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A Comparison of Cervical Flexion, Pain, and Clinical Depression in Frequency of Smartphone Use

Junhyuk Park[1], Kwangho Kim[2], Namkang Kim[2], Inwon Choi[2], Sujung Lee[2], Sajin Tak[1] and Jongeun Yim[1,2 *]

1. *Department of Physical Therapy, Graduate School of Sahmyook University, Seoul, Republic of Korea*
2. *Department of Physical Therapy, Sahmyook University, Seoul, Republic of Korea jeyim@syu.ac.kr*

Abstract

In the past decade, there has been a rapid increase in the use of mobile phones and other small hand-held devices for communication. A forward head posture (turtle neck posture) is becoming more common with the increasing popularity of smartphones. The aim of this study was to evaluate the craniovertebral angle, head position angle, pain threshold of the sternocleidomastoid and upper trapezius muscles, and presence of depression in heavy smartphone users compared to a control group. Twenty healthy students participated in the study. The participants were recruited from Sahmyook University and were divided into a heavy user group (n=10) and a control group (n=10) according to smartphone addiction proneness. All protocols and procedures were approved by the Institutional Review Board of Sahmyook University (Seoul, South Korea) and all the subjects signed a statement of informed consent. Participants in both groups were assessed for their pain pressure threshold of the sternocleidomastoid and upper trapezius muscles, craniovertebral angle and head position angle, and depression. When comparing the results between the two groups, there were significant differences in the pain threshold of the sternocleidomastoid and upper trapezius muscles, head position angle, and depression ($p<.05$), but not in the craniovertebral angle. Based on the results, this study shows that heavy smartphone use may produce considerable stresses on the cervical spine, thus changing the cervical curve and pain threshold of the muscles around the neck. Smartphones could also cause negative effects on a person's psychological status, such as depression. Therefore, individuals should make an effort to look at their phones with a neutral spine and to avoid spending hours hunched over their screens each day.

Keywords: *smartphone, cervical angle, pain threshold, depression*

1. Introduction

The smartphone has become a necessity for most people. Smartphones are used for both communication and entertainment purposes, such as messages, music, media, internet access, photos, and games[1]. According to the Pew Research Center, 56% of American adults were smartphone users in 2013. In Korea, over 24 million people owned a smartphone in 2013, and 97.4% of Koreans in their twenties had their own smartphone. Smartphone users in Korea usually spend an average of 4.1 hours a day on their smartphone, while heavy smartphone users spend 5.4 hours a day.

When using a smartphone, people usually flex their neck downwards to stare at the lowered object and maintain the head in a forward position for long periods of time, which may cause musculoskeletal disorders, such as "upper crossed

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syndrome." Moreover, the maintenance of a head-forward posture decreases cervical lordosis of the lower cervical vertebrae and creates a posterior curve in the upper thoracic vertebrae to maintain balance; this is known as the forward head posture (FHP; turtle neck posture)[2-4]. A previous study stated that FHP causes shortening of the muscular fibers around the articulation points of the atlantooccipitalis and overstretching of muscles around joints, possibly producing chronic neck pain[5]. FHP may affect not only the neck but also the thoracic spine and shoulder blades, potentially causing an overall imbalance in the musculoskeletal system[6]. According to a recent study, the weight supported by the spine dramatically increases when flexing the head forward at varying degrees. An adult head weighs 10–12 pounds in the neutral position. As the head tilts forward, the forces felt by the neck surge to 27 pounds at 15 degrees, 40 pounds at 30 degrees, 49 pounds at 45 degrees, and 60 pounds at 60 degrees. At 90 degrees, the model prediction was not reliable[7]. Good posture is defined as keeping one's ears aligned with the shoulders and having the "angel wings," or the shoulder blades, retracted. In proper alignment, spinal stress is diminished; this is the most efficient position for the spine[7-9]. Loss of the natural curve of the cervical spine produces incrementally increased stresses about the cervical spine. These stresses may lead to early wear, tear, degeneration, and possibly surgery[7].

Reliable evaluation of FHP is important for therapists to assess the impact of their therapeutic interventions. Despite the high prevalence of FHP in subjects both with and without cervical pain, there is no standard clinical method for its accurate measurement[10, 11]. Measuring the angles between anatomical references is a reliable method for evaluating the head and neck posture. Photogrammetry (measurements using photographs) is a simple and objective technique for measuring the posture of different parts of the body and has demonstrated good validity for the analysis of craniovertebral posture[12, 13].

