Effects of Body Posture while Using a Smartphone on Inspiratory Capacity and Cervical and Thoracic Postures in University Students

Dae-Hee Lee, PT, PhD[1], **Hye-Joo Jeon, PT, PhD**[*1]
[1]*Dept. of Physical Therapy, U1 University, Republic of Korea*
[*1]*Dept. of Physical Physical Therapy, U1 University, Republic of Korea*

Purpose This study aimed to investigate the effects of posture while using a smartphone on inspiratory capacity and cervical and thoracic posture in university students. ***Methods*** Thirty subjects (18 women and 12 men) participated in this study. The participants were asked to sit in a normal sitting position without using a smartphone, followed by sitting while watching a video using a smartphone. The angle was measured using an iPhone application (Goniometer Pro) to quantitatively assess cervical and thoracic flexion range of motion. We measured inspiratory capacity (strength index, peak inspiratory flow, and volume) using the Powerbreathe K5. ***Results*** Cervical and thoracic flexion angles were significantly greater when sitting while using a smartphone relative to sitting without using a smartphone ($p<0.05$). The strength index, peak inspiratory flow, and volume after smartphone use were significantly lower when compared to the period prior to smartphone use ($p<0.05$). ***Conclusion*** Poor posture while using a smartphone may be a risk factor for spinal musculoskeletal and inspiratory disorders.

Key Words Smartphone, Inspiratory capacity, Respiration, Cervical angle, Thoracic angle, Body posture

Corresponding author Hye-Joo Jeon (star-002@nate.com)

Received date 18 December 2022
Revised date 12 February 2023
Accept date 14 February 2023

Ⅰ. Introduction

Smartphones have become an essential part of students lives as they use them throughout the day for reasons such as communication, entertainment, and gaming.[1] Owing to the increasing popularity of smartphones and computers, everyday users often exhibit poor posture.[2] A previous study had shown that habitually using a smartphone while use of a smartphone could be a potential risk for nonneutral trunk posture.[3]

When a smartphone is located at the thoracic level, the neck is overly bent to allow the eyes to look down.[4] Generally, the posture of using a smartphone requires its users to look downwards to see the display, which makes the head move forward and causes an inordinate posterior curve in the upper thoracic level and an inordinate anterior curve in the lower cervical level to balance. This is referred to as forwarded head posture (FHP) and may impose excessive stress on the cervical spine.[5] Long-term stress on the cervical spine tends to result in degenerative changes in the joints.[6]

Importantly, FHP influences respiratory function by weakening respiratory muscles.[7] FHP has been reported to lead to decreased diaphragm contraction and thoracoabdominal movement and elevate the rib cage.[8]

A recent study found that FHP causes expansion of the upper thoracic level and contraction of the lower thoracic level and that these morphological alterations cause decreased respiratory capacity.[9] Another study suggested that poor posture can impair respiratory capacity, mostly in patients with respiratory diseases.[10]

Inspiratory capacity is defined as the maximal volume of air that can be inhaled from the end-expiratory lung. The direct measurement of inspiratory capacity through spirometry has been shown to be reliable.[11] In addition to physiological studies, in-

http:dx.doi.org/10.17817/2023.02.12.1111780

spiratory capacity is important for clinical evaluation in addition to physiological studies.[12] Decreased inspiratory capacity, usually due to air trapping, is predictive of decreased exercise capacity[13] and poor quality of life.[14] Han et al. measured the forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV1) in participants with FHP. These results suggest that FHP can decrease vital capacity.[15]

However, to the best of our knowledge, little to no research has been conducted on the effects of sitting posture on inspiratory capacity while using a smartphone. This study aimed to investigate the effect of posture while using a smartphone on inspiratory capacity and cervical and thoracic postures among university students. We hypothesized that sitting while using a smartphone would change the cervical flexion angle relative to normal sitting. We also hypothesized that sitting while using a smartphone, there would be a change in the thoracic flexion angle relative to normal sitting. Lastly, we hypothesized that sitting while using a smartphone would change inspiratory capacity compared to normal sitting.

II. Materials and Methods

1. Subjects

Thirty healthy young students (12 men and 18 women) were recruited from U1 university. The exclusion criteria were a history of fracture, heart disease, lung disease, and lack of understanding of the evaluator's commands. This study was approved by the institutional review board of U1 University (approval number: U1IRB2022-02). All the participants provided written informed consent. Participant characteristics are presented in Table 1.

