Journal of The Korean Society of Integrative Medicine, 2022, 10(3), 13∼25
https://doi.org/10.15268/ksim.2022.10.3.013
ISSN 2288-1174(Print)
ISSN 2383-9651(Online)

Effects of Combined Cervical Stabilization and Stretching Exercises on Craniovertebral Angle, Respiration, Disability, and Range of Motion in Office Workers with Forward Head Posture : A Randomized Control Trial

Kyung Kim, PT, Ph.D[1] · Na-Yeon Kang, PT, MS[2‡]

[1]*Dept. of Physical Therapy, Daegu University, College of Rehabilitation Science, Professor*
[2‡]*Dept. of Physical Therapy, Daegu University, College of Rehabilitation Science, Ph.D-Student*

Abstract

Purpose : The purpose of this study was to investigate the effects of combined cervical stabilization exercise (CSE) and stretching exercise (SE) on office workers with forward head posture (FHP).

Methods : A total of 32 office workers with forward head posture were randomly assigned to experimental (n=16) and control (n=16) groups. The experimental group underwent combined CSE and SE, and the control group underwent cervical self-myofascial release and SE. Both groups performed exercises for 40 min per day, thrice per week for a total of 6 weeks. Craniovertebral angle (CVA), respiration, disability, and joint range of motion (ROM) before and 6 weeks after intervention were measured and compared.

Results : There was no significant between-group difference in the general characteristics ($p>.05$). The intra-group comparison showed significant differences in the visual analog scale (VAS) and neck disability index (NDI) of both groups post-intervention ($p<.05$). CVA and forced expiratory volume in 1 seconds (FEV_1) were significantly improved post-intervention in the experimental group only ($p<.05$). In the experimental group, all ROM variables were significantly improved post-intervention. In contrast, in the control group, all ROM variables improved significantly post-intervention, except for extension ($p<.05$). The inter-group comparison showed significant differences in NDI, left lateral flexion, right lateral flexion, and left rotation between the two groups ($p<.05$).

Conclusion : The combination of CSE and SE, which stabilizes the cervical spine, had positive effects on cranial rotation angle, respiration, disability, and joint ROM in office workers with forward head posture. Therefore, the combination of the two exercises may be an effective option to reduce symptoms and prevent postural problems in office workers with FHP.

Key Words : forward head posture, respiration, stabilization exercise, stretching exercise

‡Corresponding author : Na-Yeon Kang, skdussla123@naver.com

Received : June 6, 2022 | Revised : July 17, 2022 | Accepted : July 29, 2022

Ⅰ. Introduction

Neck pain is observed in approximately 10~21 % of individuals annually, and the overall prevalence of neck pain in the general population is as high as 86 % (Genebra et al., 2017). Neck pain or dysfunction is a musculoskeletal system disorder caused by incorrect posture and leads to physical disability and functional limitation (Iqbal et al., 2013). When the cervical vertebrae muscle imbalance due to incorrect posture is prolonged, excessive loads are applied to the joints and muscles, and the problem that causes the forward head posture (FHP) becomes chronic (Lee et al., 2015). In the information society, the occurrence of FHP is increasing as the time spent using smartphones and computers increases (Lee et al., 2015). FHP is also caused by carrying a heavy backpack, sitting in front of a computer screen for a long time without using a desk and chair properly for physique, and not exercising (Lee et al., 2013).

FHP-induced changes in cervical alignment exaggerate the extension of the upper cervical vertebrae (C1–C2) and flexion of the lower cervical vertebrae (C3–C7) in the sagittal plane, increasing the load on the cervical discs and joints (Patwardhan et al., 2015). As FHP becomes severe, the damage to the cervical range of motion (CROM), especially in the rotation and flexion of the neck, is increased (Quek et al., 2013). In FHP, the deep cervical flexor (DCF), which plays an important role in the stability of the cervical vertebra, is weakened and elongated, resulting in lower cervical flexion, and the upper trapezius, suboccipital, semispinalis, splenius, sternocleidomastoid, and levator scapula muscles are shortened, resulting in hyperextension of the upper cervical vertebra (Sikka et al., 2020). Muscle imbalance due to long-term poor posture habits leads to asymmetry and functional deterioration of the musculoskeletal system (Johnson, 2015). Moreover, dysfunction of the cervical and thoracic muscles is also associated with impaired respiratory function (Dimitriadis et al., 2013). For example, incorrect posture such as FHP alters the respiratory mechanism, including diaphragmatic mobility (Melam et al., 2014), and induces limited movement of the lower ribs during inspiration (Szczygieł et al., 2015).

