Changes in the thickness of the cervical flexor depending on the contraction level of the masticatory muscle during deep cervical flexor training

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Abstract. [Purpose] This study examined the changes in the thickness of the deep cervical flexor according to the contraction intensity of the masticatory muscle during deep cervical flexor training. [Subjects and Methods] Twenty healthy adults were randomly selected and the thicknesses of their longus colli and sternocleidomastoid were measured with ultrasound when the masticatory muscle contracted during deep cervical flexor training. [Results] The thickness of the longus colli tended to increase in proportion to the contraction intensity of the masticatory muscle, with a significant difference. However, the thickness of the sternocleidomastoid did not significantly differ with the contraction intensity of the masticatory muscle. [Conclusion] During deep cervical flexor training, when co-contraction of the masticatory muscle occurs, changes in the thickness of the longus colli may be selectively increased. Deep cervical flexor training was most effective during contractions of a submaximal intensity.

Key words: Contraction intensity of masticatory muscle, Deep cervical flexor training, Thickness of neck flexors

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INTRODUCTION

The longus colli and longus capitis are representative deep cervical flexors. These muscles have many proprioceptors for postural control and therefore play a role in supporting position sense and balance of the head and neck¹⁾. However, chronic neck pain patients undergo relatively abnormal hypertension of the superficial cervical flexor²⁾ and exhibit shortening of the subocciput region due to the weaknesses of the longus colli and longus capitis during movement of the cervical area³⁾. Therefore, deep cervical flexor training is conducted for selective strengthening and retraining of the deep cervical flexor⁴⁾.

The detailed method of this training is to draw the chin in and make the curve of the cervical area flat⁵⁾. Here, chin-in motion affects the contraction of the muscles connecting the mandible and cervical area. For example, elevation (mouth closed) of the mandible triggers a contraction of the cervical flexor, while depression (mouth open) of the mandible brings about a contraction of the cervical extensor⁶⁾. In addition,

the masticatory muscle attached to the mandible plays the role of proprioceptor, as well as performing the functions of mastication, and therefore is involved in conducts postural control of the head, cervical area, and upper limb in co-ordination with the deep cervical flexor⁷⁾. Previous research has reported that during the motion of clenching, the direction and intensity of mastication resulted in significantly different activations of the cervical muscles. One study stated that changes in the location of the lower jaw, such as opening or clenching the mouth, lead to significant differences in the cervical muscles⁸⁾. This is because the fascia covering the masticatory muscle has continuity with the fascia of the cervical muscles and has the same functional unit; therefore, it affects the activity of the cervical muscles, and the contraction of the masticatory muscle in coordination with the cervical muscles increases the contraction of the cervical muscles⁹⁾. In previous research, changes in the thickness of the deep cervical flexor were observed when clenching at a submaximal intensity, but the degree of coordination of the cervical flexor will become different according to the contraction intensity of the masticatory muscle. Therefore, this study compared the thickness of the cervical flexor according to the contraction intensity of the masticatory muscle during deep cervical flexor training.

SUBJECTS AND METHODS

This study recruited 20 healthy adults who voluntarily

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consented to participate in this study and signed a written consent. This experiment was approved by the Bioethics Committee of the Catholic University of Pusan. The subjects were those who had no neck pain, temporomandibular joint pain, or headache within the last six months. During the familiarization session, the subjects were taught how to perform deep cervical flexor training, and maximal voluntary isometric contraction (MVIC) of the masseter was measured; then, clenching was performed at 10, 50, and 80% MVIC. The clenching intensity was adjusted by the subjects who were given feedback of the root mean squares values of the electromyography trace on a monitor (Myo-System DTS, Noraxon U.S.A. Inc., Scottsdale, CA, USA). In this experiment, the subjects lay in a supine position on a bed. First, a pressure biofeedback unit was placed on the cervical posterior surface of the subjects and the posterior surface of the neck was pressured to 20 mmHg with the pressure biofeedback unit. The subjects then performed chin-in with the mouth lightly closed without contraction of the masticatory muscle. In this position, the experimenter measured the thicknesses of the longus colli and sternocleidomastoid of each subject with ultrasound. Then, both masseters of the subjects were cleaned with alcohol cotton and dried. Ag-AgCl electrodes were attached to the subjects who were then instructed to conduct chin-in in the same way, while simultaneously clenching the masseter muscle at intensities of 10, 50, and 80% MVIC. The ultrasound measurement location was 2 cm downward from the thyroid cartilage. The area was marked with a marker and the measurement was taken with the ultrasound transducer placed at a right angle, 1 cm from the right side. The longest front and rear distances among the images of the muscular cross-section were measured¹⁰⁾. Each motion was measured three times and the average value was used for the analysis. To prevent damage to the subjects' teeth and temporomandibular joints, the subjects conducted clenching with a mouthpiece placed in the mouth. To prevent muscle fatigue, each motion was maintained for 5 s and 2 min of resting time was given. Ultrasound (SONOACE X4, MEDISON, Seoul, South Korea) was measured using a 7.5 MHz linear transducer in B-Mode. SPSS 19.0 was used for the statistical analysis. Descriptive statistics of the subjects' general characteristics were calculated and repeated measures analysis of variance was used to examine changes in the thicknesses of the longus colli and sternocleidomastoid according to the contraction intensity of the subjects' masticatory muscles. A significance level of $\alpha = 0.05$ was used.

