Effects of Neck Stabilization Exercises on Neck and Shoulder Muscle Activation in Adults with Forward Head Posture

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Abstract

The purpose of the study was to identify the effects of neck stabilization exercises on neck and shoulder muscle activation in individuals with forward head posture. Twenty-five healthy adults participated in the study. All subjects performed neck stabilization exercises using three methods. The types of exercise included craniocervical flexion (CCF) exercise, upper extremity and lower extremity cross exercise in a four-point kneeling posture with CCF, and gym ball exercise with CCF. Muscle activation was simultaneously assessed and recorded in the upper trapezius and splenius capitis muscles by using surface EMG. The EMG values were normalized into the variable of maximum voluntary isometric contraction (%MVIC). A paired t-test was used to compare the upper trapezius and splenius capitis muscle activation before and after the neck stabilization exercise. The results of this study showed that there were statistically significant differences in EMG activation between the two muscle groups (p<.05). These findings show that neck stabilization exercises improve unbalanced neck muscle activation and contribute to reducing neck pain.

Keywords: Forward head posture, Muscle activity, Neck stabilization exercise

1. Introduction

In the digital era, workers using computers have increased. In line with this, office workers who sit down for long hours increasingly report discomfort in the neck and shoulders [1-3]. This back and shoulder pain is caused by various factors, such as physical characteristics and psychological stress [4]. In particular, weakened neck muscles cause neck pain by creating chronic muscle fatigue [5], and poor postures related to life habits become a cause of musculoskeletal diseases [6].

Previous studies demonstrated that imbalanced muscle activation in the neck and shoulders is associated with shoulder pain. Traditionally, the structure of ligaments and the role of ligaments to limit the excessive movements of intraspinal joints were particularly emphasized to maintain the stability of cervical spines. In recent years, however, the role of muscles has been further highlighted for the maintenance of spinal stability [7]. While typing on the computer in a forward head posture, people show increased levels of muscle activation in the upper trapezius and splenius capitis [8]. In addition, individuals with shoulder pain exhibit an imbalanced pattern of muscle activation characterized by hyperactivation in the upper trapezius and low activation in the lower trapezius and serratus anterior [9]. Such diseases, which are related to musculoskeletal pain, are among the most commonly handled areas for physical therapists. The guidelines established by the orthopedic physical therapy department of the American Physical Therapy Association suggested therapeutic exercises as one of the most proven therapies among various therapeutic approaches taken in clinical practice to treat chronic neck pain [10]. Among therapeutic exercises, the importance of stabilization exercises has recently drawn attention. These exercises induce the placement of neck bones in the neutral posture by strengthening deep muscles. While a great deal of previous research suggested that neck stabilization exercises reduce neck pain, concrete evidence is still insufficient. Therefore, this study aimed to identify the effects of neck stabilization exercises on the neck and shoulder muscle activation of adults with forward head posture, which is a potential risk factor for neck pain.

2. Literature Review
In general, continuous forward head posture in the cervical spine, which is an unstable physical posture, involves both the flexion of the lower cervical vertebrae and the extension of the upper cervical vertebrae. This posture is caused by postural instability and is frequently observed in the clinical environment in patients with neck or shoulder pain [11-12]. Moreover, this posture increases weight bearing on cervical tissues and exhibits increased electromyography (EMG) activities of muscles around the cervical vertebrae [13-15]. Cook reported that muscle fatigue resulting from the long maintenance of a forward head posture or repetitive abnormal movements could cause neck pain by reducing the self-control of deep cervical muscles and creating instability in cervical vertebra segments [16]. Visser and van Dieën suggested that selective activities that occur by performing low-intensity physical tasks on a regular basis accumulate Ca2+ in the Type I exercise unit and cause problems with homeostasis, such as in local blood supply inside the muscles and the transfer of metabolites, which can eventually result in muscle damage [17].

Stabilization exercises train various structures that form spines to maintain neutrality against fine damages resulting from daily activities. They provide the means to improve flexibility, coordination, endurance, and muscular strength by retraining spinal stabilization muscles. In other words, the exercises train patients to control their unstable postures. Liebenson reported on the correlation between headache patients and decreases in isometric muscular strength and the endurance of cervical flexors due to forward head posture [18]. It also discovered that patients who felt a headache on the back of the head exhibited an identical pattern of muscular imbalance, which was not observed in healthy individuals. Given that patients who complain of neck pain have a shorter time to maintain the maximum contractile force and submaximal force compared to healthy individuals, a number of studies have supported the necessity for stabilization exercises to improve the ability to pull down the lower jaw [19]. High-quality and systematic theses also report that stabilization exercises are highly effective in reducing chronic neck pain and increasing cervical functions. [20]. In particular, neck stabilization exercises, a method of treating neck pain due to postural instability, have been introduced as a rehabilitation program that can reduce neck pain, maximize cervical functions, and prevent injuries [21–23].