Various treatment and rehabilitation methods have been used to improve problems caused by neck pain and disability, including McKenzie exercises, Kinesio taping, and myofascial relaxation (Kim et al., 2018). DCF exercise of the neck is one of many ways to treat FHP. This exercise reduces neck pain and improves functional impairment and neutral upright position (Iqbal et al., 2013; Iqbal et al., 2021; Nezamuddin et al., 2013a; Nezamuddin et al., 2013b). DCF plays a key role in supporting the cervical vertebrae and maintaining the correct posture (Gupta et al., 2013). The proper use of DCF exercises prior to strengthening the overall cervical muscles is recommended as an effective rehabilitation for cervical spine dysfunction (Iqbal et al., 2013). Previous studies suggested that using a stabilizer pressure biofeedback device for improving FHP is a more effective way to strengthen the DCF than conventional exercise (Giggins et al., 2013). In addition, it was reported that stretching exercises (SE) are effective in increasing muscle length and range of motion, and are effective in reducing FHP by changing the muscle tension involved in FHP (Cho & Choi, 2018; Park et al., 2017; Gillani et al., 2020).

Although studies have actively investigated the effects of various treatments to improve pain, functional impairment, and incorrect posture induced by FHP, there is a lack of studies on the effects of improved neck stability and mobility on respiration. Therefore, the purpose of this study was to investigate the effects of a combination of cervical stabilization exercises (CSE) and SE on the Craniovertebral angle (CVA), respiration, neck disability index (NDI), and cervical ROM in office workers with FHP. Most previous studies have compared the effects of stability exercise and SE. Herein, this study aimed to assess the effects of combined stabilization and SE. We hypothesized that the combination of CSE and SE would be effective in improving the CVA, respiration, NDI, and cervical ROM in patients with FHP.

Ⅱ. Methods

1. Participants

The participants of this study were office workers with FHP between the age of 20 and 60 years who worked at two elementary schools located in Ulsan. The participants understood the purpose of this study and the experimental procedure after hearing explanations, voluntarily obtained written consent to participate. G*power version 3.1.9.4 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) was used to determine the appropriate number of participants. A previous study of the same study design that compared the effects of isometric exercise for cervical extensor muscles used an effect size of .91 for pain (Alpayci & Ilter, 2017). The same effect size was used in this study. The Cohen's d formula was used for the effect size corresponding to the detected effect for the comparison between the experimental group and the control group within and between groups (Lakens, 2013). The .2 of effect size d represents a small, .5 a medium, and .8 a large effect size. The sample size was calculated using an effect size d of .91, 80 % of power (1-β error probability), and .05 of significance level. Therefore, a total of 32 participants were needed to be included in this study through a one-tailed test. The selection criteria for participants were those with FHP who had a neck pain (visual analog scale; VAS) score of $\geq$4 points. FHP was evaluated by photogrammetry and defined when the external auditory meatus was more than 2.5 cm away from the centerline of the scapula acromion (Salahzadeh et al., 2014) or the CVA was less than 53 ° (Lee et al., 2014). Those who had congenital or acquired orthopedic diseases, a history of cervical and thoracic surgery, and neurological symptoms similar to compression of the cervical nerve root were excluded (Cho et al., 2017). This study was approved by the Institutional Review Board of Daegu University and conducted in accordance with the Declaration of Helsinki (approval number: 1040621-201801-HR-009-02).