2. Procedure

Each participant sat on a chair without an armrest in the following two different conditions: normal sitting without using a smartphone and sitting while using the smartphone with both hands. The participants were asked to watch a 5-minute funny video. A previous study has shown that a reduced spine position sense following 5 minutes in a slouched posture.[16] The specific method for the measurement is as follows. In the sitting position, the knee joint was set at 90 degrees, and the ankle joint was placed on the knee joint and the vertical line. When using a smartphone, the elbow joint was set at 90 degrees. In both conditions, the evaluator measured the changes in cervical and thoracic flexion angles and respiratory capacity.

3. Range of motion in the cervical and thoracic spine

The cervical and thoracic flexion angles were measured using the G-pro application installed on the iPhone 12 (Figure 1). At the cervical flexion angle, the smartphone was placed just beside the external auditory meatus, and one axis of the app was aligned with the imaginary line between the base of the nostril and the external auditory meatus.[17] At the thoracic flexion angle, the smartphone was placed on the T12 spinous process.[18]

4. Inspiratory capacity

Inspiratory capacity was measured using Powerbreathe K5 (Powerbrathe K5, HaB International Ltd, UK), an

Table 1. Baseline characteristics of the participants

Variable	Mean ± SD
Gender (M/F)	12 / 18
Height (cm)	169.80±8.04
Weight (kg)	67.27±14.49
Age (years)	23.70±1.70
Duration of use of the smartphone per day (min)	367.43±132.16

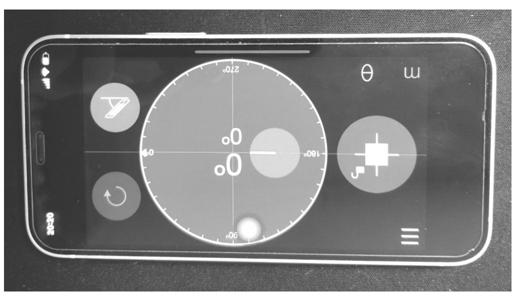

Figure 1. Goniometer Pro application.

Figure 2. Power Breathe K5

electronic device that has been shown to be reliable. The inspiratory capacity consisted of the strength index (SI), peak inspiratory flow (PIF), and volume (Figure 2). The participants were requested to inhale at their maximal effort. Nose clips were worn during the test, and verbal encouragement was provided to promote maximal effort.

5. Analysis methods

Data were processed using SPSS version 18.0, and statistical significance was set at p-values < 0.05. Differences between normal sitting without using a smartphone and sitting while using a smartphone were assessed using a paired t-test. For all measurements, the average value of the three repetitions was calculated.

III. Results

1. Angle of the cervical and thoracic spine

The cervical flexion angle was greater while sitting when using a smartphone (38.99±9.95°) compared to sitting without using a smartphone (0.34±0.56°) (p<0.001). The thoracic flexion angle was greater while sitting when using a smartphone (16.27±4.70°) compared to sitting without using a smartphone (1.32±0.37°) (p<0.001) (Table 2).

2. Inspiratory capacity

The SI was lower when sitting while using a smartphone (21.23±7.81 cmH_2O) compared to sitting without using a smartphone (31.56±11.68 cmH_2O) (p<0.001) (Table 3). The PIF was reduced when sitting while using a smartphone (1.05±0.48 L/sec) compared to sitting without using a smartphone (1.69±0.73 L/sec) (p<0.001) (Table 3). The volume was lower when sitting while using a smartphone (1.37±0.59 L) compared to sitting without using a smartphone (1.93±0.78 L) (p<0.001) (Table 3).

IV. Discussion

In our study, we investigated the effect of posture while using a smartphone on inspiratory capacity and cervical and thoracic postures. Statistically significant differences were observed in the cervical and thoracic

Table 2. Comparison of spinal angle

Index (°)	Sitting without using a smartphone	Sitting while using a smartphone	p
Cervical flexion	0.34±0.56	38.99±9.95	0.000*
Thoracic flexion	1.32±0.37	16.27±4.70	0.000*

Table 3. Comparison of inspiratory capacity

Index (°)	Sitting without using a smartphone	Sitting while using a smartphone	p
SI index (cmH_2O)	31.56±11.68	21.23±7.81	0.000*
PIF (L/sec)	1.69±0.73	1.05±0.48	0.000*
Volume (L)	1.93±0.78	1.37±0.59	0.000*