Some studies have indicated that the excessive use of smartphones has negative effects on human psychology[14-16]. Excessive smartphone use reduces an individual's social implication in the real world and, as a consequence, his or her psychological well-being because it produces the kind of isolation, loneliness, and depression the individual seeks to ease by connecting to the Internet[17]. Therefore, heavy smartphone users meet with their friends less often in person[18]. According to a previous study, the excessive user group experienced difficulty in expressing emotions than the comparison group did. Furthermore, the excessive user group had a higher level of interpersonal anxiety than the comparison group[14].

Previous studies have reported that smartphone users are more likely to complain of neck pain, muscle fatigue, and cervical range of motion than normal phone users[2, 19]. However, few studies have directly evaluated the effects of excessive smartphone use on pain, cervical angle, and especially depression in heavy smartphone users. Therefore, this study aimed to evaluate the craniovertebral angle, head position angle, pain threshold of the sternocleidomastoid and upper trapezius muscles, and presence of depression in heavy smartphone users compared with a control group.

2. Methods

2.1. Participants

Twenty healthy students participated in the study. The participants were recruited from Sahmyook University and were divided into a heavy user group (n=10) and a control group (n=10) according to their smartphone addiction proneness. The inclusion criteria were (1) no abnormal findings confirmed through physical and

neurologic examinations; (2) no congenital abnormalities in either the cervical or the lumbar spine; and (3) no history of severe surgical procedures. One hundred subjects met the criteria. All protocols and procedures were approved by the Institutional Review Board of Sahmyook University (Seoul, South Korea), and all the subjects signed a statement of informed consent before the study began.

2.2. Procedure

A questionnaire on smartphone addiction status was used to evaluate the subjects. The participants were divided into either the heavy user group or the control group according to their responses on the smartphone addiction questionnaire. Participants in both groups had their pain pressure threshold of the sternocleidomastoid and upper trapezius muscles measured; they were also assessed for craniovertebral and head position angles and depression (Figure 1).

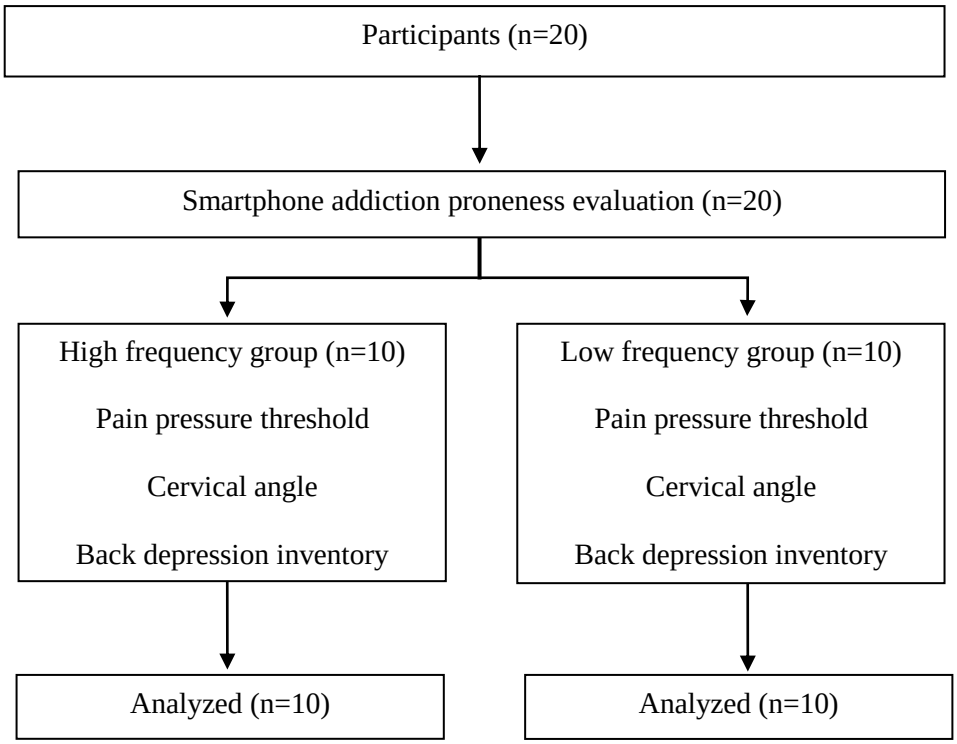

Figure 1. Flow Diagram of the Experimental Procedure

2.3. Outcome Measures

2.3.1. Smartphone Addiction Proneness Scale: We used the Smartphone Addiction Proneness Scale, which was created by the National Information Society Agency, to assess our subjects. This tool is a 4-point scale that contains 15 items. A higher score indicates a higher degree of addiction. If the score were 44 points or more, the participant was placed in the high-risk user group; subjects scoring 40–43 points were placed in the potentially dangerous use group, while those who earned 39 points or less were classified as the regular user group.

