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Original Article

The effects of eye coordination during deep cervical flexor training on the thickness of the cervical flexors

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Abstract. [Purpose] The purpose of this study was to identify changes in the thicknesses of the cervical flexors according to eye coordination during deep cervical flexor training. [Subjects and Methods] Twenty normal adults were randomly selected, and during their deep cervical flexor training and eye tracking, the thicknesses of the longus colli and the sternocleidomastoid were measured using ultrasonic waves. [Results] The thickness of the longus colli statistically significantly increased when deep cervical flexor training and eye coordination were performed simultaneously. However, the thickness of the sternocleidomastoid did not show statistically significant differences according to eye coordination. [Conclusion] Eye coordination during deep cervical flexor training is likely to increase the thickness of the longus colli selectively.
Key words: Eye coordination, Deep cervical flexor training, Thickness of cervical flexors

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INTRODUCTION

The cervical spine is surrounded by complex muscles that control the mobility and stability of the head and neck[1)]. Among them, the deep cervical flexors (longus colli, longus capitis) are known to provide the cervical spine's segmental stability, and postural stability is realized through neuromuscular control in the cervical region due to the distribution of multiple position proprioceptors[2)]. Therefore, for providing the cervical region's functional motions and stability, the deep cervical flexors should first be contracted, thereby creating cervical stability; then, the functional motions should be realized.

However, patients with chronic neck pain show a weakening of their deep cervical flexors, as well as compensatory hypertension of the superficial flexors[3)]. This weakening of the deep cervical flexors causes a reduction in the intrinsic proprioceptors of the postural senses in the muscles, and it lowers the ability to control posture through interactions between the vestibular and visual systems[4)].

Therefore, exercises that can help strengthen the deep cervical flexors have been applied in various manners[5, 6)]. In particular, deep cervical flexor training (DCFT), which retrains the deep cervical flexors, is drawing attention. In a previous study, the test group that performed DCFT showed increases in the range of motion and the cross-section of the longus colli when compared to the control group[7)]. Another study applied DCFT in patients with chronic neck pain for six weeks and observed an overall statistically significant decrease in the neck disability index (NDI)[8)]. In DCFT, each patient is instructed to flatten the cervical spine in the supine position without moving the head and to pull in the chin[9)]. However, no specific instructions were given regarding the direction of the patient's gaze or regarding whether to open or close the mouth.

However, individuals can activate different cervical muscles depending on their eye direction. In addition, the coordination of the head, neck, and eye increases the level of sensitivity to postural changes, thereby enhancing postural stability and enabling selective exercises[10)]. Therefore, during DCFT, the activation of the cervical muscles and changes in the thicknesses of the muscles are likely to show differences according to an individual's eye direction. However, relevant studies are scarce. Giannakopoulos[11)] and other researchers measured the activation of the longus colli using electromyography (EMG). However, as the longus colli is located in the deep part of the anterior cervical region, activation cannot easily be measured using surface EMG. Moreover, invasive electrical stimulation can cause abnormal muscular tension in sensitive cervical muscles. This makes it difficult to derive accurate research results. Therefore, the purpose of this study was to compare changes in the thicknesses of the cervical flexors according to eye coordination during DCFT using ultrasonic waves.

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

Variables	Value
Gender (M/F)	16/4
Age (yrs)	21.5±1.7
Height (cm)	174.2±5.5
Weight (kg)	69.7±7.8

Table 2. Differences in longus colli and sternocleidomastoid thickness according to training maneuver (Units: cm)

Muscle	Maneuver	Mean±SD
LC	DCFT	0.50±0.15
	DCFT with eye coordination	0.60±0.14*
SCM	DCFT	0.71±0.19
	DCFT with eye coordination	0.74±0.21

LC: longus colli; SCM: sternocleidomastoid; DCFT: deep cervical flexor training. *p<0.05

SUBJECTS AND METHODS

After the purpose of this study was explained, the subjects agreed to participate and submitted a written consent form. Twenty male and female adults were randomly selected. The selection criterion included those who had not experienced cervical pain, headache, or dizziness within the last six months. The study was approved by the institutional review board (IRB) of the Catholic University of Busan.

The researcher taught the subjects how to perform DCFT and then provided them with a five-minute break.