2. Procedure

All participants underwent a physical examination, and their demographic data were collected. Using the sealed envelope method, participants drew cards on which group names were written and were randomly assigned into either the experimental (n=16) or control group (n=16). The experimental group performed CSE and SE, and the control group performed cervical self-myofascial release exercise (CSRE) and stretching exercise (SE) by using massage balls. Both groups performed exercises for 40 min per day, thrice per week for a total of six weeks. The CVA, respiratory pressure, respiratory function, VAS, NDI, and CROM measurement at pre- and post-intervention were compared and analyzed. All the interventions were supervised and managed by a single physiotherapist with more than 5 years of clinical experience in musculoskeletal physical therapy.

3. Cervical Stabilization Exercises and Stretching Exercises

In this study CSE (Jull et al., 2009) and SE (Ruivo et al., 2017), which were described in previous studies, were modified and supplemented.

CSE consisted of DCF exercise performed using a stabilizer pressure biofeedback device (Chattanooga Group Inc, Hixson, USA). The participants were in a supine position facing the ceiling with their knees bent, and the stabilizer pressure biofeedback device was placed under the head. After pulling in the chin to press the stabilizer pressure biofeedback device, the participants checked the pressure level on the instrument board to maintain the target pressure for 10 seconds and rest for 5 seconds. The target level was defined as the level that the participants could hold steady for 5 seconds without contracting or using the superficial neck flexors. Two sets of ten repetitions were performed, and a one-min break was provided between each set (Fig 1). SE consisted of six movements that stretch the muscles around the cervical spine and shoulder joint. Each movement lasted for 20 seconds, followed by 5 s of rest. SE were performed for both left and right sides. One set consisted of the six stretching movements, and eight sets were performed per day (Fig 2).

Fig 1. Cervical stabilization exercise

Fig 2. Stretching exercise program

4. Cervical self-myofascial release exercise and stretching exercise

In this study CSRE (Kim et al., 2016) and SE (Choi & Choi, 2016), which were described in previous studies, were modified and supplemented.

CSRE is a cervical myofascial release exercise, and the exercises were performed using massage balls and fingertips. The participants used two durable therapeutic rubber balls that were connected to each other. The balls were 6.35 ㎝ in diameter and were made of silicone. The purpose of CSRE and the instructions on how to precisely perform the exercise were explained to the participants by using the balls an hour before the first exercise session. Thereafter, the participants performed the exercise on the precise regions of the trapezius, sternocleidomastoid, subclavius, and suboccipital muscle for 2 minutes by using the force of gravity alone while in a supine position with the knees bent. One set of CSRE consisted of five repetitions, and participants performed two sets with a one-min break between sets. SE was composed of seven movements involving the stretching of the muscles around the neck. Each movement lasted for 20 seconds, followed by 5 seconds of rest. SE were performed for both left and right sides. One set consisted of the seven stretching movements, and participants performed six sets per day.

5. Outcome measures

Outcome measures were recorded by classifying CVA, respiratory pressure (PImax) and respiratory function in the primary outcome, VAS and NDI in the secondary outcome, and CROM in the tertiary outcome in the order of measurement.

The primary outcomes of this study were CVA, respiratory pressure, and respiratory function. To measure the CVA, a photo was taken with a digital camera, and the angle was measured using Photoshop CS2 (Diab & Moustafa, 2012). The digital camera was installed 104 inches way from the participant and 33 inches above the floor. The participants were standing upright with both arms comfortably placed at the sides of their bodies. The participants held their heads up and looked straight at their eyes in the mirror in front of them. After repeating the connecting motion of maximally flexing and extending the neck three times, the motion was paused at the most comfortable position to obtain images. The CVA is the angle between the horizontal line of the seventh cervical vertebra and the line connecting the seventh cervical vertebra to the tragus. Imaging was performed three times, and the mean value was used. In a previous study, CVA measures had high reliability (Kim & Kim, 2016).

