J. Phys. Ther. Sci. 28: 1496–1498, 2016

The Journal of Physical Therapy Science

Original Article

Effect of sitting posture on respiratory function while using a smartphone

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Abstract. [Purpose] The purpose of this study was to investigate respiratory function in different sitting postures while using a smartphone. [Subjects and Methods] Fifty healthy volunteers were recruited. Participants were divided into 2 groups, a control group of participants who spent time as they liked for 1 hour, and a smartphone group of participants who spent time using a smartphone in a sitting position for 1 hour. To investigate changes in respiratory function, we measured forced vital capacity, forced expiratory volume in 1 second, ratio of forced expiratory volume in 1 second to forced vital capacity, and peak expiratory flow. [Results] There was a statistically significant difference in forced vital capacity and forced expiratory volume in 1 second between the control group and smartphone group. [Conclusion] The clinical implication of our findings is that the posture assumed while using a smartphone leads to reduced respiratory function.
Key words: Smartphone, Respiratory function, Posture

(This article was submitted Dec. 14, 2015, and was accepted Feb. 1, 2016)

INTRODUCTION

Body position can influence respiratory function[1, 2)]. Changes in body position can alter the length of a respiratory muscle, namely the diaphragm, thereby influencing its ability to generate tension[3)]. Several studies have reported that a slumped, poor posture significantly reduces lung capacity, expiratory flow, and lumbar lordosis compared with a normal upright posture[4)].

Recently, smartphones have become essential mobile devices in our daily lives, and people often demonstrate poor posture when using smartphones[5)]. Several studies have reported that frequent smartphone use can lead to adoption of a non-neutral neck posture or development of musculoskeletal disorders[6)]. Additionally, many people use smartphones with their head shifted forward and the smartphone placed near their waist or lap while in a sitting position[7)]. Changes in cervical mobility, head posture, and dysfunction of local and global muscle systems are believed to lead to changes in force-length curves, muscle imbalances, and segmental instability, all of which can potentially affect thoracic cage function and rib cage biomechanics[8, 9)].

Many previous studies have investigated alterations in cervical movement patterns during smartphone use. In addition, previous studies have focused on psychological problems, such as subjective symptoms of physical problems and stress. However, to date, no study has reported on the effects of sitting posture on respiratory function while using a smartphone. The purpose of this study was to investigate the effect of different sitting postures on respiratory function and determine whether there are differences in changes between smartphone a group of smartphone users and a control group.

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SUBJECTS AND METHODS

We recruited 50 healthy volunteers from Daegu University in Gyeongsan City, South Korea. Our study was designed as a randomized control trial. The participants were divided into 2 groups. The control group spent time as they liked for 1 hour, and the smartphone group used a smartphone while in a sitting position for 1 hour. The smartphone group subjects started the experiment in a comfortable position in which they held a smartphone with both hands and looked at the screen. When they started using the phone, they played a game.

Four participants quit during the study (control group, 3; smartphone group, 1) due to deterioration of their conditions. The mean age, height, and body weight of the control group (mean ± standard deviation) were 21.68 ± 1.99 years, 166.07 ± 10.64 cm, and 59.86 ± 15.08 kg (8 men and 14 women), respectively. The mean age, height, and body weight of the smartphone group (mean ± standard deviation) were 22.83 ± 2.39 years, 169.00 ± 8.91 cm, and 67.00 ±13.42 kg (13 men and 11 women). Participants were excluded if they had spinal structure problems, neurological disorders, or respiratory dysfunctions (e.g., asthma), if they were smokers, or if they had become nonsmokers within the last 5 years. All participants understood the purpose of the study, and informed written consent was obtained prior to enrollment. Our study was approved by the Institutional Review Board of Daegu University in accordance with the ethical guidelines established in the Declaration of Helsinki.

