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Effects of Exercise on Deep Cervical Flexors in Patients with Chronic Neck Pain

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Abstract. [Purpose] The purpose of this study was to investigate whether a cranio-cervical flexor exercise is effective at improving the cross-sectional area (CSA) of the longus colli (LC), the absolute rotation angle (ARA) and neck disability index (NDI) of patients with chronic neck pain. [Subjects] The subjects of this study were 35 patients who had chronic neck pain. [Methods] The experimental group (n=17) did cranio-cervical flexor exercises and the control group (n=18) did neck isometric exercises. [Results] Paired t-test analysis revealed significant changes in CSA, ARA and NDI within both groups. CSA, ARA and NDI showed significant post-intervention differences between groups. The experimental group showed greater improvement than the control group in CSA of the LC, with a between group difference of 0.07 cm^2, in ARA, with a between group difference of 0.39 degree, and in NDI, with a between group difference of 3.47 points. [Conclusion] These results suggest that the cranio-cervical flexor exercise was more effective at enhancing CSA, ARA and treating functional disabilities.
Key words: Cranio-cervical flexor exercise, Chronic neck pain, Cross-sectional area

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INTRODUCTION

Neck pain occurs in the region between the occipital condyle and C7 and 67% of the entire population experiences this pain at some time in their lives[1)]. If the pain endures for more than three months, it is called chronic neck pain[2)]. Symptoms of neck pain are difficult to generalize by a single standard because there are multiple elements related to the symptoms of neck pain, such as the level of pain and physical, mental, and socio-medical factors[3)].

Previous research has indicated that most neck pain is related to weakening of the muscles around the spine. This may result in diminished endurance and isotonic muscle strength of neck flexor muscles, limitation of joint movement, and inhibited posiyioning of the head. After the onset of pain or injury, weakening of deep cervical flexor muscles (DCF) also begins[4, 5)]. Kristjansson[6)] proposed that patients with neck pain caused by whiplash injury have reduced ability of DCF. As a result of this phenomenon, the outer muscles overreact to cause an imbalance in the surrounding muscles, resulting in alteration of cervical lordosis.

Recent research concerning posture control and stability of cervical vertebrae has emphasized the role of deep muscles, such as the longus colli (LC) and longus capitis (Lca) rather than neck flexors[7)]. To provide stability of cervical vertebrae, the LC and sternocleidomastoid (SCM) cooperate as the main muscles[8)]. Previous research indicates that patients experiencing neck pain have LC disorders[9)], while patients with chronic neck pain have low muscle activity in DCF[9, 10)]. Low muscle activity signifies a change in neck flexor size[11)], and changes in muscle size and cross sectional area (CSA) are good indicators of muscle function[12)].

Therapeutic exercise is one method for curing chronic neck pain. It focuses on solving the dynamic problems, that are reported to be the main cause of chronic neck pain, and emphasizes the value and importance of remediation[9)]. One of these therapeutic exercises, cranio-cervical flexion, is effective for reducing cervicogenic headache that minimizes the activity of surface muscles, such as SCM, and trains the DCF[13)]. Falla[14)] indicated that SCM and the anterior scalene (AS) activate during the early stage, and the muscle strength and function of LC and Lca are reduced during cranio-cervical flexion of chronic neck pain patients. Retraining damaged DCF reduces the pain of neck pain patients and increases patients' ability to maintain an upright posture by increasing the activity of DCF[15)].

There are many studies that have compared muscle activities involving cranio-cervical flexor exercises on chronic neck pain patients; however, studies that have compared quantitative data using CSA are rare. In the present study,

Table 1. Demographic features of both groups (N=35)

	Experimental group (n=17)	Control group (n=18)
Sex n (%)	M 10(58.8%) / F 7(41.2%)	M 10(55.6%) / F 8(44.4%)
Age (years)	35.41 ± 8.53	37.06 ± 10.44
Height (cm)	168.06 ± 7.87	166.39 ± 6.92
Weight (kg)	63.41 ± 11.20	62.11 ± 7.25
Illness Duration (months)	12.12 ± 4.62	13.44 ± 6.98

Note. Values are mean ± SD. Abbreviation M: Male, F: Female

we investigated the effects of cranio-cervical flexor exercises on CSA of LC, absolute rotation angle (ARA), and neck disability index (NDI) of chronic neck pain patients.

