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The Effect of Joint Mobilization and Deep Cervical Flexor Training Applied to the Neck on Muscle Tone and Pain in Adults with Non-Specific Neck Pain

Kim Tae Ho, Kang Min Bong*

Department of Physical Therapy, College of Rehabilitation Science, Daegu University, Daegu, South Korea

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Abstract This study was conducted to investigate the effects of cervical mobilization and deep cervical flexor training on muscle tone and pain in adults with non-specific neck pain. Using the Neck Disorder Index (NDI), 30 patients in the normal group and 30 patients in the neck pain group were classified, and comparisons were made between groups to clearly select subjects and identify the characteristics of non-specific neck pain. For 30 adults with non-specific neck pain, each was classified into the joint mobilization group, the deep cervical flexor training group, or the mixed group, and training was conducted twice a week for 10 minutes each for 4 weeks. As a result of comparing normal subjects with adults with non-specific neck pain, there was a significant difference only in the sternocleidomastoid muscle ($p<.05$). As a result of comparing the tone between groups, there was a significant difference in upper trapezius, sternocleidomastoid, levator scapulae ($p<.05$). And there was no significant in all three groups in the comparison of pain ($p>.05$). As a result of comparing the tone between groups, there was a significant difference in all muscles ($p<.05$), and there was no significant difference in all three groups in the comparison of pain between groups ($p>.05$).

Keywords Non-Specific Neck Pain, Mobilization, Deep Cervical Flexor Training, Muscle Tone, Neck Disability Index

1. Introduction

Non-specific neck pain refers to pain that occurs outside and behind the neck without any pathological signs and symptoms [1]. If these symptoms in the neck last for more than 12 weeks, the condition is called non-specific neck pain [2]. According to a review of literature related to the neck between 1980 and 2006 by Hogg-Johnson et al. [3], the prevalence of neck pain without specific diagnosis lasting for more than 12 months was between 30% and 50%; notably, according to a survey by the Korea Health Insurance Review and Assessment Service in 2020, the number of patients with musculoskeletal diseases related to the neck increased 1.38 times from 2009 to 2019 [4]. Many previous studies have reported that the incidence of neck problems is increasing, which poses a huge problem to society [5-7].

The cause of non-specific neck pain is unknown [8]. However, most people who work in the same posture for a long time cause non-specific neck pain [9,10]. Maintaining the neck in one position for a long time increases fatigue on the neck's surface and deep muscles, which also reduces muscle endurance and decreases the sense of joint position and the range of movements of the neck in the neck bone [11,12]. This is a result of keeping a changed length of the muscles maintaining posture and going against gravity [13]. If these unhealthy practices were continued, there will be a recurrence of non-specific pain in the neck area and chronic pain [1,14].

Non-specific neck problems include pain, decreased neck range of motion, increased fatigue and tone in the muscles around the neck, and a wide range of damage observed around the neck [11,12,15]. Sjøgaard et al. [16] reported that muscle fatigue occurs even in the continuous contraction of muscles with low loads; fatigue and continuous contraction cause tone in the upper trapezius and sternocleidomastoid, which play major roles in head and neck movements, resulting in tension-neck syndrome [17].

As a therapeutic method for various pains in the neck, the American Physical Therapy Association (APTA) suggests interventions such as joint mobilization and exercise training [1], which are generally used in manual therapy. The specific technique used is the posterior-anterior joint mobilization technique [18]. In posterior-anterior joint mobilization technique, a vertical force is applied to the spinous process of the cervical [19]. Ganesh et al. [20] reported a significant increase in the cervical mobility by applying Maitland mobilization to patients with cervical pain who complained of symptoms for less than 12 weeks. Meanwhile, Joshi et al. [21] reported that in a patient complaining of pain at the junction of the cervical vertebrae and the vertebrae, Maitland mobilization was applied to the cervical vertebrae to significantly increase the mobility in cervical flexion and extension, as well as outward flexion and rotation.

Deep cervical muscles, such as the scalene, longuscolii, and longuscapitis, which surround the cervical vertebra and provide substantial stabilization, are vital elements of neuromuscular control in the cervical vertebra [22]. One of the methods of deep cervical muscles training is using a biofeedback stabilization unit [23]. Deep cervical flexor training focuses on correct the alignment in the neck [24]. Chiu et al. [25] reported a significant reduction in neck pain by applying deep cervical flexor training to patients who visited the hospital for neck problems. Similarly, Kang et al. [26] reported that deep cervical flexor training is an effective method for maintaining neck motion and muscular endurance.

