Comparison of the Effects of Deep Neck Flexor Strengthening Exercises and Mackenzie Neck Exercises on Head Forward Postures Due to the Use of Smartphones

Eun-Young Kim¹, Keun-Jo Kim²* and Hee-Ryong Park³

¹Department of Physical Therapy Gumi University, Korea
²Department of Physical Therapy Gimcheon University, Korea; kmjb042@gimcheon.ac.kr
³Department of Counseling Psychology, Gimcheon University, Korea

Abstract

In this study, experiments were conducted to compare the effects of deep neck flexor strengthening exercises and Mackenzie neck exercises on head forward postures resulting from the use of smartphones. In this study, 25 adult males and females who were students of G University, were using a smartphone for at least three hours per day, had round shoulder postures with a distance between the floor and the acromion exceeding 2.5cm in a supine position during tests, and showed 10 points or higher neck function disability indexes were selected and randomly assigned to a deep neck flexor strengthening exercise group using PBU of 12 subjects which was an experimental group or a Mackenzie neck exercise group of 13 subjects which was a control group and the exercises were performed three times per week for four weeks. When the neck disability indexes and the levels of static deep neck flexor muscle strength before and after training were compared, both the deep neck flexor strengthening exercise group using PBU and the Mackenzie neck exercise group showed significant differences (p<.05). The degrees of changes in the level of breathing, neck disability indexes and the levels of static deep neck flexor muscle strength of the two groups were compared and the results did not show any significant difference. Although no significant differences were shown when the deep neck flexor strengthening exercise group using PBU and the Mackenzie neck exercise group were compared with each other, improvement in neck disability indexes and the levels of static deep neck flexor muscle strength were shown when those before and after training were compared. Therefore, these exercises can be said to contribute to the improvement of posture control. These active exercises can be said to be important in obtaining long-term treatment effects on neck pain.

Keywords: Component, Forward Head Posture, Mckenzie Exercise, PBU Exercise, Work-Related Musculoskeletal Disorder

1. Introduction

In general, forward head posture refers to the posture that accompanies forward bending of the lower cervical vertebrae and excessive extension of the upper cervical vertebrae¹. Factors causing this posture in modern people include occupations and habits²³, and most cases except the occupational factor are largely influenced by the habit of using electronic devices such as computers and smartphones⁴. The use of visual display terminals such as smartphones for long hours can cause improper postures such as forward head posture⁵⁶, and the subsequent increases in cervical lordosis and thoracic or lumbar kyphosis cause round shoulders and decreases in vital capacity and thoracic cavity⁷. Moreover, the continuous maintenance of forward head and slouched postures can cause damage not only to structures around the cervical and lumbar
Among 160 normal adults, this study selected 25 men and women who used smartphones for over three hours each day, had a round-shoulder posture with a distance of 2.5cm or longer between the floor and the shoulder blade in a supine position, and scored 10 or higher points in the NDI. The subjects were randomly placed into the deep cervical flexor strengthening exercise group using a PBU, which consisted of 12 subjects (six men, six women), and the McKenzie cervical exercise group that consisted of 13 subjects (six men, seven women). Those who had musculoskeletal or neurological disorders were excluded. The subjects received a full explanation of the study's purpose and the experiment's overall contents and submitted their written consent forms.

The test group was, on average, 21.50±0.92 years of age, 169.33±2.27cm in height, and 61.29±3.58kg in weight. The control group was, on average, 21.85±0.70 years of age, 169.23±2.32cm in height, and 64.62±3.55kg in weight. The subjects' age, height, and weight were analyzed by processing the relevant data using an independent t-test, and a homogeneity test showed no statistically significant differences between the two groups (p>0.05)(Table 1).

| Character of Subjects (n=25) | Experimental group (n=12) | Control group (n=13) |
|-----------------------------|---------------------------|---------------------|
| Age (yrs)                   | 21.50±0.92                | 21.85±0.70          |
| Weight (kg)                 | 61.29±3.58                | 64.62±3.55          |
| Height (cm)                 | 169.33±2.27               | 169.23±2.32         |