3. Experimental method
3.1. Subject

The study’s subjects were healthy 25 adults (15 men and 10 women) who were students at B University. The inclusion criteria stipulated subjects have a forward head angle (FHA) and forward shoulder angle (FSA) at FHA > 40° and FSA > 45°, respectively. This was determined using the image analysis soft program Dartfish [24] (Figure 1). The subjects’ general characteristics are presented in Table 1. This study excluded those who had neurological and psychological diseases, systematic and cardiovascular diseases, rheumatoid arthritis, spinal arthritis, acute infections, shoulder pain or diseases, or cervical diseases and had been treated for these diseases within the last six months.

Figure 1. Diagnostic criteria of forward head posture
### Table 1. General characteristics of subjects (N=25)

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Height (㎝)</th>
<th>Weight (㎏)</th>
<th>FHA(^b)</th>
<th>FSA(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.36±2.02(^a)</td>
<td>172.24±7.68</td>
<td>64.24±10.29</td>
<td>42.81±1.93</td>
<td>48.93±5.71</td>
</tr>
</tbody>
</table>

\(^a\)Average ± Standard Deviation  
\(^b\)FHA (Forward head angle)  
\(^c\)FSA (Forward shoulder angle)

### 3.2. Experiment instrument

This study performed a surface EMG using Trigno (Delsys Inc., USA) to measure surface muscle activation in the neck and shoulders. The muscle activation using surface electrodes cannot directly exhibit the motor unit and firing rate of muscles. However, it is still commonly used in studies on muscular tension because it generally exhibits the electrical activation of muscles. The sampling rate of EMG signals was set at 1,000 Hz and band-pass filtering was performed in the range of 10 to 500 Hz. The collected data were analyzed using the software program EMGworks 3.7 Analysis. The surface EMG electrodes were attached to the upper trapezius and splenius capitis in which cumulative trauma disorders are known to frequently occur during static exercises [25-26]. In the upper trapezius, an electrode was attached to a point two-thirds of the distance from the spinous process of the seventh cervical vertebra to the back side of the peak of the shoulder blade. In the splenius capitis, an electrode was attached to a point on the dominant side, which is 2cm lateral to the spinous process of the fourth cervical vertebra. To standardize the root mean squares (RMS) for the upper trapezius and splenius capitis, the respective values were normalized into the variable of maximal voluntary isometric contraction (%MVIC). The maximum voluntary isometric contraction of each muscle was measured for five seconds and the values for the first and final one second were excluded. After three repeated measurements, peak to peak values were selected. The measurement method for each muscle’s %MVIC is explained in Table 2.

### Table 2. Methods to measure MVIC

<table>
<thead>
<tr>
<th>Muscle type</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper trapezius</td>
<td>Sit up straight on a chair, flex the lateral side of the neck and extend the</td>
</tr>
<tr>
<td></td>
<td>upper limbs at 90°, and perform resistance above the elbow joint</td>
</tr>
<tr>
<td>Splenius capitis</td>
<td>Lie on one’s face with the head placed toward outside of the table, extend</td>
</tr>
<tr>
<td></td>
<td>the head at 90°, and perform resistance above the head</td>
</tr>
</tbody>
</table>

### 3.3. Exercise method

Before the experiment, the subjects received a full explanation of the exercise method and received cautions during exercise. Prior to the intervention, they underwent the measurement of muscle activation for an evaluation in a sitting position. They were also measured in terms of the %MVIC of each muscle in prone and sitting positions. After the measurement of %MVIC, the subjects performed stretching for five minutes as a warm-up, and then performed three types of exercise intervention in the sequence shown below. After finishing the exercise, they took a rest for 30 minutes to prevent the accumulation of muscle fatigue. Finally, after the break, the subjects’ muscle activation according to their cervical postures was measured in a sitting position (Figure 3).

#### 3.3.1. Craniocervical flexion exercise
The subjects were first instructed to perform a cervical flexion posture while seated and then performed a craniocervical flexion (CCF) using a pressure biofeedback unit (Chattanooga Group Inc., Hixson, USA) in a supine position. They performed the posture at an initial pressure point of 20 mmHg in a resting position, using a bag inflated by injecting air. Three sets of exercise were performed 10 times, 10 seconds each time, at varied pressures of 30 mmHg, 40 mmHg, and 50 mmHg [19].