Numerous researches have reported that the ratio of non-specific problems in the neck is higher than that have specific problems. However, there is a dearth of studies comparing the characteristics of non-specific problems and the effects of each intervention on their characteristics. Therefore, in this study, non-specific neck pain subjects were accurately selected through comparison between normal adults and adults with non-specific neck pain, and how joint mobilization techniques and deep cervical flexor training affect muscle tone and pain in the subjects.

2. Method

2.1. Study Design

This study was approved by the Bioethics Committee of Kyungwoon University (KW-2020-A-17) and proceeded according to the procedure. In this study, Program G-power 3.1.9.2 was used to determine the appropriate number of subjects in the neck dysfunction group. Based on the power analysis presented by Cohen, we calculated an effect size of 0.5, a significance level of 0.05, and a power of 80% to calculate 10 subjects for each group according to the intervention [27]. In this study, the Korean version of the Neck Disability Index(NDI), which has been verified for reliability and validity, was used to classify normal people and non-specific neck pain [28].

2.2. Participants

The subjects of this study were 60 adults residing in Daegu Metropolitan City and Gumi-si, Gyeongsangbuk-do, and asked to fill out the K-NDI, and then set the mild disability score of 5 to 14 points as participants with non-specific neck pain. The final participants were 30 [27]. The general characteristics of the study subjects are shown in Table 1. Subject selection criteria were those who did not have other orthopedic diseases that could affect the experiment, those who did not take drugs that could affect the experiment, and those who had not been diagnosed with a disease in the neck area or had no experience in receiving surgical treatment. A person who does not have human, mental, or cognitive problems and can communicate was selected. If the subject complains of pain or extreme fatigue during the experiment, the study was immediately stopped and the subject was asked to take a break.

2.3. Intervention

2.3.1. Mobilization

In this study, Maitland's PA mobilization was used. The subject was asked to lie down on the bed, and a towel was placed on the forehead and the bed and the forehead overlapped. The examiner had limited movement on the head side of the bed. Mobilization was applied from the back to the front using the thumbs of both hands, holding the spinous process in the area where it was judged to have been confirmed or the subject felt pain. It was applied for 30 seconds at the intensity of grade III, which is a large amplitude up to the range, and the rest time was set to 30 seconds, and it was applied 10 times twice a week for 4 weeks [29].

Table 1. General Characteristic of Participants

	NG(n=30)	NPG(n=30)	MG(n=10)	DC(n=10)	CG(n=10)
Age(year)	25.1±6.86a	23.23±2.84	23.8±3.82	21.8±1.03	24.1±3.67
Height(cm)	170.06±8.84	167.1=81±7.43	167.54±6.1	169±5.82	166.9±10.38
Weight(Kg)	66.8±11.16	67.77±14.32	66.10±16.52	69.28±9.19	67.9.2±17.26

[a]mean±standard deviation

NG: Normal group

MG: Neck pain group

MG: Mobilization group

DG: Deep cervical flexor training group

CG: Combined group

2.3.2. Deep Cervical Flexor Training

In this study, deep cervical flexor training was performed using an air-filled with the digital pressure biofeedback unit. After asking the subjects to lie down, the device was placed between the participant's nape and the occipital condyle, digital pressure biofeedback. The manometer of the device was set at 20 mmHg, and participants were asked to nod lightly as if their chin was touching the sternum. The final stage was finished at 30 mmHg, and the pressure was increased by 2 mmHg at each stage. The final stage was reached. 1 set was considered complete, and the rest time was 5 seconds per training session, and 30 seconds per set. The total training time was less than 10 minutes, and the experiment was conducted twice for 4 weeks, with 10 seconds per training session for a total of 3 times a day. Sets were performed [30,31].

2.4. Equipment and Measurement

2.4.1. Muscle Tone

In this study, Myoton (Myoton®PRO, MyotonAS, Estonia) was used to measure the change in the tone of the subject's muscles around the neck. In previous studies, the validity of this device was verified through a high correlation comparison with the established diagnostic method for quantifying muscle tone such as intra-rater reliability ICC 0.99 in the upper trapezius muscle, electromyography.