### 2. Method

#### 2.1 Subject

Patients with acute cervical pain mostly show changes in the cervical Range Of Motion (ROM), muscle endurance, and proprioception. Moreover, as with defects in the automatic feedforward of transversus abdominis and lumbar multifidus muscles, which are commonly exhibited in back pain patients, defects in the automatic feedforward of cervical flexors can be discovered in cervical pain patients. To manage this condition effectively, it is important to improve its symptoms, but it may be more important to prevent the recurrence of the symptoms and chronic in acute cervical pain patients. As an active exercise method that can recover such damage, McKenzie exercises are widely used to manage spinal pain caused around the spines. Another method is head-neck bending exercises that can strengthen deep cervical flexors. While a patient is kept in a supine position, a Pressure Biofeedback Unit (PBU) is placed behind the patient's cervical region, and the patient pushes his/her head toward the floor while drawing the chin inward. In this method, the strength of deep cervical flexors is indicated as the pressure applied to the PBU. Falla et al. also used this method to evaluate the functions of deep cervical flexors. In this regard, this study intends to compare the breathing, Neck Disability Index (NDI), and muscular strength of individuals with a forward head posture according to the time spent using smartphones by applying McKenzie exercises and deep cervical flexor strengthening exercises using a PBU, which are both active exercise methods, and then to suggest an appropriate active exercise method based on the results of the training.

#### 2.2 Research Tools

This study applied deep cervical flexor strengthening exercises using a PBU, and McKenzie cervical exercises. In the test group, which is the deep cervical flexor strengthening exercise group using a PBU, while the subjects were kept in a supine position, a PBU was placed between the back side of their upper cervical region and a therapy table. With their head relaxed in a comfortable manner not to cause movements, the subjects were instructed to hold a pressure gage with one hand to provide visual feedback of their contractile force produced using the pressure gage connected to the PBU, and to place the other hand on their manubrium of sternum to limit the movement.
of their ribs during the contraction of their deep cervical flexors. To remove lumbar lordosis, the subjects had to maintain hip and knee flexion in their both legs. During the contraction of the deep cervical flexors, they were instructed to draw their chin inward without the contraction of the sternocleidomastoid muscle and apply a strain to the abdominal muscle to restrict the movement of the ribs. These exercises were performed on a hard therapy table to measure changes in the pressure gage accurately. The subjects maintained static contraction for ten seconds, and then took a rest for five seconds, which was defined as a one-time exercise. One set of exercises consisted of ten-time exercises, and a total of five sets were performed each day. The subjects performed the exercises three times each week for a four-week period. The control group performed McKenzie cervical exercises for 20 minutes each time and three times each week for a four-week period. The exercise method was as follows. The subjects maintained the following motions for ten seconds: pulling the head backward in a sitting position, throwing the head back in a sitting position, drawing the chin inward in a supine position, throwing the head back in a supine position, throwing the neck to one side, turning the head, and bending the head in a sitting position. Ten times of this performance comprised one set of exercises, and the subjects performed a total of five sets each day.

2.3 Measurement

2.3.1 Neck Disability Index (NDI)

The NDI consisted of five items produced from the Oswestry Low Back Pain Disability Questionnaire and five items modified by reflecting the results of a literature review and the feedback from clinical experts. These items included the degree of pain, self-management, holding objects, reading, headache, concentration, performing tasks, driving, sleeping, and leisure activities. Based on the degree of performance by patients, scores ranged from 0 (the state of no pain) to 5 (the state of extreme pain). A lower score indicates a corresponding lower level of physical disorders.

2.3.2 Breath Testing Unit

For a device to test pulmonary volumes and ventilation, Cardio Touch 3000S (Bionet, England) was used to measure Forced Vital Capacity (FVC) and Forced Expiratory Volume for one second (FEV1) among the indicators of pulmonary functions.

After measuring each variable in each subject three times, an average of the three measurement values was used for data analysis.

2.3.3 Air Pressure Measurement Unit

A PBU was used to measure the contractile force of deep cervical neck flexors. The standard pressure of the PBU was adjusted to be 60mmHg when the PBU was inserted into the back side of the upper cervical region in the patients while they lay face down comfortably with their head relaxed. Before conducting a cranio-cervical flexion test, a preliminary simulation test was performed to set the standard pressure of the PBU, at which the subject felt most comfortable.

The maximum contractile force was measured as the pressure when the PBU was pressed to maximum based on the standard pressure during the contraction of the deep cervical flexors. After a one-minute break, the tester measured the time for which a 50% submaximal force was maintained. After another one-minute break, the tester measured the time for which 80% submaximal force was maintained. When a subject could not maintain submaximal forces or an error of over ±2mmHg based on the standard pressure occurred, the training was discontinued, and the time spent until that time was measured. Each performance was measured three times and an average of the three measurement values was used for data analysis. Between the performances, a 30-second break was provided. The muscular strength produced from the contraction of the deep cervical flexors was indicated as the pressure applied to the PBU, and the measurement unit was mmHg.

