A Comparison of the Deep Cervical Flexor Muscle Thicknesses in Subjects with and without Neck Pain during Craniocervical Flexion Exercises

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Abstract. [Purpose] The purpose of the present study was to examine the amount of change in the thicknesses of the deep cervical flexor (DCF) and sternocleidomastoid (SCM) muscles in subjects with neck pain and subjects without neck pain during craniocervical flexion exercise (CCFE). [Subjects] The total number of subjects was 40, comprising 20 in the no-pain group (males 11, females 9) and 20 in the pain group (males 8, females 12). [Methods] Muscle images were obtained using ultrasound, and the thicknesses of the individual muscles were measured using the NIH ImageJ software. [Results] During CCFE, as pressure increased, the no-pain group recruited the DCF more than the pain group, while the pain group recruited the SCM more. [Conclusion] Selective DCF contraction exercises are considered very useful in the treatment of patients with neck pain.

Key words: Craniocervical flexion exercise, Deep cervical flexor, Sternocleidomastoid

INTRODUCTION

The craniocervical flexion test (CCFT) has been developed as an indirect measuring method for the clinical evaluation of deep muscles, such as the longus colli and the longus capitis1). Hudswell et al.2) determined that the inter-rater reliability and intra-rater reliability of practitioners who used the CCFT were excellent.

In the CCFT, if the deep cervical flexor (DCF) is weakened and thus the activities of the longus colli and the longus capitis are not properly controlled, the sternocleidomastoid (SCM) and the anterior scalene muscle (ASM), which are superficial muscles, will be activated early. Consequently, the chin and the head will move excessively, and the upper part of the cervical spine will be hyperextended3). Jull et al.4) ascertained that during the CCFT for chronic neck pain patients, whereas the electromyographic (EMG) activity of the DCF decreased, the EMG activity of the superficial cervical flexor increased. In a study in which EMG was used, Falla et al5) proved that deep muscular atrophy and delayed activities exist in patients with chronic neck pain.

The fact that the maximum voluntary contractile strength of the DCF, the time to maintain the submaximal voluntary contractile strength, and the ability to pull the lower jaw are reduced in neck pain patients compared with people without neck pain supports the need for stabilization exercises6). Studies verifying the beneficial effects of craniocervical flexion exercise (CCFE) on neck pain patients7, 8) and research regarding the CCFT and exercises using pressure biofeedback units (PBUs)2, 6) have already been conducted. However, studies to visualize and measure the deeply located DCF are relatively insufficient because of the nature of the muscle. Furthermore, no studies to measure the amount of change in the thicknesses of the DCF in patients with neck pain and people without neck pain have been conducted.

Therefore, the purpose of this study was to measure the thicknesses of the DCF and the SCM during CCFE using a PBU in neck pain patients as well as those without neck pain through the use of ultrasound. It further examines the differences in muscle recruitment in relation to the changes in muscle thickness.

SUBJECTS AND METHODS

The subjects for the present study were 40 students (19 males and 21 females) of D college in Daegu, Korea, who were of similar age, height, and weight. The subject groups consisted of 20 students in the neck pain group (males 8, females 12) and 20 students in the no-pain group (males 11, females 9). The subjects were 23.8 ± 0.3 years of age (mean ± standard deviation) in the pain group and 24.8 ± 0.7 years of age in the no-pain group. Their heights and weights were 167.4 ± 1.7 cm and 59.4 ± 2.1 kg in the pain group and 168.5 ± 1.7 cm and 61.1 ± 2.2 kg in the no-pain group, respec-
The neck pain subjects were selected on the basis of minor disabilities: they scored between 5–15 points on the neck disability index (NDI) and 4 points or lower on the visual analog scale (VAS) and had had persistent or intermittent neck pain within the previous three months. The pain group’s NDI was 6.5 ± 0.6 points with a VAS of 2.2 ± 0.8 points. When the subjects were selected, those who had had neck surgery within the last one year, were receiving drug treatment or other exercise therapy, or had experienced any neurological or orthopedic disease in the neck were excluded. All included patients understood the purpose of this study and provided written informed consent prior to their participation in the study in accordance with the ethical standards of the Declaration of Helsinki.