(EMG) and intramuscular pressure. This device is capable of non-invasive measurement, and the probe attached to the device is placed vertically on the skin, and the measured value is recorded numerically by pressing it momentarily for 15msec with a force of 0.4N. The value of the frequency displayed through the equipment was used, and the frequency means muscle tone [32]. Using this device, in a sitting position, examines the trapezius by placing the probe on the line passing from the cervical triangle in front of the upper trapezius to the acromion and the spinous. The sternocleidomastoid was examined by making a point between the anterior surface stop of the sternum and the apex of the temporal bone [33]. The levator scapulae was measured at the point where the muscle belly of the muscle around the transverse process of the lower cervical vertebra appeared thickest in the quadrupedal device posture [34]. For accurate data, the frequency value was measured three times and the average value was used. A 10-minute break was given between measurements.

2.4.2. Neck Disability Index

In this study, a Korean-translated NDI was used to classify healthy adults and adults with non-specific neck pain. The pre-translational NDI has an ICC.93 reliability rating. The questionnaire was translated into Korean by a previous study and cultural application and the response point setting was completed, and it was verified through a message that there were no errors to the original author of the questionnaire. For the interpretation of the questionnaire, for a total of 10 questions, the sum of the total score was 0 to 4, no impairment, and 5 to 14, slight impairment, 15-24 were interpreted as moderate disability, 25-34 severe disability, and a score of 35 or higher was interpreted as a complete disability. In this study, subjects with a score of 5 or higher were considered adults with non-specific neck impairment [27].

2.5. Data Analysis

In this study, statistical processing was performed using SPSS 20.0 for window to confirm the characteristics of non-specific neck pain and to analyze the effects of mobilization and deep cervical flexor training on neck pain. In the homogeneity test, an independent sample t-test was performed for age, height, and weight, which are continuous data. The results of the obtained experimental data were described as Mean±Standard deviation. An independent sample t-test was used to compare the normal group and the neck pain group to characterize non-specific neck pain, and to compare the effects before and after the intervention within the neck pain group, paired t-test was performed. Normality was tested before the intervention between the mobilization group, the deep cervical flexor training group, and the mixed group. One-way ANOVA was performed, and Fisher's least significant difference (LSD) was used as a post hoc test for interactions. The statistical significance level (α) was set to 0.05.

3. Result

3.1. Comparison between Groups According to Normal Group and Neck Pain Group

The results of measurement of muscle tone between groups according to the normal group and the pain group are as follows (Table 2). In the group comparison between the normal group and the neck pain group, in the right sternocleidomastoid, the normal group was 12.89±.85, the neck pain group was 13.58±.92 and in the left sternocleidomastoid, the normal group was 12.58±.48, the neck pain group was 13.63±1.5. As a result, the normal group showed significantly lower muscle tone ($p<0.05$), and there was no significant difference between the groups in the bilateral upper trapezius and levator scapulae muscles ($p>0.05$).

The pain measurement results between the groups according to the normal group and the neck pain group are as follows (Table 2). As a result of the pain measurement, the normal group showed 1.23±.68 and the neck pain group 3.83±1.26, indicating significantly less pain in the normal group ($p<0.05$).

Table 2. Comparison of the results of muscle tone and pain measurement between normal group and neck pain group on each group(Unit: Hz, score)

	NG	NPG	t	*p*
Rt. UTZ	18.12±2.13	17.64±1.92	.92	.36
LT. UTZ	17.56±1.16	17.94±1.58	-1.08	.28
Rt. SCM	12.89±.85	13.58±.92	-3.02	.00*
Lt. SCM	12.58±.48	13.63±1.5	-3.66	.00*
Rt. LEV	18.28±1.91	17.84±1.78	.92	.36
LT. LEV	17.79±1.32	18.19±1.6	-1.14	.26
Pain	1.23±.68	3.83±1.26	-9.94	.00*

[a]mean±standard deviation

*p<.05

NG: Normal group

NPG: Neck pain group

UTZ: upper trapezius

SCM: sternocleidomastoid

LEV: levator scapulae

3.2. Comparison of Muscle Tone between Groups According to Intervention

One-way ANOVA showed a significant difference in all muscles between interventions ($p<0.05$). As a result of the post-hoc analysis, as a result of measuring the tone of the right upper trapezius and both sternocleidomastoid, levator scapulae muscle according to intervention, there was a significant difference between the mobilization group (EGI), the deep neck flexor training group (EGII), and the mixed group (MG) ($p<.05$) (Table 3).