SUBJECTS AND METHODS

Subjects

Thirty-five patients, who complained of neck pain for more than 12 weeks without any anatomical or neuro-physiological causes, were recruited from H. hospital in Seoul. These patients were divided into two groups: an experimental group (n=17) and a control group (n=18). The experimental group performed cranio-cervical flexor exercises, and the control group performed isometric neck exercises. Patients with cervical vertebral radiculopathy, spinal disease, fibromyalgia syndrome, previous neck surgery, major degenerative arthritis, neck function disorder scale of higher than 34 or less than 5, pregnancy, drugs that affect muscle size, or skin disorder in the region of ultra-sound testing were excluded from the study.

Methods

The experimental group performed cranio-cervical flexor exercises, while the control group performed neck isometric exercises for 30 minutes, three times a week for 8 weeks. For 4 weeks, patients performed the exercises three times a week the hospital. For 6 weeks, patients performed the exercises once a week at the hospital and two times a week at home. For 8 weeks, patients performed the exercises three times a week at home, which were self-recorded. Neck flexor, extensor, lateral flexor, and rotator muscles were stretched for 30 seconds, three times in ten minutes before and after each exercise[16].

Cranio-cervical flexor exercises were performed with the patients' hip joints and knee joints flexed. Towels were placed between the patient's head and floor to reduce friction while the patient was lying down. During the cranio-cervical flexor contraction, bending by SCM and AS contraction were prevented. To contract the LC and Lca, the jaw was pulled down to make a nodding movement. To accurately perform the exercises, a pressurized biofeedback instrument (PBU-1 Weart Inc., Korea) was used to gradually increase the pressure from 20 mm Hg to 40 mm Hg in increments of 4 mm Hg[5]. On the first, second, third and fourth week, 12 repeats of 10-second, 15 repeats of 10-second, 15 repeats of 15-second, and 15 repeats of 20-second exercises were performed[17], respectively. Each set was repeated three times and a one-minute rest was given between the sets.

Neck isometric exercise is an exercise in which a subject, in either a sitting or standing position, holds the neck in a straight posture by flexing the neck muscle for 10 seconds. Resistance is manually applied in six directions (front, rear, right, left, upper right, upper left) to increase the intensity of the muscle contraction around the neck. In the present study, three sets of ten repeats were performed and one minute rest was given between the sets[18].

CSA of LC was measured by an expert using a 12.5 MHz linear transducer of an ultrasound instrument (Terason T-3000, Teratech Corp., USA).

ARA of cervical vertebral lordosis was measured on X-rays. Patients were allowed to stand in their natural posture and X-rays were taken from the lateral side. The posterior tangent method was used to evaluate cervical vertebral lordosis. This method measures the intersect on angle of a line drawn vertically downward from the posterior cranial side of C2 and a line drawn vertically upward from the posterior caudal side of C7[19].

To evaluate the functional impairment caused by neck pain in daily life, the Korean version of the neck disability index (NDI) was used[20].

SPSS for Windows (Version 18.0) was used for the statistical analysis. To verify the demographic factors and homogeneity of dependent variables, the independent t-test was performed. To compare the within group differences between before and after intervention, the paired t-test was used. The independent t-test was used to evaluate differences between the two groups. The level of statistical significance was chosen as 0.05.

RESULTS

The experimental group (n=17) had averages of 35 years in age, 168 cm in height, 63 kg in weight, and 12 months duration of chronic neck pain. The control group (n=18) had averages of 37 years in age, 166 cm in height, 62 kg in weight, and 13 months duration of chronic neck pain. There were no significant differences in these average measures between the groups, indicating that the two groups were homogeneous (Table 1).

CSA of LC changed from 0.67 cm^2 to 0.82 cm^2 in the experimental group, and from 0.64 cm^2 to 0.71 cm^2 in the control group. ARA changed from 16.88° to 17.57° in the

Table 2. Comparison of CSA, ARA and NDI within groups and between groups (N=35)

		Experimental group (n=17)	Control group (n=18)
CSA (cm^2)	pre	0.67 ± 0.11	0.64 ± 0.13
	post	0.82 ± 0.11*	0.71 ± 0.14*
	change	0.14 ± 0.01†	0.07 ± 0.02
ARA (°)	pre	16.88 ± 5.92	18.08 ± 6.18
	post	17.57 ± 5.94*	18.38 ± 6.34*
	change	0.69 ± 0.58†	0.29 ± 0.56
NDI (points)	pre	19.71 ± 6.48	20.17 ± 5.68
	post	10.24 ± 4.77*	14.17 ± 5.23*
	change	9.47 ± 5.02†	6.00 ± 1.53

Note. Values are mean ± SD. Abbreviation CSA: Cross-sectional area, ARA: Absolute rotation angle, NDI: Neck disability index. * $p<0.05$ by paired t-test. † $p<0.05$ by independent t-test.