SI, strength index; PIF, peak inspiratory flow angles before and after smartphone use (p<0.001). Our results agree with findings from studies in the literature, demonstrating that participants maintained head flexion of 33-45° from the vertical when using a smartphone.[19] Szeto et al. reported that students adopted significantly greater angles of cervical and thoracic flexion while using smartphones relative to when they were not using smartphones.[20]

If neck flexion occurs for a prolonged period of time, it causes increased loading in the vertebral column, in addition to increased neck muscle activity required to counteract the effects of gravity.[21] The posture of smartphone users can affect their musculoskeletal load on their necks.[22] Additionally, Gustafsson suggested avoiding sitting with the head fixed forward to prevent neck pain.[23]

The slumped posture had a significantly lower lung capacity and expiratory flow than the normal sitting posture. The slumped posture restricts diaphragm movement and pressure organs compared with the normal sitting position. In addition, a slumped posture results in the lowest lung capacity, and expiratory flow readings may be obtained in the flexed head position.[24] According to a previous study, the dimensions of the free airway are affected by head extension and flexion.[25]

Previous studies have shown that higher thoracic kyphosis results in decreased respiratory capacity.[26] Respiration is influenced by complicated biomechanical factors, and the stability of the cervical and thoracic parts is important for respiratory capacity.[27] The results of our study demonstrated that inspiratory capacity after smartphone use was significantly lower than that before smartphone use (p<0.001). In a previous study, students with a generally poor posture had decreased FVC and FEV1 values compared to those with a good posture,[28] which aligns with our findings.

A previous study reported that maximal inspiratory pressure showed significant decreases, such as weaknesses of the scalene, sternocleidomastoid, and trapezius muscles, and a decrease in kinetic control of the neck.[10] These are accessory respiratory muscles that are used in addition to the diaphragm.[29] Zafar et al. reported that changes in cervical position had an immediate effect on respiratory capacity, characterized by decreased diaphragm strength.[30] Changes in cervical and thoracic flexibility impair usual breathing mechanics by decreasing diaphragm mobility.[31]

Researchers have indicated that FHP can reduce vital capacity due to weakness of the accessory respiratory muscles.[15] Previous studies have found that weakness of the neck and respiratory muscles in patients with neck pain resulted in a decline in thoracic flexibility, thus decreasing maximal inspiratory and expiratory pressure and that these effects were considerably associated with FHP.[32]

Our present study has several limitations. Firstly, our study cohort involved a sample with a limited age range, thus inherently limiting the generalization of our results. Another major limitation is that this study collected kinematic data after watching videos for approximately five minutes, which may be too short to represent the participant's typical pattern of behaviors. According to time, smartphone use may change more diverse and various postural patterns.

Nevertheless, the clinical implication of our findings is that changes in cervical and thoracic posture (while using a smartphone) reduce inspiratory capacity. Poor posture while using a smartphone may lead to the development of risk factors for spinal musculoskeletal and inspiratory problems.