Table 3. Comparison of the results of muscle tone(unit: Hz)

		Muscle tone	*F*	*p*
Rt UTZ	EGI	.33±3.23[abd]	8.59	.00*
	EGII	-1.72±1.12[b]		
	MG	-1.44±.76[d]		
Lt UTZ	EGI	-.78±1.33[d]	3.76	.04*
	EGII	-.99±.90[c]		
	MG	-1.57±.80[cd]		
Rt SCM	EGI	-.03±.39[bd]	4.10	.03*
	EGII	-.55±.49[b]		
	MG	-.30±.33[d]		
Lt SCM	EGI	-.65±2.04[bd]	4.43	.02*
	EGII	-.73±1.08[b]		
	MG	-.31±.31[d]		
Rt LEV	EGI	.38±2.43[bd]	9.48	.00*
	EGII	-1.25±1.50[b]		
	MG	-1.08±1.07[d]		
Lt LEV	EGI	-.32±.91[bd]	5.13	.01*
	EGII	-.70±1.55[b]		
	MG	-.74±.75[d]		

[a]mean±standard deviation

p<.05

UTZ: Upper trapezius

SCM: Sternocleidomastoid

LEV: Levator scapulae

EG I: Mobilization group

EG II: Deep cervical flexor training group

MG: Mixed group

[b]: There is a significant difference between EGI and EGII

[c]: There is a significant difference between EGII and MG

[d]: There is a significant difference between MG and EGI

3.3. Comparison of Pain between Groups According to Intervention

As a result of the significance test between each group through one-way ANOVA, there was no significant difference (p<.05) (Table 4).

Table 4. Comparison of the results of pain (unit: Score)

	Pain	*F*	*p*
EGI	1.9±.74[a]		
EGII	1.7±.48	.37	.69
MG	2.0±1.05		

[a]mean±standard deviation

p<.05

EGⅠ: Mobilization group

EGⅡ: Deep cervical flexor training group

MG: Mixed group

4. Discussion

In modern society, instances of working from home or spending time working in front of a computer are increasing due to the augmentation of individual roles and the development of technology [35]. The long-term maintenance of fixed posture and abnormal movement has a tremendous impact on personal health [36]. Abnormal alignment and movement cause problems in the neck and spine alignment, along with symptoms such as limited range of motion and increased muscle tone and pain [37]. The causes of pain include specific and non-specific causes of neck trauma [11], especially non-specific causes of pain in the neck [38]. It is worth emphasizing that further studies are needed in this area.

In this study, muscle tone and pain were compared between normal adults and adults with non-specific neck pain to clearly select patients by confirming the difference between normal people and adults with non-specific neck pain. In comparison results, significant differences were found in the tone and pain of the sternocleidomastoid. According to a previous study on the characteristics of normal adults and adults with non-specific neck pain, the use of sternocleidomastoid was at its peak when performing cervical rotation in adults with neck pain [39]. Moreover, the percentage of use of the sternocleidomastoid was significantly higher in normal adults based on a measurement of the percentage of muscle use during neck rotation in five movements, such as the forward head posture and the quadrupedal machine posture, which were artificially taken [40]. In addition, as a result of measuring muscle activity and fatigue at one-hour intervals after three hours of computer use in normal adults and adults with neck pain, it was reported that stiffness and muscle fatigue were the most severe in the sternocleidomastoid of the neck of adults with neck pain [41]. Therefore, the reason for the significant difference in the tone and pain in this study is thought to be the tone in the sternocleidomastoid, which is the working muscle. It increased due to rotation, as it is the most used during neck movement. Therefore, pain occurred. It is posited that the characteristics of the neck can serve as a preemptive step to prevent non-specific neck pain.