RESULTS

The general characteristics of the subjects are shown in Table 1.

The thickness of the longus colli tended to increase in proportion to the contraction intensity of the masticatory muscle when the masticatory muscle was concurrently contracted, compared to when only deep cervical flexor training was conducted, with a significant difference ($p < 0.05$). However, there was no significant difference in the muscle thickness of the sternocleidomastoid according to contraction intensity ($p > 0.05$) (Table 2).

Table 1. Characteristics of the subjects (N=20)

Variables	Value
Gender (M/F)	15/5
Age (yrs)	21.4 (1.8)
Height (cm)	172.7 (4.4)
Weight (kg)	68.8 (7.76)

Table 2. Difference in the longus colli and sternocleidomastoid thickness according to the contraction intensity of masticatory muscle (units: cm)

Muscles	Intensity	Mean±SD	Post-hoc
LC	80%MVIC d	0.60±0.14*	a·b·c<d
	50%MVIC c	0.55±0.13	
	10%MVIC b	0.51±0.12	
	Control a	0.50±0.15	
SCM	80%MVIC d	0.77±0.21	a·b·c·d
	50%MVIC c	0.74±0.25	
	10%MVIC b	0.77±0.26	
	Control a	0.71±0.19	

DISCUSSION

This study measured changes in the thickness of cervical flexors in accordance with the contraction intensity of the masseter muscle using ultrasound during deep cervical flexor training. The result was that as the contraction intensity of the masticatory muscle increased, the thickness of the longus colli significantly increased, but the thickness of the sternocleidomastoid exhibited no significant difference. In addition, the thickness of the longus colli grew significantly thicker during the concurrent contraction of the masticatory muscle to 80% of the MVIC relative to during only deep cervical flexor training. When the masticatory muscle contracted to 10% and 50% of the MVIC, there was a tendency for the muscle to become thick in proportion to the amount of contraction, but the differences were not significant.

Therefore, it is our considered opinion that during deep cervical flexor training, the concurrent contraction of the masticatory muscle at a submaximal intensity selectively increased the thickness of the longus colli without contraction of the sternocleidomastoid, and the probable mechanism behind this result is coordination of the masticatory muscle and the longus colli.

The mastication system connects chains of the front and back muscles of the body. In particular, the mandible and tongue are directly connected to the chains of the front muscles, and the hyoid bone is pressured with the role of a basic axis.

During clenching, contraction of the masticatory muscle, and input of sensation by proprioceptors within the teeth, gums, and temporomandibular joints, deliver a sensation to the mesencephalic nucleus area within the brain stem and the sensation of mastication in the mesencephalic nucleus is delivered to the trigeminal nuclei for activation.

The trigeminal nuclei are arranged lengthwise along the

efferent pathway, which provides descending delivery of postural information where information for tonic system equilibrium is combined.

Resultant, excitation of the trigeminal nuclei affects the equilibrium of the tonic muscles during clenching, and the masseter muscle is neurally dominated by the trigeminal nuclei; therefore, it probably stimulates the contraction of the longus colli, and cervical postural maintenance muscles¹¹⁾. Lee et al.¹²⁾ reported that the contraction intensity of the neck, upper limbs, and core muscles increased during masticatory muscle contraction, compared to no-contraction, due to improved postural stability of the upper-lower jaw bite. Crispin et al.¹³⁾ also noted that utilization of mandibular orthopedic repositioning appliances moves the mandible to a normal position, thereby affecting the temporomandibular joint and improving the muscle strength, endurance, and motor ability of the whole body muscles, as well as those of the masticatory muscle.

The reason there was no significant change in the deep cervical flexor thickness when the masticatory muscle was concurrently contracted at intensities of 10% and 50% MVIC was because the weak muscle contraction failed to reach the threshold triggering coordination with the cervical muscles. Thus, when the masticatory muscle is co-contracted at a submaximal intensity, it would be more effective at strengthening the deep cervical flexor. A future study should investigate the effect in patients with chronic neck pain, because the subjects of this study were normal adults.

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