The inspiratory pressure test was performed in a sitting position using a Micro RPM respiratory pressure meter (Care Fusion, Basingstoke, UK). The MIP and maximum expiratory pressure (MEP) were measured (Fig 3). Before measuring, the participants were trained to become familiar with the test method. The mean value of three measurements was used for the analysis. The inspiratory function test was performed using a Cardiotouch3000 electrocardiogram (Bionet, Seoul, Korea). Forced vital capacity (FVC), forced expiratory volume in 1 seconds (FEV_1), and FEV_1/FVC were measured (Fig 4). The participants were seated on a chair in an upright posture with a nose plug. The participants inhaled at the mouthpiece connected to the sensor of the measuring device. The participants breathed normally three times. When a notification sound was heard from the measuring device, the participants inhaled to the maximum and exhaled at the maximum intensity and quantity for more than 6 seconds. The mean value of three measurements was used for the analysis.

The secondary outcomes of this study were VAS and NDI. The subjective severity of neck pain was measured using the VAS. The VAS is a reliable method with an inter-rater correlation coefficient (ICC) of .96~.98 (Rasmussen et al., 2020). A test strip with a 10 ㎝ horizontal line was used to indicate the level of pain: 0 on the far left indicated no pain, and 10 on the far right indicated extreme pain. To prevent possible bias of the participants, numbers were not marked on the line. Instead, a ruler was used to measure the distance from the starting point to the point marked by the participants. NDI was used to assess the level of functional limitation in daily life due to neck pain. The NDI consisted of 10 items on pain severity, personal care, lifting heavy objects, reading, headache, concentrating, working, driving, sleeping, and leisure activities. Each item was evaluated on a five-point scale, and the maximum total score for the NDI was 50 points. The total score was the sum of the scores of all items, and a higher total score indicated a more severe neck disorder. The NDI is a widely used and reliable method with an ICC of .98 (Ludvigsson et al., 2015).

The tertiary outcomes of this study were CROM using a tape measure (Clarkson, 2000). To measure CROM, participants were seated in a chair, and the cervical and thoracic regions of their spine were supported against the back of the chair. Instead of being restrained in position by the researcher, the participants were shown how to fix the shoulder girdle themselves to prevent the cervical and thoracic regions of the spine from moving while the CROM was measured. CROM was measured twice, and the average of two measurements was used in the analysis. In neck flexion–extension, participants flexed and extended the neck until they could move the neck without straining. During flexion, the distance between the chin and upper sternal notch was measured. Participants were allowed to touch the chest with the chin. When the chin did not touch the chest, a reduction in ROM was the assessment (i.e., limited ROM). During extension, the distance between the same areas as those indicated above was measured in the anatomical position and with the neck extended such that the measurement value indicated the ROM during neck extension. In neck lateral flexion, participants flexed the neck laterally without rotating it until they could move without straining the neck. The distance between the mastoid process of the skull and the acromion process of the scapula was measured. The measurement was performed in the anatomical position and with the neck laterally flexed without straining. Participants were not allowed to raise the shoulder girdle toward the ears. In neck rotation, participants rotated the head while neither flexing nor extending the neck until they could move the head without straining. The distance between the bottom end of the chin and the acromion process of the scapula was measured in the anatomical position and when the participants could move their head without straining. The participants were not allowed to raise the scapular toward the chin or push it forward.

Fig 3. Respiratory pressure measuring instrument (MicroRPM)

Fig 4. Lung capacity measuring instrument (Cardiotouch 3000)

6. Statistical analysis

Statistical analysis was performed using the IBM SPSS for Windows version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were presented in mean±standard deviation (SD), median (min-max) or number and frequency, where applicable. A normality test was performed using the Shapiro-Wilk test. For homogeneity test of the experimental and control groups, independent sample t-test and chi-square test were conducted. Matching sample t-test was used to compare pre- and post-intervention results of measurement within the two groups. An independent t-test was used to confirm the curative effect between the two groups. A p value of $<.05$ was considered statistically significant. In order to confirm the therapeutic effect between the experimental group and the control group, an independent t-test was performed.

Ⅲ. Results

1. Participants' general characteristics

A total of 32 participants were assigned to the experimental group (CSE and SE) and the control group (CSRE and SE) (n=16 for each group). There was no significant between-group difference in the general characteristics ($p>.05$)(Table 1).