In this study, the alteration in the tone of the upper trapezius based on the four-week intervention was significant before and after the experiment in the neck flexor training group (EGII) and the mixed group (MG), where the tone in both upper trapezius muscles was deep compared with the muscle tone within the group. Thereafter, a decrease in comparison of the right upper trapezius muscle between groups was observed. The deep neck flexor training group (EGII) and the mixed group (MG) showed a significant difference in the decrease in tone compared to the joint mobilization group (EGI). In the left upper trapezius muscle MG, the mixed group (EGII) showed a significant decrease in tone compared to the joint mobilization group (EGI).

Kang. [26] reported that six weeks of deep neck flexor training increased the muscle endurance of the upper trapezius, while Borisut et al. [42] reported that deep neck flexor training had a beneficial effect on pain of the upper trapezius, and sternocleidomastoid.

In this study, in comparing the tone of the sternocleidomastoid muscle before and after the experiment within the group following the four-week intervention, the right sternocleidomastoid muscle tone showed a significant decrease before and after the experiment in the neck flexor training group (EGII) and the mixed group (MG), which had deep tone. The mixed group (MG) showed a significant decrease in tone before and after the experiment in the left sternocleidomastoid. In the comparison of the right sternocleidomastoid between groups, the deep neck flexor training group (EGII) showed a significant difference in tone reduction compared to the mobilization group (EGI), while in the left sternocleidomastoid, the deep neck flexor training group (EGII) and the mixed group (MG) showed a significant difference in tone reduction compared to the mobilization group (EGI). Decreased activity of the sternocleidomastoid muscle weakens the deep neck flexors, which interferes with maintaining neck alignment [43]. Saleh et al. [44] reported that deep cervical flexor exercise had a favorable effect on neck pain, dizziness, muscle strength, proprioception. Meanwhile, Lee Myung-hyo et al. [45] reported that deep neck flexor exercise for teenagers with neck pain had a significant effect on cervical alignment, NDI, and pain reduction.

In this study, the change in levator scapulae tone following the four-week intervention showed a significant decrease in the deep cervical flexor training group (EGII) and the mixed group (MG) in the left levator scapulae muscle. In the comparison of both levator scapulae between the groups, the deep cervical flexor training group (EGII) and the mixed group (MG) showed a significant difference in tone between the mobilization group (EGI). Janda. [46] stated that upper cross syndrome includes tone in the levator scapulae. Previous studies on the effects of cervical stabilization training on adults with non-specific neck pain have reported that cervical stabilization training in adults with non-specific neck pain has a good effect on levator scapulae tone, stiffness, elasticity, and tenderness threshold [47,48].

In a previous study that reported the effect of deep neck flexor training on muscle tone around the neck, the results of applying deep neck flexor training using a pressure feedback device to patients with headaches due to neck pain showed that the suboccipital and upper trapezius was relieved. It has been reported that it helps in effectively managing neck pain by lowering the muscle tone of the muscles around the neck and increasing the muscle activity of the sternocleidomastoid [49]. Deep cervical flexor training has been applied in the treatment of chronic stroke patients, and there is a report that it increases muscle thickness and lung capacity around the neck [50]. Yang and Da. [51] reported that deep cervical flexor training was effective in decreasing muscle fatigue and muscle tone in both upper trapezius and sternocleidomastoid muscles, while Cho He-young [52] reported that deep cervical flexor training applied to chronic neck pain had a significant effect on increasing maximum muscle strength and cross-section. This muscle tone reduction effects are believed to be due to increased neuromuscular efficiency in that muscles directly connected to the neck through active deep cervical flexor training [53].

In this study, the four-week intervention showed significant differences before and after in terms of neck pain in the group. There was no significant difference between the groups. Numerous studies showing changes in neck pain due to neck intervention have been reported [54,55]. The results of this study are consistent with the results of previous studies [56]. Reported that mobilization applied to the neck had an advantageous effect on neck pain, static and dynamic balance, and range of motion, while Falla [53] reported that deep cervical flexor training was effective in reducing neck pain and increasing muscle strength and muscle activity. Considering the results of previous research and those obtained from the current study, it is postulated that appropriate deep cervical flexor training can be performed in adults with neck pain to induce a reduction in pain. In addition, the application of deep cervical flexor training is believed to strengthen deep-layer muscles and increase the activity of shallow-layer muscles in individuals with neck pain and stimulated mechanical receptors, such as Golgi tendon organs and muscle spindle [57].

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