To measure muscle thickness during CCFE, each subject placed his/her forehead and chin horizontally to achieve the standardized position of the neck in a supine position, and a PBU (Chattanooga, USA) was placed at the rear of the neck and inflated with a baseline pressure of 20 mmHg. During CCFE, each subject was instructed to nod his/her head with each of five different levels of pressure (22 mmHg, 24 mmHg, 26 mmHg, 28 mmHg, and 30 mmHg) and to continue nodding for 10 seconds. Each subject then took a rest for two minutes after each experiment. To measure the DCF and SCM while each subject was performing each level of exercise, a 7.5 MHz transducer of a Z.ONE ultra Convertible Ultrasound System (ZONARE Medical System, Inc., Mountain View, CA, USA) was placed at the front of the neck in a longitudinal direction 5 cm away from and parallel to the center of the trachea so that images of the muscle, the carotid artery (CA), and the vertebra lamina (VL) could be clearly seen and captured. The left DCF and SCM were measured two times at each level of CCFE in all subjects, and the best images were selected.

From the images derived through ultrasound, the thicknesses of the DCF and the SCM were measured using the NIH ImageJ software (version 1.44 for Windows). When the thicknesses were measured, a reference line was aligned to the center of each image, and vertical lines were drawn at 0.5 cm, 1 cm, and 1.5 cm to the right of the reference line. Then, for each of the lines, the distance between the upper boundary of the SCM and the CA was measured as the thickness of the SCM, and the distance between the CA and the boundary of the VL was measured as the thickness of the DCF. The average values of the measured muscle thicknesses were used, and the changes in muscle thicknesses as a result of pressure changes were calculated using the following formula: (muscle thickness during the contraction period – muscle thickness during the resting phase)/muscle thickness during the resting phase.

The data collected during the present study were analyzed using SPSS 17.0 and presented as means and standard deviations. Repeated measures analysis of variance (ANOVA) was conducted to determine the amount of change in the thickness of the individual muscles following pressure changes. The statistical significance level α was set as 0.05.

**RESULTS**

The change (mean ± SD) in the thicknesses of the DCF and the SCM are presented in Table 1. As pressure increased while CCFE was performed, the thickness of the SCM significantly increased in the pain group (p<0.05), while the no-pain group showed no significant difference (p>0.05). The amount of change in the thickness of the DCF showed significant increases in both the pain group and the no-pain group (p<0.05).

**DISCUSSION**

Ultrasound to measure muscle activity can only be done when there are changes in the pennation angle, fascicle length, and thickness of each muscle because muscles consist of continuous elastic components.

Fabianna reported that when she conducted ultrasound measurements to study the recruitment of the SCM and DCF in persons without neck pain, although recruitment of the DCF increased during the CCFT, there was little difference between the DCF and the SCM. Similarly, in the present study, the amount of increase in the DCF in the no-pain group seemed to be slightly greater than that in the SCM, although the difference was not large. In the no-pain group, the DCF and the SCM showed similar amounts of changes because they co-contracted.

Many studies have reported that in the case of patients with neck pain, the SCM and the ASM, which are superficial muscles, were activated early when CCFE commenced. Similarly, in the present study, the amount of increase in the SCM seemed larger than that in the DCF in the pain group. Given these results, in the case of the neck pain group, due to a decrease in the DCF’s ability to contract, the SCM, which is a superficial muscle, was considered to be relatively activated for the purpose of movement. If ab-
normal movements made by excessive use of the superficial muscles are not appropriately controlled by the DCF, the cervical spine may become unstable and cause neck pain. Although causes of neck pain are not clear yet, the degree of fatigue surrounding the neck flexor becomes increasingly severe due to increased abnormal movements of the neck bones as the neck bends increasingly or through overwork due to one’s work environment or lifestyle. In particular, it is considered that weakened DCF, which stabilizes the neck, and delayed contraction occurs. In addition, the SCM is activated in the early stage when the DCF is weak during the CCFT, which causes movement of the chin and head. This causes hyperextension of the upper cervical spine and leads to an abnormal array, which can cause headaches and neck pain due to pressure on the facet joints and disks of the cervical spinal area. As a result, activation of the DCF is important because it controls the posture of the cervical spinal area and stabilizes the spinal units. Similar to several other studies, we consider the CCFE to be important as a movement that activates the DCF.

Finally, CCFE is considered to be very useful in evaluating and solving the diverse problems caused by neck pain.

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