experimental group and from 18.08° to 18.38° in the control group. NDI changed from 19.71 points to 10.24 points in the experimental group and from 20.17 to 14.17 in the control group. Each item in each group showed significant differences ($p < 0.05$). Changes in CSA of LC of the experimental and control groups were 0.14 cm^2 and 0.07 cm^2, respectively. Changes in ARA of the experimental and control groups were 0.69° and 0.29°, respectively. Changes in NDI of the experimental and control groups were 9.47 points and 6.00 points, respectively. Between the two groups, differences in CSA of LC, ARA and NDI were 0.07 cm^2, 0.39° and 3.47 points, respectively, all of which were statistically significant ($p < 0.05$) (Table 2).

DISCUSSION

Neck pain is the most common type of pain among musculoskeletal disorders, and it progresses to chronic neck pain 13% of the time[21)]. Chronic neck pain patients lack the ability to control cervical vertebrae due to weakening of DCF[9)], which causes forward head posture due to limited cranio-cervical flexion arising from increased activity of surface cervical flexors. Also, limited functionality of DCF causes neck disability and pain[22)]. To eliminate these causes, neck pain patients perform conservative therapies and spine-stabilizing exercises; however, data to prove the effectiveness of these exercises is still very limited[23)]. Jull et al.[13)] reported an increase in cervical vertebral muscle exercise performance in cervicogenic headache patients after performance of cranio-cervical flexor exercises. However, they did not compare the effectiveness of the cranio-cervical flexor exercise with general isometric exercises; therefore, it cannot be concluded that this exercise has a superior effect in the treatment of neck pain patients.

Kristjansson[6)] measured the CSA of chronic neck pain patients' and healthy females' multifidus, and concluded that chronic neck pain patients had reduced sizes of muscles compared to healthy subjects. Mayoux-Benhamou et al.[8)] studied CSA of healthy subjects' LC and dorsal neck muscles and concluded that CSA of LC was related to cervical lordosis, and the stability of the cervical vertebrae. Javanshir et al.[11)] measured chronic neck pain patients' CSA of LC, which was 0.66: 0.68 cm^2. In our research, the CSA of the experimental and control groups were 0.67 cm^2 and 0.64 cm^2, respectively, which was in agreement with the results of previous research into muscle atrophy of LC. Cranio-cervical flexor exercises have been shown to be more effective than isometric exercises. Boyd-Clark et al.[7)] indicated that LC has more type II fibers than type I fibers, and have a high density of muscle spindles, which affects postural and stability. In the present study CSA of LC increased in the experimental group by 0.07 cm^2 compared to the control group. This would be the result of activation of muscle spindles of LC by cranio-cervical flexor exercises[7)], and enhanced neuromuscular control of cervical vertebrae due to sensory feedback.

Cervical lordosis forms during the tenth week of fetal development[24)]. McAviney et al.[25)] indicated that a normal cervical lordotic angle is between 31–40°, and an angle of less than 20° is related to neck pain. In our research, cervical lordotic angles of the experimental and control groups were 16.88° and 18.08°, respectively, which were relatively low. After the exercises, the experimental group, although still in the painful range, showed a 0.39° increase of lordotic angle. In their osteoarthritis research, Gogia et al.[26)] found that ROM and improvement of symptoms do not have any relationship. However, our research, similar to previous studies of neck pain patients[25, 27)], supports the idea that therapeutic exercises enhance cervical spine functions.

Ko et al.[17)] investigated the effect of neck pain on daily activites, and found that NDI was decreased from 18.35 to 12.45 by cranio-cervical flexor exercise. Jull et al.[28)] found that NDI was decreased from 11.0 to 6.0 by cranio-cervical flexor exercise, and from 9.6 to 6.1 by muscle exercises. Dusunceli et al.[23)] found that NDI was decreased from 19.3 to 9.9 by stabilizing exercise, and from 19.2 to 17.3 by isometric exercise. Our research also found that NDI was decreased from 19.71 to 10.24 by cranio-cervical flexor exercises, and from 20.17 to 14.17 by isometric exercises, both of which were statistically significant differences. As a result of the exercises, DCF was retrained, and CSA and muscle activity were increased. Also, stabilization of the neutral posture of cervical vertebrae and enhancement of balance[15] enhanced the function of cervical vertebrae, which improved the quality of everyday life.

The results of this research indicate that cranio-cervical flexor exercises are an effective treatment for improvement of CSA of LC and ARA and treating functional disabilities. It can be readily suggested for retraining and improving muscle functions. Future work should study more chronic neck pain patients and the long-term effects of exercises.

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