2.3.2. Pain Pressure Threshold: The pain pressure thresholds (PPTs) were measured using an electronic algometer (JTECH Medical, USA) over potential trigger points on the body. The examiner identified a trigger point by palpating and exerting vertical pressure on the skin. The examiner increased the pressure at a rate

of 1 kg/s until the subject experienced a pain or an unpleasant feeling, and then the PPT values were measured 3 times for each muscle. The participants were instructed to verbally express their first perception of pain or an unpleasant feeling, at which point the application of pressure was stopped. The PPT has been proven to be a reliable measure (interclass correlation, 0.78–0.93).

2.3.3. Cervical Angle Measurement: Posture was assessed by an examiner with 5-years of experience. The FHP was determined based on both observation and a review of the status of the participant's head and neck compared to the plumb line. Subjects were placed into 1 of the 3 following groups according to the vertical alignment of the ear tragus in relation to the middle of the shoulder or trunk: non FHP (ear tragus was perpendicular to the shoulder or trunk), slight FHP (ear tragus was forward but the posterior part of the ear was perpendicular to the shoulder or trunk), and moderate-severe FHP (ear tragus was forward from the shoulder or trunk). This classification was determined based on the clinical experience of the physical therapist as an examiner. Two angles—the craniovertebral angle and head position angle—were measured to quantify FHP, and the head tilt angle was computed to measure the subjects' head position. All of these angles were measured using Adobe Acrobat software.

The craniovertebral angle was identified at the intersection of a horizontal line passing through the C7 spinous process and a line joining the midpoint of the tragus of the ear to the skin overlying the C7 spinous process. There was no clear cut-off point threshold to identify the FHP using the craniovertebral angle, but in general, subjects with a smaller craniovertebral angle had a greater FHP.

This angle evaluates the head status in relation to the trunk and indicates the vertical distance between the chin and sternum. It is the angle between the tragusmanubrium line and the line extending from the center point of the chin to the tragus. Similar to the craniovertebral angle, there is no standard cut-off point for this value, but a larger head position angle may be associated with a longer FHP.

2.3.4. Back Depression Inventory: The beck depression inventory (BDI), a 21-question, multiple-choice self-report inventory, is one of the most widely used instruments for measuring the severity of depression. Its development marked a shift among health care professionals, who had until then viewed depression from a psychodynamic perspective instead of being rooted in the patient's own thoughts.

2.4. Statistical Analysis

The independent t-test was used for a comparison of the pain pressure threshold, cervical angle, and back depression inventory between the heavy user group and the control groups. The Statistical Package for the Social Sciences (SPSS) version 18.0 for Windows was used to perform all statistical analyses, and p values <0.05 were regarded as significant.

3. Results

3.1. General Characteristics of Participants

In this study, there were no significant differences in age, height, or body weight between the two groups. However, the scores on the smartphone addiction scale were significantly different between the two groups. In the heavy user group, the mean age of participants was 23.3±2.3 years, while the mean score on the smartphone addiction scale was 45.10±3.63. In the control group, the mean age of participants was 22.6±1.4 years, and the mean point of the smartphone addiction scale was 26.50±4.48 (Table 1).

Table 1. General Characteristics of Participants

	Heavy users group (n=10)	Control group (n=10)	X^2/t
Age (years)	23.30 (2.31)	22.60 (1.42)	.426
Height (cm)	168.60 (8.84)	167.20 (8.53)	.723
Body weight (kg)	62.20 (9.0)	57.90 (11.4)	.363
Smartphone addiction scale (score)	45.10 (3.60)	26.50 (4.48)	.000

Values are presented as mean (standard deviations).

3.2. Comparison of the Pain Threshold in the Sternocleidomastoid and Upper Trapezius Muscles

When comparing the pain threshold on three different parts of the sternocleidomastoid muscle, there were significant differences in all three parts between the two groups ($p<.05$). The pain threshold for the two parts of the upper trapezius muscle were also significantly different for the two parts between the two groups ($p<.05$) (Table 2).

3.3. Comparison of Cervical Angles and Depression Status

When comparing the cervical angles and depression, there were significant differences in cervical angle B and depression status between the 2 groups ($p<.05$). For cervical angle A, there were different angles between the 2 groups, but this difference was not significant (Table 3)

Table 2. Comparison of Pain Thresholds in the Sternocleidomastoid and Upper Trapezius Muscles

	Heavy users group (n=10)	Control group (n=10)	*P*
SCM1	13.37 (3.40)	21.35 (5.22)	.001*
SCM2	11.97 (4.04)	17.27 (5.71)	.028*
SCM3	14.61 (3.55)	21.59 (5.25)	.003*
UTRA1	19.31 (5.61)	32.65 (11.53)	.004*
UTRA2	24.17 (7.31)	37.99 (11.38)	.005*

Values are presented as mean (standard deviation).

