.4) | 29 (51.8) | 44 (55.7) | 29 (50.0) | 53 (60.9) | 11 (39.3) |
| Smartphone (places in use) | Home | 120 (55.8) | 158 (55.8) | 155 (58.9) | 55 (61.1) | 53 (59.6) | 76 (57.6) | 57 (56.7) | 85 (55.2) | 27 (52.9) |
|                 | Library | 20 (9.3) | 23 (8.1) | 21 (8.0) | 8 (6.7) | 6 (7.6) | 10 (9.1) | 9 (9.1) | 14 (9.1) | 6 (11.8) |
|                 | Classroom | 37 (17.2) | 50 (17.7) | 43 (16.3) | 15 (16.7) | 16 (18.0) | 21 (15.9) | 26 (16.2) | 28 (18.2) | 8 (15.7) |
|                 | Cafeteria | 27 (12.6) | 35 (12.4) | 31 (11.8) | 10 (11.1) | 10 (11.2) | 18 (13.6) | 13 (13.1) | 17 (11.0) | 6 (11.8) |
|                 | Others | 11 (5.1) | 17 (6.0) | 13 (4.9) | 2 (4.5) | 4 (5.3) | 7 (4.0) | 4 (4.5) | 10 (6.5) | 4 (7.8) |
| Smartphone (postures in use) | Sitting | 78 (36.4) | 105 (38.6) | 115 (42.0) | 32 (36.4) | 38 (40.4) | 57 (43.2) | 43 (43.0) | 64 (40.0) | 20 (42.6) |
|                 | Lying on the back | 80 (37.4) | 101 (37.1) | 95 (34.7) | 36 (40.9) | 39 (41.5) | 51 (38.6) | 36 (32.5) | 52 (34.0) | 16 (35.0) |
|                 | Standing | 21 (9.8) | 25 (9.2) | 25 (9.1) | 7 (8.0) | 8 (8.5) | 11 (8.3) | 9 (9.0) | 17 (10.6) | 5 (10.6) |
|                 | Lying on the face | 31 (14.5) | 38 (14.0) | 38 (13.9) | 13 (14.8) | 9 (9.6) | 13 (9.8) | 12 (12.0) | 26 (16.3) | 6 (12.8) |
|                 | Others | 4 (1.9) | 3 (1.1) | 1 (0.4) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 1 (0.6) | 0 (0.0) |
| Smartphone (purposes of use) | Searching | 83 (38.6) | 103 (36.5) | 105 (38.2) | 36 (37.5) | 41 (41.4) | 56 (40.6) | 42 (40.8) | 60 (39.0) | 18 (36.7) |
|                 | Playing game | 29 (13.5) | 39 (13.8) | 36 (13.1) | 13 (13.5) | 14 (14.1) | 20 (14.5) | 12 (11.7) | 19 (12.3) | 7 (14.3) |
|                 | Chatting | 91 (42.3) | 123 (43.6) | 115 (41.8) | 37 (38.5) | 37 (37.4) | 54 (39.1) | 40 (38.8) | 66 (42.9) | 21 (42.9) |
|                 | Writing documents | 5 (2.3) | 8 (2.8) | 7 (2.5) | 5 (5.2) | 5 (4.0) | 5 (3.6) | 4 (4.9) | 1 (1.9) | 2 (1.9) |
|                 | Others | 7 (3.3) | 9 (3.2) | 12 (4.4) | 5 (5.2) | 3 (3.0) | 3 (2.2) | 4 (3.9) | 6 (3.9) | 2 (4.1) |
| Smartphone (phone-use hours) | Less than 1 hour | 2 (1.6) | 3 (1.8) | 5 (3.1) | 2 (3.6) | 2 (3.6) | 2 (1.3) | 1 (1.7) | 1 (4.6) | 3 (10.7) |
|                 | 1–2 hours | 6 (4.9) | 13 (8.0) | 14 (8.7) | 5 (8.9) | 6 (10.7) | 6 (6.3) | 5 (10.3) | 6 (10.3) | 9 (21.4) |
|                 | 2–3 hours | 35 (28.5) | 38 (23.3) | 43 (26.7) | 10 (17.9) | 11 (19.6) | 22 (27.8) | 11 (19.0) | 17 (19.5) | 4 (14.3) |
|                 | 3–4 hours | 22 (17.9) | 35 (21.5) | 31 (19.3) | 8 (14.3) | 12 (21.4) | 17 (21.5) | 12 (20.7) | 23 (26.4) | 4 (14.3) |
|                 | More than 4 hours | 58 (47.2) | 74 (45.4) | 68 (42.2) | 31 (55.4) | 25 (44.6) | 34 (43.0) | 28 (48.3) | 34 (39.1) | 11 (39.3) |
experiencing pain in the legs and feet increased 0.70-fold, which was found to be statistically significant (p<0.05); however, in the cases of pain in the eyes, neck, shoulders, arms, hands, wrists, fingers, and waist, there was no statistically significant (p>0.05).

### DISCUSSION

The objective of this study was to provide material that could be used to help prevent musculoskeletal disorders caused or exacerbated by smartphone use. The average height of the 20 year old female participants was 161.5 cm and their average weight was 52.8 kg. These participants, 51% used a smartphone with an LCD screen that was greater than 5 inches, and 49% used a smartphone with an LCD screen that was less than 5 inches. Therefore, it appeared that the majority of subjects preferred a large LCD screen.

According to the results relating to smartphone use, 42.5% used smartphones for chatting, 38.2% used them for searching the Internet, 12.5% used them for playing games, 3.8% used them for other activities, and 3.0% used them for writing documents. Chatting and searching the Internet accounted for 80.7% of use, which indicates that most students use their smartphones for these activities.

