The Effects of Cervical Stabilization Exercises on the Electromyographic Activity of Shoulder Stabilizers

SANGYONG LEE, PhD, PT¹), JUNGSEO PARK, PhD, PT¹), DAEHEE LEE, PhD, PT¹)*

¹) Department of Physical Therapy, Youngdong University: 12 Yeongdong-eup, Yeongdong-gun, Chungcheongbuk-do 370-701, Republic of Korea

Abstract. [Purpose] The purpose of the present study was to examine the effects of cervical stabilization exercises on the electromyographic activity of the shoulder stabilizers in normal adults. [Subjects] In the present study, 20 normal adults were divided into an experimental group (EG, n=10) that performed cervical stabilization exercises and shoulder stabilization exercises and a control group (CG, n=10) that performed shoulder stabilization exercises. [Methods] The EG and CG performed their exercises three times per week for four weeks. The cervical stabilization exercises consisted of Craniocervical flexion exercises (CCFEs) that were performed using pressure biofeedback units (PBUs). The shoulder stabilization exercises consisted of scapula-setting exercises, wall stretching, and external rotation exercises. To examine the electromyographic activity of the upper trapezius (UT) muscle, lower trapezius (LT) muscle, and serratus anterior (SA) muscle, the electromyograms for these muscles were compared and analyzed. [Results] In comparisons within the groups, the EG showed statistically significant differences in the UT, the LT and the SA. The CG did not show any significant differences. [Conclusion] Cervical stabilization exercises and shoulder stabilization exercises are considered to be an effective intervention for the electromyographic activity of the shoulder stabilizers, the UT, LT, and SA.

Key words: Cervical stabilization, Stabilizer, Electromyographic activity

INTRODUCTION

People often lean their shoulders forward or move their neck frequently when sitting in the work environment, such as when driving or working in front of a computer or desk for long periods of time, and use desks and chairs that are not suitable for their body types, as well as inappropriate bedding. These poor lifestyle habits may cause muscle spasticity in the neck and shoulders and induce muscle fatigue that hampers effective biomechanical functions, and this may weaken soft tissues³).

Endogenous risk elements, such as forward head postures, change the kinematics and muscle activation of the scapula region and increase stress on the shoulder joints, thereby causing instability and bringing about dysfunction³). Therefore, because stability can be more effectively provided when the locations and alignments of all joints in the body, such as those in the head, neck, and shoulders, are in neutral areas, to maintain shoulder stability, stability for maintaining the normal posture of the neck is important. Thus, cervical stability is very important. Recently, the roles of the longus colli and the longus capitis, which are deep muscles, have been emphasized further in relation to the maintenance of cervical stability because increases in the strength and endurance of the deep muscles can improve the ability to maintain a standing posture and the proper neutral position of the neck.

Normal use of the arm is one of the essential elements for holding objects and maintaining balance, and the stability of the shoulder complex is very important for functional and efficient use of the arm. Shoulder complex stability can improve flexibility, coordination, endurance, and muscle strength, thereby facilitating more efficient movements of the distal part of the upper limbs and improving muscle endurance. Unlike various joints that rely on ligaments, shoulder complex stability relies on muscles. Muscles that are essential for the provision of stability include the rotator cuff muscles, the serratus anterior muscle, and the trapezius muscle. These muscles are known to be important elements in maintaining normal scapulohumeral rhythms. If these muscles are weakened, scapular winging will occur³). Along with the serratus anterior muscle, the trapezius muscle is important for scapula stability, and it is also a very important muscle because if it is weakened, the serratus anterior muscle’s control ability will decrease, resulting in instability. The effects of shoulder complex stability are not limited to the shoulder, because biomechanical units such as the head, the neck, and the shoulder are interconnected with one another through many complicated soft tissues, and thus, individual segments can exert normal motor skills
The present study was conducted with 20 healthy males in their 20s at Y University in Chungbuk, Republic of Korea. The study subjects were divided into an experimental group (EG) (mean age 23.88±2.42 years, height 176.5±7.82 cm, and weight 68.88±12.93 kg) that performed cervical stabilization exercises and shoulder stabilization exercises and a control group (CG) (mean age 24.50±0.84 years, height 176.17±5.15 cm, and weight 65.17±9.62 kg) that performed shoulder stabilization exercises. All the study subjects heard explanations of the purpose of the present study and exercise methods and voluntarily agreed to the experiment. All the subjects read and signed consent forms in accordance with the ethical standards of the Declaration of Helsinki. Each exercise was performed three times per week for four weeks. Thus, each exercise was performed twelve times in total. The selection criteria of the study subjects were that they must have a sufficient range of joint motion only when relatively appropriate positions of the connected joints are maintained.