2. Inter-group and intra-group comparisons between primary outcomes

Table 2 shows the comparison of the primary outcomes between the experimental and control groups. CVA changed significantly post-intervention only in the experimental group ($p<.05$) and showed a large effect size (d=.81). There were no significant differences in the primary outcomes between the two groups post-intervention ($p>.05$). MIP,

Table 1. General characteristics of participants (Mean±SD)

	EG (n=16)	CG (n=16)	*p*
Gender (male, %)	7 (43.7)	7 (43.7)	1.000 †
Age (years)	35.75 ± 8.00	35.38 ± 12.47	.920 ‡
Height (㎝)	168.63 ± 9.59	167.88 ± 9.03	.821 ‡
Weight (㎏)	64.38 ± 11.11	65.69 ± 13.26	.764 ‡
BMI (㎏/㎡)	22.48 ± 2.19	23.08 ± 2.63	.508 ‡

EG; experimental group (cervical stabilization exercises and stretching exercises), CG; control group(cervical self-myofascial release exercise and stretching exercise), † Chi-square test, ‡Independent t-test

MEP, and FVC were not significantly changed post-intervention in both groups and were not significantly different post-intervention between the two groups (p>.05). FEV_1 changed significantly post-intervention only in the experimental group (p<.05) and showed a large effect size (d=.74). FEV_1 was not significantly different post-intervention between the two groups (p>.05). FEV_1/FVC was not significantly different in both intra- and inter-group comparisons (p>.05).

Table 2. Comparison of primary outcomes according to within-group and between-group (Mean±SD)

Measure	Within-group								Between-group	
	EG (n=16)				CG (n=16)					
	Pre	Post	MD	*p* (*d*)	Pre	Post	MD	*p* (*d*)	t	*p* (*d*)
CVA	49.99±1.21	52.21±2.69	2.22±2.76	.006 (.81)	50.34±1.74	50.75±2.61	.41±2.13	.450	2.00	.055
MIP	68.77±23.45	73.98±22.55	5.21±12.29	.111	69.10±19.10	71.07±18.05	1.97±5.99	.207	.95	.351
MEP	84.21±27.40	85.90±3.70	1.69±12.27	.588	82.91±22.35	83.91±23.72	1.00±3.64	.289	.21	.840
FVC	2.68±1.09	2.84±1.13	.16±.57	.281	3.11±.99	3.20±.90	.09±.29	.224	.44	.660
FEV_1	1.97±1.00	2.28±.95	.31±.41	.009 (.74)	2.37±1.02	2.49±.91	.12±.37	.214	1.35	.186
FEV_1/FVC	73.02±17.85	79.26±10.60	6.23±14.86	.114	76.34±24.02	77.76±18.57	1.42±11.71	.635	-1.02	.317

EG; experimental group (cervical stabilization exercises and stretching exercises), CG; control group (cervical self-myofascial release exercise and stretching exercise), CVA; Craniovertebral Angle, MIP; Maximum inspiratory pressure, MEP; Maximum expiratory pressure, FVC; Forced Vital Capacity, FEV_1; Forced Expiratory Volume at one second, MD; Mean Differences, d; effect size d

3. Inter-group and intra-group comparisons between secondary outcomes

A comparison of the secondary outcomes of the experimental and control groups is shown in Table 3. VAS scores changed significantly post-intervention in both the groups (p<.05) and showed a large effect size (d=2.37 and 4.25, respectively). There was no significant difference in VAS scores post-intervention between the two groups (p>.05). NDI also changed significantly post-intervention in both the groups (p<.05) and showed a large effect size (d=2.92 and 2.58, respectively). In inter-group comparison, NDI was significantly different post-intervention between the two groups (p<.05) and showed a medium effect size (d=.74).