3.3.2. Upper extremity and lower extremity cross exercise in a four-point kneeling posture with CCF

Each subject started this exercise in a four-point kneeling posture with CCF. The initial exercise was performed on the dominant side. When the subject lifted an upper limb, he or she also lifted the lower limb on the opposite side. The lifting angle was set to be within the range of which each individual was capable. Performing the given exercise once on each side counted as one set of exercise. Based on this, each subject performed 10 sets of exercise.

3.3.3. Gym ball exercise with CCF

After forming an upper-body motion while the CCF was applied, each subject slowly placed his or her body on a gym ball while maintaining balance. When both legs were placed on the gym ball, the subject maintained the posture for 10 seconds. During this position, if the subject had difficulty maintaining balance, the tester held the gym ball behind the subject. Based on the definition that the maintenance of the posture for 10 seconds is one set of exercise, 10 sets of exercise were performed in total.

4. Results and Discussion

The results of a paired t-test were as follows: When individuals with forward head posture performed neck stabilization exercises, their muscle activation was statistically significantly reduced in both the upper trapezius and splenius capitis (p<.05)(Table 3). This result supports the findings of existing studies in which cervical stabilization exercises were used as a useful exercise for controlling forward head posture [27]. For individuals with a risk factor that can cause pain due to an unstable and imbalanced cervical posture, neck stabilization exercises may reduce the probability that the postural problem evolves into diseases. Moreover, neck stabilization exercises are likely to reduce neck pain by strengthening the muscles that stabilize the regions around the neck and shoulders and lowering the
activation of the surface muscles that are relatively hyperactivated [28]. The outcome of the present study coincides with that of existing studies, which reported that the application of neck stabilization exercises in patients with neck pain due to poor postures caused by continuous postural instability was effective for the control of neck pain and the mobility of joints [29–31]. Based on the above findings, this study will serve as the evidential data that can explain the mechanism by which neck pain is reduced when neck stabilization exercises are applied to individuals who complain of neck pain due to unstable cervical postures.

### Table 3

<table>
<thead>
<tr>
<th>Muscle type</th>
<th>Before the intervention</th>
<th>After the intervention</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper trapezius</td>
<td>3.65±2.78a</td>
<td>2.07±1.45</td>
<td>4.06</td>
<td>.00*</td>
</tr>
<tr>
<td>Splenius capitis</td>
<td>8.70±7.48</td>
<td>4.78±2.92</td>
<td>3.18</td>
<td>.00*</td>
</tr>
</tbody>
</table>

*a mean ± standard deviation

*p<.05

Furthermore, the splenius capitis was revealed to have higher average values than the upper trapezius both before and after the intervention. This corresponds to the results of existing studies in which individuals with forward head posture exhibited high levels of muscle activation in the upper trapezius and splenius capitis [8]. This is generally because an increase in the flexion of the neck bone in the trunk results in a greater contraction of the body’s flexors to maintain a state of equilibrium. In addition, the splenius capitis located around the neck is likely to yield higher levels of muscle activation than the upper trapezius located around the neck and shoulders. To control such complex movements of the head, the control of jaw movements is important. A neutral head posture that simultaneously involves the flexion of the atlanto-occipital joint and the extension of the neck bone limits forward jaw movements to a certain extent. Therefore, this posture will help reduce musculoskeletal pressure during computer-based tasks and will adjust the chronic forward head posture that can originate from the upper trapezius and splenius capitis.

The present study confirmed a decline in muscle activation of the upper trapezius and splenius capitis that are located around the neck and shoulders after the implementation of neck stabilization exercises. Accordingly, neck stabilization exercises may be an appropriate treatment for preventing chronic neck pain and maintaining correct postures. However, this study has some limitations. For example, it was conducted on a relatively small number of healthy adults with forward head posture. Therefore, the extension of the present study’s findings and implications for other shoulder exercises are problematic. Thus, future studies are required to select various patients groups that complain of actual pain. They should also use more diverse evaluation measures such as joint angle, pain scale, and muscle thickness.

### 5. Conclusions

This study has drawn the following conclusion based on earlier results and discussions. To learn about changes in muscle activation around the neck after neck stabilization exercises, this study performed CCF exercise, upper-extremity and lower-extremity cross exercise in a four-point kneeling position with CCF, and gym ball exercise with CCF on 25 healthy adults with forward head posture. The test results confirmed statistically significant differences in muscle activation of the upper trapezius and splenius capitis. Accordingly, neck stabilization exercises will be able to reduce the likelihood that individuals with risk factors for neck and shoulder pain develop diseases by inducing a balanced activation of the neck and shoulder muscles. In addition, these exercises will present an effective method for disease prevention and healthcare.
6. References


