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Original Article

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

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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

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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 people[1)]. 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 disorders[2, 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 stress[4, 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 arms[6–9)]. 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

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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 eyes, neck, shoulders, fingers, and waist, but a lower complaint rate in the arms, hands, legs, and feet than the group of subjects with a height of more than 163 cm. The group of subjects weighing was less than 50 kg had a lower complaint rate than the group of subjects weighing was more than 50 kg. Those who use smartphones whilst sitting and lying on their back had a relatively high complaint rate. It was also found that those who use smartphones for searching the Internet and chatting had the highest complaint rate and that those who used a smartphone for less than 2 hours each day had a lower complaint rate than the other groups. Subjective musculoskeletal symptoms by body regions are presented in Table 3. As shown in this table, 42.1%, felt pain in their eyes, 55.8% felt pain in their neck, 54.8% felt pain in their shoulders, 19.2% felt pain in their arms, 19.2% felt pain in their hands, 27.1% felt pain in their wrists, 19.9% felt pain in their fingers, 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 hours	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 3. Subjective musculoskeletal symptoms by body regions (n=292)

Categories	NO		YES	
	n	%	n	%
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)	95 (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 (57.6)	85 (55.2)	27 (52.9)
	Library	20 (9.3)	23 (8.1)	21 (8.0)	8 (8.9)	6 (6.7)	10 (7.6)	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)	16 (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 (2.2)	4 (4.5)	7 (5.3)	4 (4.0)	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 (36.0)	52 (32.5)	16 (34.0)
	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)	4 (4.0)	5 (3.6)	5 (4.9)	3 (1.9)	1 (2.0)
	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 (smartphone-use hours)	Less than 1 hour	2 (1.6)	3 (1.8)	5 (3.1)	2 (3.6)	2 (3.6)	1 (1.3)	1 (1.7)	4 (4.6)	3 (10.7)
	1–2 hours	6 (4.9)	13 (8.0)	14 (8.7)	5 (8.9)	6 (10.7)	5 (6.3)	6 (10.3)	9 (10.3)	6 (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)

Table 4. Correlations between subjective musculoskeletal symptoms and smartphone-related characteristics

Categories	Eyes	Neck	Shoulder	Arms	Hands	Wrists	Fingers	Waist	L/F	Use hours	LCD size
Eyes	1										
Neck	0.200**	1									
Shoulder	0.142*	0.293**	1								
Arms	0.254**	0.206**	0.230**	1							
Hands	0.236**	0.241**	0.265**	0.403**	1						
Wrists	0.199**	0.216**	0.239**	0.291**	0.467**	1					
Fingers	0.218**	0.149*	0.156**	0.303**	0.586**	0.450**	1				
Waist	0.066	0.218**	0.302**	0.196**	0.215**	0.143*	0.182**	1			
L/F	0.146*	0.126*	0.224**	0.285**	0.285**	0.221**	0.304**	0.296**	1		
Use hours	0.088	0.080	−0.040	0.072	0.000	0.033	0.048	−0.046	−0.127*	1	
LCD size	0.017	−0.044	0.012	0.042	0.007	0.057	−0.010	0.129*	−0.076	0.061	1

*$p<0.05$, **$p<0.01$

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 statistical significance ($p>0.05$).

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[10]. Regarding the average daily use, 42.1% used smartphones for more than 4 hours, and 21.6% use them for between 3 and 4 hours. In short, 80% of the students used smartphones for more than 2 hours every day[11].

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[12, 13]. According to studies by Bendix et al.[14], Lee et al.[11], and by Mekhora et al.[15], 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.[16] and O'Sullivan et al.[17], 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.[18] and Szeto and Lee[5] 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[8] 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.

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