Craniocervical flexion exercises (CCFEs), Swiss ball exercises, sling exercises, etc., are used to reinforce the endurance and strength of the deep cervical muscles that play important roles in maintaining posture and improving stability. CCFEs pull the jaw downward and maintain the posture in a supine position, and they are frequently applied which is frequently used in clinics in order to improve cervical stability. Falla et al. applied CCFEs by using a pressure biofeedback unit (PBU) to improve the ability of cervical pain patients to maintain proper neck alignment. Retraining the deep muscles of the neck can increase the activity of these deep muscles and improve the ability to maintain standing postures and neutral positions of the neck. However, studies on the effects of CCFEs, which are cervical stabilization exercises, on shoulder stability are insufficient. Therefore, the aim of the present study was to examine the effects of cervical stabilization exercises on the electromyographic activity of the shoulder stabilizers.

SUBJECTS AND METHODS

The present study was conducted with 20 healthy males in their 20s at Y University in Chungbuk, Republic of Korea. The study subjects were divided into an experimental group (EG) (mean age 23.88±2.42 years, height 176.5±7.82 cm, and weight 68.88±12.93 kg) that performed cervical stabilization exercises and shoulder stabilization exercises and a control group (CG) (mean age 24.50±0.84 years, height 176.17±5.15 cm, and weight 65.17±9.62 kg) that performed shoulder stabilization exercises. All the study subjects heard explanations of the purpose of the present study and exercise methods and voluntarily agreed to the experiment. All the subjects read and signed consent forms in accordance with the ethical standards of the Declaration of Helsinki. Each exercise was performed three times per week for four weeks. Thus, each exercise was performed twelve times in total. The selection criteria of the study subjects were that they must have a sufficient range of joint motion to perform the exercises required in the experiment and have no pain in the neck or shoulder joints. Those who had received muscle strength reinforcement training within the last six months or sustained orthopedic or neurologic damage were excluded.

Pressure biofeedback units (PBUs; stabilizer, Chattanooga Group Inc, Hixson, TN, USA) were used to perform the cervical stabilization exercises. The PBU is a representative stabilization apparatus using air pressure that can be applied to the waist, back, arms, and neck. It consists of a pressure gauge and pressure cuff. The pressure gauge enables numerical identification of the weight of the exercises being performed, thereby providing visual feedback regarding whether the exercises are accurately performed qualitatively so that the exercises can be observed in detail.

The scapula stabilization-related muscles were measured while the subjects performed the push-up plus exercise. For the starting posture, the subjects were instructed to take a crawling position, placing their hands at the shoulders to support their weight, with both hands and both knees. Then, while maintaining the neck bone region and the backbone region in a straight line to maintain the neutral position of the neck bone region, the subjects were instructed to maintain a position in which the maximum isometric contraction could be measured when the scapula was protracted for five seconds, which was done in response to the verbal command “Start”. The experimenter measured the maximum isometric contraction three times when the subjects held the posture correctly, and the subjects rested for two minutes after each performance.

To measure changes in the electromyographic activity of the muscles, an MP150 (BIOPAC Systems, Inc. Santa Barbara, CA, USA), which is a type of electromyographic (EMG) equipment, was used. Surface electrodes were attached to the upper trapezius muscle (UP), lower trapezius muscle (LT), and serratus anterior muscle (SA). The EMG signals were sent to the MP150 system, converted into digital signals in the system, and processed in the PC using the Acqknowledge software (Version 4.01). The average value of the EMG signals from each subject was expressed as a percentage of the maximum value of isometric contraction (%MVIC).

The EG performed cervical stabilization exercises and shoulder stabilization exercises, while the CG performed only shoulder stabilization exercises. For the cervical stabilization exercises, CCFEs were performed to reinforce the deep cervical flexor. The exercise method was as follows: first, after taking the ready position by placing a PBU below the upper neck bone in a supine position and inflating the PBU to 20 mmHg, the subject gently nodded his or her head, as if saying “yes”. The subject was instructed to nod his or her head until the targeted pressure of 22 mmHg was reached, and then, the subject maintained the pressure accurately. Thereafter, the pressure was reduced to the initial pressure of 20 mmHg so that the subject could rest. The exercise was performed by maintaining the targeted pressure for 10 seconds, followed by a rest for five seconds. This exercise was performed ten times in total. After performing this exercise ten times, the pressure was increased by 2 so that the subject had to maintain a pressure of 24 mmHg, and this was repeated until the target pressure reached 30 mmHg. A rest period of one minute was given every time the pressure was changed. To prevent the activity of the platysma or the hyoids as a form of compensation, the subject was instructed to keep the tongue between the upper and lower teeth while performing the exercise. The exercise was performed three times per week for four weeks. Thus, it was performed twelve times in total.