The majority of the students used their smartphone at home (58.4%) and most preferred sitting (40.0%) or lying on their back (34.9%) when using a smartphone. As shown earlier, many of the subjects used smartphones in poor working environments, as indicated by their sitting and lying positions. Therefore, there is a high likelihood that they will suffer from musculoskeletal disorders. Regarding the average daily use, 42.1% used smartphones for more than 4 hours, and 21.6% used them for between 3 and 4 hours. In short, 80% of the students used smartphones for more than 2 hours every day.

When smartphones are constantly used at home without any rest, and a poor posture is maintained over a long period of time, musculoskeletal pain can occur. Repeated motions whilst in a static posture can result in a variety of problems, such as shoulder and neck pain. According to studies by Bendix et al., Lee et al., and by Mekhora et al., the longer that display terminals are used, the more the bending angles of the neck bone and the waist bone are increased.

According to studies by Burnett et al. and O’Sullivan et al., adopting an incorrect posture for a long period of time can lead to a lowering in the function of waist muscles, triggering pain in the waist. Therefore, it is evident that using smartphones whilst in a sitting posture for a long time can trigger musculoskeletal disorders. In this study, it was observed that neck pain and shoulder pain were the most commonly experience kinds of pain. The studies by Straker et al. and Szeto and Lee also revealed that the bending angles of the neck and back bones increased significantly. As mentioned earlier, in this study, it was found that pain in the waist had a positive correlation with the size of an LCD screen. Pain in the legs and feet were negatively correlated with the period of smartphone use, while there was no statistically significant correlation between the size of the LCD screen and pain in the eyes, neck, shoulders, arms, hands, wrists, fingers, or waist. This indicates that since larger LCD screens are more comfortable and convenient, their use will lead to a reduction in the complaint rate of musculoskeletal symptoms. Lee also reported that as display terminal screens became smaller, the bending angles of the neck and back bones significantly increased. In other words, the larger the terminal display screens, the lower the complaint rate of musculoskeletal symptoms.

The results of this study are important in a number of areas: First, they provide university students with fundamental information and advice on their use of smartphones. Second, the data shows that the size of the LCD screen is closely correlated with pains in specific body regions. Third, the amount of time that a smartphone is used is also correlated with pain. This study has limitations in that it is not representative of the whole population, as it specifically focused on university students. Additionally, it should be noted that a self-administered questionnaire does increase the risk of response bias.

### REFERENCES

1. Han YS, Choi JK, Hwang BH, et al.: A study on elderly for improvement of usability on smart phone. J Soc e-Bus Stud, 2012, 17: 39–52. [CrossRef]
2. Lee J, Seo K: The comparison of cervical repositioning errors according to...
smartphone addiction grades. J Phys Ther Sci, 2014, 26: 595–598. [Medline] [CrossRef]
3) 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]
4) Janwantanakul P, Sithipornvorakul E, Paksaichol A: Risk factors for the onset of nonspecific low back pain in office workers: a systematic review of prospective cohort studies. J Manipulative Physiol Ther, 2012, 35: 568–577. [Medline] [CrossRef]
5) Szeto GP, Lee R: An ergonomic evaluation comparing desktop, notebook, and subnotebook computers. Arch Phys Med Rehabil, 2002, 83: 527–532. [Medline] [CrossRef]
6) Rossignol AM, Morse EP, Summers VM, et al.: Video display terminal use and reported health symptoms among Massachusetts clerical workers. J Occup Med, 1987, 29: 112–118. [Medline]
7) Shim JM: The effect of carpal tunnel changes on smartphone users. J Phys Ther Sci, 2012, 24: 1251–1253. [CrossRef]
8) Lee DU: Impact of personal computer use on musculoskeletal symptoms in middle and high school students. J Korean Acad Fam Med, 2002, 23: 760–768.
9) Park HS: The effect of VDT work on work-related musculoskeletal disorders in the deluxe hotel. J Tour Stud, 2006, 20: 217–225.
10) Bonney RA, Corlett EN: Head posture and loading of the cervical spine. Appl Ergon, 2002, 33: 415–417. [Medline] [CrossRef]
11) Lee JH, Park SY, You 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]
12) Hagberg M: ABC of work related disorders. Neck and arm disorders. BMJ, 1996, 313: 419–422. [Medline] [CrossRef]
13) Luopajärvi T, Kuorinka I, Virolainen M, et al.: Prevalence of tenosynovitis and other injuries of the upper extremities in repetitive work. Scand J Work Environ Health, 1979, 5: 48–55. [Medline] [CrossRef]
14) Bendix T, Biering-Sørensen F: Posture of the trunk when sitting on forward inclining seats. Scand J Rehabil Med, 1983, 15: 197–203. [Medline]
15) Mekhora K, Liston CB, Nathavannij S, et al.: The effect of ergonomic intervention on discomfort in computer users with tension neck syndrome. Int J Ind Ergon, 2000, 26: 367–379. [CrossRef]
16) Burnett AF, Cornelius MW, Dunkaerts W, et al.: Spinal kinematics and trunk muscle activity in cyclists: a comparison between healthy controls and non-specific chronic low back pain subjects-a pilot investigation. Man Ther, 2004, 9: 211–219. [Medline] [CrossRef]
17) O'Sullivan PB, Burnett A, Floyd AN, et al.: Lumbar repositioning deficit in a specific low back pain population. Spine, 2003, 28: 1074–1079. [Medline] [CrossRef]
18) 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]