2.4 Data Processing

The measured data were processed using SPSS 12.0 for Windows. Paired t-tests were performed to compare changes within each group before and after the training. In addition, independent t-tests were employed to compare differences between the two groups. The statistical significance level was set at ≤.05.

3. Results

3.1 A Comparison of the Degree of Breathing, NDI, and the Static Muscular Strength of Deep Cervical Flexors within Each Group Before and After the Experiment
In a comparison of the degree of breathing, NDI, and the static muscular strength of deep cervical flexors within each group before and after the experiment, both the PBU-based deep cervical flexor strengthening exercise group and the McKenzie cervical exercise group exhibited statistically significant differences in the NDI and static muscular strength (p<.05)(Table 2).

Table 1. Comparison of FVC, FEV1, NDI, PBU with-in pre-test and post-test in each group

| Category | Experimental group(n=12) | Control group(n=13) |
|----------|--------------------------|---------------------|
| FVC(ℓ)   | pre-test 2.20±.23         | post-test 2.25±.21  |
|          | post-test 2.25±.21        | 2.34±.20            |
| FEV1(ℓ)  | pre-test 2.18±.22         | post-test 2.22±.21  |
|          | post-test 2.22±.21        | 2.33±.20            |
| NDI      | pre-test 8.08±.68         | post-test 3.75±.58* |
|          | post-test 3.75±.58*       | 3.77±.90*           |
| PBU      | pre-test 81.64±1.61       | post-test 93.78±2.31* |
| (mmHg)   |                          | 92.67±1.70*         |

| Mean±SD  | 105                      |

FVC: Forced vital capacity
FEV1: Forced expiratory volume for 1 second
NDI: Neck disability index
PBU: Pressure biofeedback unit

3.2 A Comparison of Differences in the Degree of Breathing, NDI, and the Static Muscular Strength of Deep Cervical Flexors between the Two Groups Before and After the Experiment

Independent t-tests were performed regarding the degree of breathing, NDI, and the static muscular strength of deep cervical flexors before the experiment, after the experiment, and differences before and after the experiment. As a result, while the post-experiment values showed statistically significant differences between the groups, the pre-experiment values and changes before and after the experiment exhibited no statistically significant differences between the two groups (Table 3).

4. Discussion

When an individual maintains a posture with the cervical vertebrae bent to focus on the screen of a smartphone, it causes temporary creeps in muscles and ligaments behind the neck. This shape around the cervical region either reduces the ROM or causes physical changes such as weakened muscular strength and endurance. Moreover, when this posture becomes chronic, it can result in psychological and social problems by causing limited daily activities and discomfort. When noncognition in our body perceives stimuli such as pain caused by acute cervical pain, inhibitory effects are generated to restrict the use of the affected region. To compensate for this, motor pattern reconfiguration occurs in the form of exercises with increased uses of the other regions. Eventually, the overloaded region, in which damage has been controlled, leads to myoatrophy in its specific muscular fibers, and causes pain and changes in muscular characteristics. When this phenomenon is prolonged, it can develop into chronic cervical pain.

This study applied deep cervical flexor strengthening exercises using a PBU and postural correction exercises using the McKenzie method in patients who complained of chronic cervical pain caused by using smartphones. After the experiment, the degree of breathing, NDI, and the static muscular strength of deep cervical flexors were compared to identify the effects of these exercises. A study reported that the chin tuck exercise to strengthen deep craniovertebral flexors and the head bending exercise to improve the muscular endurance of cervical flexors...
reduce the pain in patients with chronic cervical pain and improve their muscular functions\cite{28}.

Chiu et al\cite{29} cited that isometric exercises in the cervical region are effective for pain reduction in patients with cervical pain. Kjellman and Oberg\cite{30} implemented postural correction exercises using the McKenzie method in 77 cervical pain patients. A reexamination 12 months after the experiment showed that the rate of those visiting a hospital among the subjects was statistically significantly low in the postural correction exercise group.

In the present study, the comparison of differences between the deep cervical flexor strengthening exercise group using a PBU—and the postural correction group using the McKenzie method exhibited no statistical significance. However, both groups showed statistically significant changes after the experiment. This indicated that the applied exercises were effective in improving muscular strength around the cervical region and postural control. In addition, the result showed the importance of active exercises methods to deliver long-term treatment effects on cervical pain. However, future studies should be continued on the same patient groups that consist of larger numbers of patients to generalize the results of the present study. Those studies are also required to include various variables and verify their correlations. In addition, studies that suggest therapeutic evidence and advantages in clinical terms should be carried out.