For the shoulder stabilization exercises, the shoulder stabilization manual used in a study conducted by Jung was used after revising it to fit the situation of the present experimental study. The shoulder stabilization exercises consisted of scapula setting exercises, wall stretching, and external rotation exercises. For the scapula setting exercises, the subject took a posture in which the lobe of the auricle was aligned with the acromion of the scapula in a prone position, and the experimenter instructed the subject, saying, “Bring your shoulder toward your spine.” For the wall stretching
exercises, the subject was instructed to stand away from the wall at arm’s length in a vertical position, bend 90°, push the wall, and maintain that state. For the shoulder external rotation exercises, the subject was instructed to maintain the shoulder joint in a neutral position and the elbow joint in 90° flexion in a standing position sideways to the wall, make the forearm touch the wall, perform an external rotation, and maintain this state. During these exercises, each posture was maintained for 10 seconds, followed by a rest for 5 seconds. This was performed five times, and four sets of these five repetitions were performed. A rest period of one minute was applied after each set. Each exercise was performed three times per week for four weeks. Thus, each exercise was performed 12 times in total.

In the present study, to examine changes in electromyographic activity within the groups, paired sample t-tests were conducted. SPSS 12.0 for Windows was used for statistical processing, and the significance level α was set to 0.05.

RESULTS

According to the results of the present study, comparisons within the groups revealed that although the EG showed statistically significant differences in the UT, SA, and LT (p<0.05), the CG did not show any significant differences (p>0.05) (Table 1).

DISCUSSION

The head-, neck-, and shoulder-related structures are biomechanically interconnected in a complex way, and individual segments can exert normal motor skills only when appropriate positions of the joints are maintained. CCFEs were implemented using PBU’s to exercise the longus capitis and the longus colli, which are deep flexors that play important roles in cervical stability.

In a study conducted by Dusunceli et al. 8), it was reported that 55 chronic cervical pain patients were followed up at 1, 3, 6, 9, and 12 months, and according to the results, the group given physical therapy and a cervical stabilization exercise program showed significant pain relief and functional improvement, even 12 months after the treatment. Jull et al. 9) reported that when CCFEs and cervical flexion exercises (CFEs) were performed by chronic cervical pain patients for seven weeks to reinforce flexor muscle strength and endurance, the strength of the deep flexor muscles of the neck increased. McDonnell et al. 10) reported that when exercise programs including CCFEs were applied to relieve headaches, the headaches were relieved, and neck bone functions were improved.

Falla et al. 5) reported that performing CCFEs for six weeks could relieve pain, as well as help in maintaining a neutral position of the cervical spine. O’Leary et al. 11) reported that coordination exercises through CCFEs and muscle endurance exercises through CFEs showed immediate local mechanical hypoalgesic responses with regard to hyperalgesia in chronic cervical pain patients. Cho 12) reported that when cervical stabilization exercises were applied to adult chronic cervical pain patients for eight weeks, the patients’ pain was significantly relieved, and maximum cervical muscle strength, muscle endurance, the range of joint motion, and muscular cross-sectional areas increased significantly. In their study, Chiu et al. 13) reported that when patients with chronic cervical pain performed deep flexor exercises for six weeks, their level of pain and disability index decreased significantly, and their cervical muscle strength increased significantly as compared to with group that did not perform these exercises.

In the present study, electromyographic activity levels were compared within the EG and CG. According to the results, whereas the EG showed significant increases in the UT, SA, and LT, the CG did not show any significant differences. The significant increases in the electromyographic activity of the UT, SA, and LT in the comparison of electromyographic activity within the EG are consistent with reports in previous studies as follows: Lee 14) reported that when CCFEs were performed for five weeks to enhance the strength and endurance of the longus capitis and the longus colli included in the deep cervical muscles, the muscle strength and endurance of the deep cervical muscles were enhanced and that when shoulder muscle strength was measured through using a Cybex device, increases in muscle strength were shown. Hur 15) reported in his study that when CCFEs were performed for eight weeks to enhance the endurance of the longus capitis and the longus colli, the strength and endurance of the deep cervical muscles were enhanced. Given these reports, it is believed that as the muscle strength of the longus capitis and longus colli, which are included in the deep cervical muscles, included in the deep cervical muscles increased, the neck position was properly aligned, and a balance was achieved between muscle lengths and muscle strength that enhanced the electromyographic activity of the muscles around the shoulder: the UT, the SA, and the LT. The results of the comparison with the electromyographic activity within the CG, where no significant differences were shown, are inconsistent with the following results of previous studies: in a study conducted by Jung 17), scapula stabilization exercises performed for eight weeks enhanced shoulder muscle strength, and in a study conducted by Choi 18), when wall stretching and scapula setting exercises were performed for six weeks, the electromyographic activity of the SA, UT, and LT increased. The reason for these inconsistencise is believed to

| Group | Muscle | Pre | Post |
|-------|--------|-----|------|
| UT*   | 5.6±5.5| 33.9±21.9|
| EG    | SA*    | 29.2±25.9| 69.6±10.7|
|       | LT*    | 17.9±13.4| 55.3±16.2|
|       | UT     | 9.1±7.0 | 15.8±10.9|
| CG    | SA     | 37.3±32.2| 60.8±28.8|
|       | LT     | 37.4±25.2| 54.7±26.6|