To investigate changes in respiratory function, we measured forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), ratio of forced expiratory volume in 1 second to forced vital capacity (FEV1/FVC), and peak expiratory flow (PEF). These variables were measured using a spirometer (Spiropalm, COSMED, Rome, Italy). All participants sat on a stool and looked straight ahead. After the participant's nose was clamped with a nose clip, the participant breathed into the mouthpiece of the spirometer. The best performance out of 3 tries was recorded as the FVC. Measurements were performed before and after the experiment.

We used IBM SPSS Statistics v20.0 (IBM, Armonk, NY, USA) to analyze the data. Analysis of covariance (ANCOVA) was used for statistical analyses, and the level of statistical significance was set at $p<0.05$.

RESULTS

There were no differences between both groups in gender, age, height, or weight. There were initially 25 subjects in each group, but 4 participants were excluded due to deterioration of their conditions (control group, 3; smartphone group, 1). There were statistically significant differences in FVC and FEV1 between the control group and smartphone group ($p<0.05$) (Table 1).

DISCUSSION

In our study, we investigated the effect of using a smartphone while in different sitting postures on respiratory function. The smartphone group exhibited significant decreases in FVC and FEV1 compared with the control group. These results suggest that a sitting posture while using a smartphone can reduce respiratory function.

In the current study, the results of the smartphone group decreased significantly from 3.2 ± 0.9 to 3.0 ± 0.8 for FVC and from 3.0 ± 0.8 to 2.7 ± 0.8 for FEV1. There are 2 possible causes of respiratory dysfunction. First, individuals using smartphones have been found to have reduced global and local muscle performance[8]. It is believed that dysfunction of these muscles leads to reduced respiratory performance; this is mainly due to the common function of the sternocleidomastoid, trapezius, and scalene muscles in cervical movement and inspiration. Additionally, weakness of the deep neck flexor and

Table 1. Respiratory function of the two groups

		Control group	Smartphone group
FVC*	Pre	2.4 ± 0.9	3.2 ± 0.9
(l)	Post	2.5 ± 0.9	3.0 ± 0.8
FEV1*	Pre	2.2 ± 0.2	3.0 ± 0.8
(l)	Post	2.4 ± 0.8	2.7 ± 0.8
FEV1/FVC	Pre	92.3 ± 11.4	92.8 ± 7.0
(%)	Post	94.1 ± 4.9	90.0 ± 10.3
PEF	Pre	4.7 ± 1.6	5.6 ± 2.1
(l/sec)	Post	4.2 ± 1.4	5.2 ± 2.2

Values are means ± standard deviation.
*Indicates a significance difference ($p<0.05$) between the control group and smartphone group.

extensor muscles can lead to reduced stability of the cervical and thoracic spine, as well as changes in rib cage biomechanics[10]. These changes in rib cage biomechanics can also lead to associated changes of respiratory muscles by altering their force-length curves and force production abilities[11].

Second, changes in force-length curves, muscles imbalances, and segmental instability of the cervical spine are also possible causes of respiratory dysfunction. Segmental instability of the cervical spine might also be observed in the thoracic spine because of certain muscles, such as the longus colli, that attach to both neck proprioceptor impairment areas, thus rendering it difficult to attain optimal spine alignment[8, 12]. Furthermore, sagittal postures of the thoracic spine were found to be associated with forward head posture, cervical mobility, and neck pain[13]. Concerning respiratory function, it was shown that thoracic kyphosis was accompanied by dyspnea and ventilator dysfunction[14]. In young healthy participants with a normally positioned diaphragm, a slumped sitting posture results in increased intra-abdominal pressure by approximating the ribs to the pelvis. This makes it difficult for the diaphragm to descend caudally during inspiration[4].

The clinical implication of our findings is that the posture when using a smartphone leads to reduce respiratory function. The limitations of our study include a small sample size with a limited age range; this makes generalization of results difficult. Furthermore, other kinematic data, such as electromyography, were not assessed. Further studies will be required to obtain kinematic measurements related to motor function of the posture when using a smartphone.

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