In the experiment, the subjects were instructed to lie down on the bed in the supine position and then bend their hip and knee joints at 90°. The researcher placed a pressure biofeedback unit (PBU) between the surface and the curve formed in the back of the subject's neck and maintained 20 mmHg of pressure while performed DCFT to prevent excessive contractions of the sternocleidomastoid and anterior scalenus. The subjects were asked to look straight ahead and to pull in the chin. In this position, the researcher measured the thicknesses of the longus colli and the sternocleidomastoid located in the subject's anterior cervical region using ultrasonic waves (SonoAce X4, Medison, Korea). After this process, while the subject performed DCFT in the same manner, he or she was instructed to look straight ahead at the start and, following a verbal comment signaling the start of the training, to look at the end of the jaw and follow the direction in which the jaw was moving (inferior medial portion). During this process, the thicknesses of the respective muscles were measured using the same method. Regarding the location that was measured using ultrasonic waves, the researcher perceived the thyroid cartilage by touch, which was located in the anterior cervical region, indicated the area was 2 cm down from the cartilage using a marker, and measured the right side of the area using a 7.5 MH linear transducer in B-mode. The transducer was contacted vertically based on the axis of ordinates. After measuring cross-sectional images, the longest among the anterior and posterior lengths was selected for use[12)]. The subjects had to maintain the chin-in motion for 10 seconds, and they were provided with a one-minute break after each motion to prevent muscle fatigue[7)].

Each measurement was taken three times alternately and the average was used for statistical analysis. SPSS 19.0 was used for data processing, and the general characteristics of the subjects were obtained by applying descriptive statistics. Paired t-tests were performed to identify differences in the thicknesses of the longus colli and the sternocleidomastoid depending on the application of eye coordination.

RESULTS

General characteristics of the subjects are shown in Table 1.

Changes in the thicknesses of the longus colli and sternocleidomastoid were compared when eye coordination was applied and not applied during DCFT. When eye coordination was applied, the thickness of the longus colli statistically significantly increased ($p<0.05$), whereas that of the sternocleidomastoid did not show statistically significant changes after the application of eye coordination (Table 2).

DISCUSSION

This study measured the thicknesses of the deep cervical flexors during DCFT and eye coordination.

The longus colli showed a statistically significant increase in its thickness when DCFT was combined with eye coordination; however, the sternocleidomastoid did not exhibit a statistically significant difference according to eye coordination. The coordination of head and eye movements delivers information on vision and posture regarding the tecleus reticularis gigantocellularis (NRG) in the subcortical region, and it delivers postural information from the NRG to motorneurons in the cervical spinal cord. In doing so, the coordination derives postural stability by properly controlling the level of tension in the cervical muscles[13)]. In particular, proprioceptors in the deep cervical flexors and eye movement muscles keep the head position in the space, and they control postural balance through real-time sensitive responses to postural changes. For this reason, the coordination of the eye and of the neck muscles is likely to have strong correlations. In addition, during eye tracking, in which the eye follows the direction in which the head moves, the central mesencephalic reticular formation (cMRF) within the subcortical region is first activated, and then information is again delivered from the cMRF to the brain stem's eye movement control part, the occulari system, and the NRG's head movement center. Therefore, the cMRF's preceding activation was reported to play an essential role in eye-head movement coordination[14)]. In the present study, therefore, eye tracking during DCFT simultaneously delivered postural information to the NRG and cMRF through the vestibular and visual systems. This may have induced increases in the contraction of the longus colli by intensifying eye cognition.

However, the sternocleidomastoid did not show statistically significant differences after the application of eye coordination. By nature, DCFT selectively strengthens the deep cervical flexors while minimizing the activation of the superficial cervical flexors. Therefore, the thickness of this muscle may not have shown differences according to eye coordination. Bolton[15] reported in his study that complicated reflexive activities occur as the vestibular and visual systems and the cervical spine interact to process afferent postural information for postural control.

Moreover, Treleaven[16] stated that patients with neck pain have trouble in sensory-motor control, and they need head–eye movement control to resolve this problem.

Given that the results of the present study also showed correlations between the eyes and the cervical flexors, DCFT combined with eye coordination is likely to be effective in enhancing the contraction of the deep cervical flexors.

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