SCM: sternocleidomastoid; TRA: upper trapezius muscles.
* $p < .05$

4. Discussion

Billions of people use cell phone devices worldwide, which can result in poor posture. Heavy smartphone users are commonly found to have forward head

syndrome and a slouched posture[3, 4]. Staring at a smartphone display, which is located below a comfortable height for eyesight, for extended periods of time makes the head tilt forward. Extended smartphone use can cause FHP, myofascial syndrome of the hand, forearm, shoulder, and neck muscles, and depression[2]. In addition, the weight supported by the spine dramatically increases when the head is flexed forward at varying degrees. Therefore, heavy smartphone users lose the natural curve of the cervical spine and instead place increased amounts of stress on the cervical spine[7]. These stresses may lead to changes in the cervical angle and the pain threshold of the neck and shoulder muscles. In addition, a high frequency of smartphone use could be a risk factor for symptoms of depression[20]

Table 3. Comparison of Cervical Angles and Depression Status

	Heavy users group (n=10)	Control group (n=10)	*P*
Cervical angle A	53.00 (7.56)	51.20 (6.61)	.578
Cervical angle B	34.85 (5.39)	39.70 (3.02)	.023*
Depression	20.20 (10.62)	9.10 (4.12)	.006*

Values are presented as mean (standard deviation).

*p < .05

In this study, the cervical angle, pain threshold of the sternocleidomastoid and upper trapezius muscles, and depression were measured in heavy smartphone users compared to a control group. There was a significant difference between the two groups ($p<.05$) in regards to the pain threshold of the sternocleidomastoid and the upper trapezius muscles. When comparing the cervical angle between the two groups, there was a significant difference in the head position angle ($p<.05$) but not in the craniovertebral angle. In regards to depression, a significant difference was seen between the two groups ($p<.05$).

Most smartphone tasks require users to stare sharply downwards or to hold their arms out in front of them to read the screen, which makes the head move forward and causes an excessive anterior curve in the lower cervical vertebrae and an excessive posterior curve in the upper thoracic vertebrae to maintain balance and places stresses on the cervical spine and neck muscles[2, 19]. Finally, smartphone use produces chronic neck pain by reducing cervical lordosis and the pain threshold of the neck muscles. In this study, the head position angle and the pain threshold of the sternocleidomastoid and upper trapezius muscles showed significant differences between the two groups. According to a previous study by Kenneth et al., when flexing the head forward at varying degrees, the forces experienced by the cervical spine considerably increase and lead to cervical curve loss, which may cause neck pain[7]. Studies on the prevalence of smartphone use have reported that the distribution of musculoskeletal symptoms or pain of any severity was most common in the neck, followed by the upper back and then the shoulders. These results showed that the total time spent using a smartphone was significantly associated with any pain in the neck and shoulder[19, 21]. Therefore, the results of this study are consistent with other previous studies, which reported that the excessive use of a smartphone could produce considerable stress on the cervical spine and therefore cause neck pain.

Heavy smartphone use has been associated with somatic complaints, anxiety, and insomnia, depression, psychological distress, and an unhealthy lifestyle[20]. Individuals who constantly use smartphones may experience a decrease in the

amount of time they have for other social relations, especially activities that involve face-to-face interactions. This situation may also make individuals lonely. Although smartphones are used as communication tools, their excessive use causes individuals to become addicted and isolated[22]. In this study, there was a significant difference in the depression scale between the two groups. A previous study found that excessive users of smartphones experienced more depressive symptoms and difficulty in expressing emotions than the comparison group did[14]. In addition, a greater number of face-to-face interactions was associated with lower levels of loneliness; however, more smartphone use was associated with greater loneliness[15].

5. Conclusion

In this study, the cervical angle, pain threshold of the sternocleidomastoid and upper trapezius muscles, and depression were measured in heavy smartphone users compared to a control group. There was a significant difference between the two groups ($p<.05$) in regards to the pain threshold of the sternocleidomastoid and the upper trapezius muscles. When comparing the cervical angle between the two groups, there was a significant difference in the head position angle ($p<.05$) but not in the craniovertebral angle. In regards to depression, a significant difference was seen between the two groups ($p<.05$). Based on the results, this study shows that heavy smartphone use may produce considerable stresses on the cervical spine, thus changing the cervical curve and pain threshold of the muscles around the neck. Smartphones could also cause negative effects on a person's psychological status, such as depression. Therefore, individuals should make an effort to look at their phones with a neutral spine and to avoid spending hours hunched over their screens each day.

Conflict of Interests

None declared

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