EG, experiment group; CG, control group; UT, upper trapezius; LT, lower trapezius; SA, serratus anterior. *Mean±SD. *Paired t-test, *p<0.05
be the fact that in the present study, shoulder stabilization exercises were performed for four weeks, which was shorter than the periods of exercise in previous studies. Therefore, the EG, which used both cervical stabilization exercises and shoulder stabilization exercises, improved the strength and endurance of the longus capitis and longus colli, deep cervical muscles, more than the CG, which used only shoulder stabilization exercises. This improved the ability to maintain the standing position and proper neutral position of the neck, which in turn induced correct alignment of the shoulder girdle, resulting in the improved activity of the muscles around the shoulder.

The present study has the following limitations. First, because the subjects were normal males, the study results cannot be generalized. Second, because the stabilization exercises were performed for a relatively short period of four weeks, it is difficult to consider the results of the present study to be long-term treatment effects. Studies of the effects of cervical stabilization exercises on the shoulder stabilizers should be conducted with cervical pain patients in the future.

REFERENCES

1) Hur JK: Effects of neck stabilization exercise to the patients with chronic neck pain. Korea Sport Research, 2006, 17: 121–133.
2) Kisner C, Colby LA: Therapeutic Exercise: Foundations and Techniques (5th ed). Philadelphia: FA Davis. 2010, pp 439–480.
3) Ekstrom RA, Bifulco KM, Lopau CJ, et al.: Comparing the function of the upper and lower parts of the serratus anterior muscle using surface electromyography. J Orthop Sports Phys Ther, 2004, 34: 235–243. [Medline] [CrossRef]
4) Bonney RA, Corlett EN: Head posture and loading of the cervical spine. Appl Ergon, 2002, 33: 415–417. [Medline] [CrossRef]
5) Falla D, Jull G, Russell T, et al.: Effect of neck exercise on sitting posture in patients with chronic neck pain. Phys Ther, 2007, 87: 408–417. [Medline] [CrossRef]
6) Falla D, Jull G, Hodges P, et al.: An endurance-strength training regime is effective in reducing myoelectric manifestations of cervical flexor muscle fatigue in females with chronic neck pain. Clin Neurophysiol, 2006, 117: 828–837. [Medline] [CrossRef]
7) Jung KH: The effects of taping with before and after scapula stability exercise on pain, function and muscle activation in patients with myofacial pain syndrome. Chung-Ju National University, Dissertation of master’s degree, 2012.
8) Dusunceli Y, Ozturk C, Atamaz F, et al.: Efficacy of neck stabilization exercises for neck pain: a randomized controlled study. J Rehabil Med, 2009, 41: 626–631. [Medline] [CrossRef]
9) Jull G, Falla D, Hodges P: Cervical flexor muscle retaining: physiological mechanisms of efficacy. Paper presented at 2nd, International conference on movement dysfunction, Edinburgh: Scotland, 2005, pp 435–460.
10) McDonnell MK, Sahrmann SA, Van Dillen L: A specific exercise program and modification of postural alignment for treatment of cervicogenic headache: a case report. J Orthop Sports Phys Ther, 2005, 35: 3–15. [Medline] [CrossRef]
11) O’Leary S, Falla D, Hodges PW, et al.: Specific therapeutic exercise of the neck induces immediate local hypalgesia. J Pain, 2007, 8: 832–839. [Medline] [CrossRef]
12) Cho HY: Effects of cervical stabilization exercise type on muscle strength and endurance, cross sectional area of cervical in patients with chronic cervical pain. Korea University, Dissertation of doctor’s degree, 2011.
13) Chiu TT, Lam TH, Hedley AJ: A randomized controlled trial on the efficacy of exercise for patients with chronic neck pain. Spine, 2005, 30: 1–7.
14) Lee HY: The Effects of The Cervical Stabilizing Exercise on Cervical Proprioception, Shoulder Strength and Hand Grip Strength. Daegu University, Dissertation of master’s degree, 2012.
15) Choi SH: The Effect of Shoulder Stability Exercise on Shoulder Pain and Function in Middle-aged Women. Sahmyook University, Dissertation of master’s degree, 2012.