References

1. Kwon M, Lee JY, Won WY, et al. Development and validation of a smartphone addiction scale (SAS). PloS One. 2013;8(2):e56936.
2. Lee NK, Jung SI, Lee DY, et al. Effects of exercise on cervical angle and respiratory function in smartphone users. Osong Public Health and Research Perspectives. 2017;8(4):271-4.
3. Lee DH, Jeon HJ. Comparison of cervical, thoracic, and shoulder posture while the one-handed and two-handed use of smartphone in university students. Journal of Korean Society for Neurotherapy. 2022;26(2):33-9.
4. 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(4):540-55.
5. Berolo S, Wells RP, Amick BC III. Musculoskeletal symptoms among mobile hand-held device users and their relationship to device use: a preliminary study in a Canadian university population. Applied Ergonpmics. 2011;42(2):371-8.
6. Kim SY, Koo SJ. Effect of duration of smartphone use on muscle fatigue and pain caused by forward head posture in adults. Journal of Physical Therapy Science. 2016;28(6):1669-72.
7. Kapreli E, Vourazanis E, Billis E, et al. Respiratory dysfunction in chronic neck pain patients. A pilot study. Cephalalgia. 2009;29(7):701-10.
8. Ucar FI, Ekizer A, Uysal T. Comparison of craniofacial morphology, head posture and hyoid bone position with different breathing patterns. The Saudi Dental Journal. 2012;24(3-4):135-41.
9. Koseki T, Kakizaki F, Hayashi S, et al. Effect of forward head posture on thoracic shape and respiratory function. Journal of Physical Therapy Science. 2019;31(1):63-8.
10. Dimitriadis Z, Kapreli E, Strimpakos N, et al. Respiratory weakness in patients with chronic neck pain. Manual Therapy. 2013;18(3):248-53.
11. Yan S, Kaminski D, Sliwinski P. Reliability of inspiratory capacity for estimating end-expiratory lung volume changes during exercise in patients with chronic obstructive pulmonary disease. American Journal of Respiratory and Critical Care Medicine. 1997;156(1): 55-9.
12. Belén A. ATS/ERS Statement on respiratory muscle testing. American Journal of Respiratory and Critical Care Medicine. 2002;166:518-624.
13. Pellegrino R, Viegi G, Brusasco V et al. Interpretative Strategies for Lung Function Tests. European Respiratory Journal. 2005;26(5):948-68.
14. Tantucci C, Pinelli V, Cossi S et al. Reference values and repeatability of inspiratory capacity for men and women aged 65-85. Respiratory Medicine. 2006;100(5): 871-7.
15. Han J, Park S, Kim Y, et al. Effects of forward head posture on forced vital capacity and respiratory muscles activity. Journal of Physical Therapy Science. 2016;28(1):128-31.
16. Dolan KJ, Green A. Lumbar spine reposition sense: the effect of a ‘slouched’ posture. Manual Therapy. 2006;11(3):202-7.
17. Pourahmadi MR, Bagheri R, Taghipour M et al. A new iPhone application for measuring active craniocervical range of motion in patients with non-specific neck pain: a reliability and validity study. The Spine Jounal. 2018;18(3):447-57.
18. Shahri YFK, Hesar NGZ. Validity and reliability of smartphone-based Goniometer-Pro app for measuring the thoracic kyphosis. Musculoskeletal Science and Practice. 2020;49:102216.
19. Lee S, Kang H, Shin G. Head flexion angle while using a smartphone. Ergonomics. 2015;58(2):220-6.
20. Szeto GP, Tsang SM, Dai J, et al. A field study on spinal postures and postural variations during smartphone use among university students. Applide Ergonomics. 2020;88:103183.
21. Namwongsa S, Puntumetakul R, Neubert MS, et al. Effect of neck flexion angles on neck muscle activity among smartphone users with and without neck pain. Ergonomics. 2019;62(12):1524-33.
22. Sarraf F, Varmazyar S. Comparing the effect of the posture of using smartphones on head and neck angles among college students. Ergonomics. 2022;1-8.
23. Gustafsson E. Ergonomic recommendations when texting on mobile phones. Work. 2012;41(supplement 1):5705-6.
24. Lin F, Parthasarathy S, Taylor SJ, et al. Effect of different sitting postures on lung capacity, expiratory flow, and lumbar lordosis. Archives of Physical Medicine and Rehabilitation. 2006;87(4):504-9.
25. Hellsing E. Changes in the pharyngeal airway in relation to extension of the head. The European Journal of Orthodontics. 1989;11(4):359-65.
26. Culham EG, Jimenez HA, King CE. Thoracic kyphosis, rib mobility, and lung volumes in normal women and women with osteoporosis. Spine. 1994;19(11):1250-5.
27. Kapreli E, Vourazanis E, Strimpakos N. Neck pain causes respiratory dysfunction. Medical Hypotheses. 2008;70 (5):1009-13.
28. Pawlicka-Lisowska A, Motylewski S, Lisowski J, et al. Faulty posture and selected respiratory indicators. Polski Merkuriusz Lekarski: Organ Polskiego Towarzystwa Lekarskiego. 2013;35(206):67-71.
29. Jung JH, Kim NS. Relative activity of respiratory muscles during prescribed inspiratory muscle training in healthy people. Journal of Physical Therapy Science. 2016;28(3):

1046-9.
30. Zafar H, Albarrati A, Alghadir AH et al. Effect of different head-neck postures on the respiratory function in healthy males. BioMed Research International. 2018;4518269.
31. Chaitow L. Functional movement and breathing dysfunction. Journal of Bodywork and Movement Therapies. 2016;20(3):455-6.
32. Wirth B, Amstalden M, Perk M, et al. Respiratory dysfunction in patients with chronic neck pain-Influence of thoracic spine and chest mobility. Manual Therapy. 2014;19(5):440-4.