### Table 3. Comparison of FVC, FEV1, NDI, PBU between experimental group and control group

| Category | Experimental group (n=12) | Control group (n=13) |
|----------|--------------------------|----------------------|
| FVC(ℓ)   |                          |                      |
| pre-test | 2.20±.23                 | 2.13±.13             |
| post-test| 2.25±.21                 | 2.34±.20             |
| difference of pre and post test | 0.04±.98                 | 0.21±.07             |
| FEV1(ℓ)  |                          |                      |
| pre-test | 2.18±.22                 | 2.09±.13             |
| post-test| 2.22±.21                 | 2.33±.20             |
| difference of pre and post test | 0.03±.99                 | 0.24±.07             |
| NDI      |                          |                      |
| pre-test | 8.08±.68                 | 9.38±.96             |
| post-test| 3.75±.58*                | 3.77±.90*            |
| difference of pre and post test | -4.33±.95                | -5.62±.86            |
| PBU (mmHg)|                          |                      |
| pre-test | 81.64±1.61               | 81.95±1.72           |
| post-test| 93.78±2.31*              | 92.67±1.70*          |
| difference of pre and post test | 12.14±3.02                | 10.72±0.82           |

Mean±SD

*1.05

### 5. Conclusion

This study conducted an experiment to compare the effects of deep cervical flexor strengthening exercises and McKenzie cervical exercises on patients with a forward head posture caused by using smartphones.

25 men and women were selected among students at G University, who used smartphones for over three hours each day, had a round-shoulder posture with a distance of 2.5cm or longer between the floor and the shoulder blade in a supine position, and scored 10 or higher points in the NDI. The subjects were randomly placed into the deep cervical flexor strengthening exercise group using a PBU (12 patients) and the McKenzie cervical exercise group (13 patients). This study examined changes in the degree of breathing, NDI, and the static muscular strength of deep cervical flexors after the experiment, and derived the following results.

In the comparison of FVC and the degree of breathing in expiratory volumes before and after the training, both the PBU-based deep cervical flexor strengthening exercise group and the McKenzie cervical exercise group showed no statistically significant changes. The comparison of the NDI before and after the training revealed statistically significant changes in both groups. The comparison of the static muscular strength of deep cervical flexors before and after the training also revealed statistically significant changes in both groups. On the other hand, no statistically significant
differences were shown between the two groups in changes in the degree of breathing, NDI, and the static muscular strength of deep cervical flexors. As this shows, the comparison of the PBU-based deep cervical flexor strengthening exercise group and the McKenzie cervical exercise group revealed no statistically significant differences. However, each group showed improvement in the NDI and static muscular strength after the training. Therefore, the exercises applied in this study may have contributed to postural control in the patients. In conclusion, these active exercise methods may be important in delivering long-term treatment effects on cervical pain.

6. References

1. Hanten WP, Olson SL, Russel JL, Lucio RM, Campbell AH. Total head excursion and resting head posture: normal and patient comparisons. Arch Phys Med Rehabil. 2000; 81(1):62–5.
2. Berg HE, Berggren G, Tesch PA. Dynamic neck strength training effect on pain and function. Arch Phys Med Rehabil. 1994; 75(4):661–5.
3. Cailliet R. Neck and arm pain. 3rd. Philadelphia: F.A. Davis Co; 1991. p. 75–7.
4. Salahzadeh Z, Maroufi N, Ahnadi A, Behtash H, Razmojoo A, Gohari M, Parnianpour MJ. Assessment of forward head posture in females: observational and photogrammetry methods. Back Musculoskelet Rehabil. 2013; 92(9):746–54.
5. Janwantanakul P, Sithipornvorakul E, Paksaičol A. Risk factors for the onset of nonspecific low back pain in office workers: a systematic review of prospective cohort studies. J Manipulative Physio Ther. 2012; 35(7):568–77.
6. Szeto GP, Lee R. An ergonomic evaluation comparing desktop, notebook, and subnotebook computers. Arch Phys Med Rehabil. 2002; 83(4):527–32.
7. Bonney RA, Corlett EN. Head posture and loading of the cervical spine. Appl Ergon. 2002; 33(5):415–7.
8. Fernandez-de-las-Penas C, Alonso-Blanco C, Cuadrado ML, et al. Forward head posture and neck mobility in chronic tension-type headache: a blinded, controlled study. Cephalalgia. 2006; 26(3):314–9.
9. Kendall FP, McCreaey EK, Provance PG, et al. Muscles: testing and function with posture and pain. 5th ed. Baltimore, MD: Lippincott Williams & Wilkins; 2005. p. 85–93.
10. Page P, Frank C, Lardner R. Assessment and treatment of muscle imbalance: the Janda approach. Champaign, IL: Human Kinetics; 2009. p. 27–30.
11. Boyd-Clark LC, Briggs CA, Galea MP. Muscle spindle distribution, morphology, and density in longus colli and multifidus muscles of the cervical spine. Spine. 2002; 27(7):694–01.
12. Falla D, Jull D, Dall'Alba P, Rainoldi A, Merletti R. An electromyographic analysis of the deep cervical flexor muscles in performance of cranio-cervical flexion. Phys Ther. 2004; 83(10):899–06.
13. Lee H, Nicholson LL, Adams RD. Cervical range of motion associations with subclinical neck pain. Spine. 2003; 29(6):34–40.
14. Jull GA. Deep cervical flexor muscle dysfunction in whiplash. J Musculoskel Pain. 2000; 8(1):143–54.
15. Mckinney LA. Early mobilization and outcome in acute whiplash sprains of the neck. BMJ. 1995; 299(2):1006–8.
16. Humphreys B, Irgens P. The effect of rehabilitation exercise program on head repositioning accuracy and reported levels of pain in chronic neck pain subjects. Journal of Whiplash & Related Disorders. 2002; 1(4):99–112.
17. Sahrmann SA. Diagnosis and treatment of movement impairment syndromes. Missouri: Mosby; 2002. p. 193–245.
18. Vernon HT, Aker P, Aramenko. Evaluation of neck muscle strength with a modified sphygmomanometer dynamometer: reliability and validity. J Manipulative Physiol Therapeut. 1992; 15(6):343–49.
19. Battie MC, Cherkin DC, Dunn R, Ciof MA. Wheeler DJ. Managing low back pain: attitudes and treatment preference of physical therapists. Phys Ther. 1994; 74(3):1219–26.
20. Vernon HT, Mior S. The neck disability index a study of the Dutch version of the neck disability index in patients with acute neck pain on general practice. Eur Spine J. 2006; 15(11):1729–36.
21. Petersen SM, Wyatt SN. Lower trapezius muscle strength in individuals with unilateral neck pain. J Orthop Sports Phys Ther. 2011; 41(4):260–5.
22. Jeong Y-J. The effects of breathing exercises on pulmonary functions in patients with amyotrophic lateral sclerosis. Physical Therapy Korea. 2001; 8(4):48–60.
23. Solomonow M, Baratta RV, Zhou BH, et al. Muscular dysfunction elicited by creep of lumbar viscoelastic tissue. J Electromyogr Kinesiol. 2003; 13(4):381–96.
24. Hakkinen A, Salo P, Tarvainen U, Wiren K, Ylinen J. Effect of manual therapy and stretching on neck muscle strength and mobility in chronic neck pain. J Rehabil Med. 2007; 39(7):575–79.
25. Ylinen J, Salo P, Nykanen M, Kautiainen H, Hakkinen A. Decreased isometric neck strength in women with chronic neck pain and the repeatability of neck strength measurements. Arch Phys Med Rehabil. 2004; 85(6):1303–08.
26. Hoving JL, Koes BW, Vet HC, van der Windt DA, Assendelft WJ, van Mamere H, Deville WL, Pool JJ, Scholten RJ, Boutier LM. Manual therapy, physical therapy or continued care by a general practitioner for patients with neck pain: a randomized controlled trial. Ann Intern Med. 2002; 136(10):713–22.
| No. | Reference |
|-----|-----------|
| 27. | Bronfort G, Evans R, Nelson B, Aker PD, Goldsmith CH, Vernon HA. 2001 A randomized clinical trial of exercise and spinal manipulation for patients with chronic neck pain. Spine. 2001; 26(7):788–99. |
| 28. | Falla D, Jull G, Hodges P. Training the cervical muscles with prescribed motor tasks does not change muscle activation during a functional activity. Man Ther. 2008; 13(6):507–12. |
| 29. | Chiu TT, Hui-Chan CW, Chein GA. Randomized clinical trial of TENS and exercise for patients with chronic neck pain. Clin Rehabil. 2005; 19(8):850–60. |
| 30. | Kjellman G, Oberg B. A randomized clinical trial comparing general exercise, McKenzie treatment and a control group in patient with neck pain. J Rehabil Med. 2002; 34(4):183–90. |