Table 3. Comparison of secondary outcomes according to within-group and between-group (Mean ± SD)

Measure	Within-group								Between-group	
	EG (n=16)				CG (n=16)					
	Pre	Post	MD	*p (d)*	Pre	Post	MD	*p (d)*	t	*p (d)*
VAS	5.00±1.27	2.06±1.44	-2.94±1.24	.000 (2.37)	5.63±1.78	2.44±1.59	-3.19±.75	.000 (4.25)	.69	.495
NDI	10.38±6.1	3.81±4.43	-6.56±2.25	.000 (2.92)	11.63±5.71	2.94±3.8	-8.69±3.36	.000 (2.58)	2.1	.044 (.74)

EG; experimental group (cervical stabilization exercises and stretching exercises), CG; control group (cervical self-myofascial release exercise and stretching exercise), VAS; Visual Angle Scale, NDI; Neck Disability Index, MD; Mean Differences, d; effect size d

4. Inter-group and intra-group comparisons between tertiary outcomes

Table 4 presents a comparison of the tertiary outcomes of the experimental and control groups. In the experimental group, all ROM variables were significantly improved post-intervention. In contrast, in the control group, all ROM variables except for extension improved significantly post-intervention ($p<.05$). ROM showed medium to large effect sizes (d=.53 to 1.02 and .59 to 1.9, respectively). In the inter-group comparison, left lateral flexion, right lateral flexion, and left rotation were significantly different between the two groups ($p<.05$) and showed large effect sizes (d=.81 to .99).

Table 4. Comparison of tertiary outcomes according to within-group and between-group (Mean±SD)

Measure	Within-group								Between-group	
	EG (n=16)				CG (n=16)					
	Pre	Post	MD	*p (d)*	Pre	Post	MD	*p (d)*	t	*p (d)*
Flexion	3.81±2.21	1.88±1.69	-1.94±1.89	.001 (1.02)	4.63±1.91	2.31±2.11	-2.31 ±2.24	.001 (1.03)	.51	.613
Extension	18.14±2.12	18.98±1.84	.84±1.54	.045 (.55)	18.17±1.67	18.47±1.75	.30 ±1.92	.546	.85	.400
Left lateral flexion	15.97±2.54	14.53±1.82	-1.44±1.61	.003 (.89)	16.41±2.33	13.38±2.19	-3.03±1.60	.000 (1.90)	.61	.009 (.99)
Right lateral flexion	15.56±2.85	14.67±2.08	-.89±1.66	.049 (.53)	15.38±1.72	12.84±1.76	-2.53±2.03	.000 (1.25)	2.50	.018 (.88)
Left rotation	13.56±1.91	12.75±2.17	-.81±1.05	.007 (.78)	14.13±2.22	11.63 ±2.28	-2.50±2.76	.002 (.91)	2.29	.034 (.81)
Right rotation	14.81±2.07	12.97±1.97	-1.84±1.89	.001 (.97)	14.50±1.80	10.53 ±6.35	-3.97±6.67	.031 (.59)	.74	.467

EG; experimental group (cervical stabilization exercises and stretching exercises), CG; control group (cervical self-myofascial release exercise and stretching exercise), MD; Mean Differences, d; effect size d

Ⅳ. Discussion

If muscle lengthening and weakness or imbalances is prolonged, it can negatively affect cervical spine mobility and decrease muscular performance, which is demonstrated by decreased strength or endurance of the deep cervical flexors (Kang, 2015). In addition, continuous muscle stress on the head and cervical vertebrae causes muscle spasms as well as local pain in the trapezius and suboccipital muscles (Jang, 2017). Prolonged static and abnormal postures, such as looking at a monitor below eye level, are well known to worsen FHP (Sun et al., 2014). FHP induces upper chest expansion and lower chest contraction (Koseki et al., 2019), and the more severe the FHP, the lower the respiratory circulation function (Lee & Chu, 2014). Therefore, this study investigated the effects of combined CSE and SE on CVA, inspiration, NDI, and joint ROM in office workers with FHP.

1. Inter-group and intra-group comparisons between primary outcomes

The CVA increased significantly post-intervention compared with pre-intervention in the experimental group only ($p<.05$, $d=.81$); however, it was not significantly different between the two groups post-intervention ($p>.05$). CSE is considered an ideal method to maintain the cervical vertebrae in a normal position by strengthening the deep DCFs, including the longus coli and longus capitis muscles (Noh et al., 2013). In a study by Heredia, relaxation of the suboccipital muscle significantly improved the head position by increasing the CVA in participants with FHP (Rizo et al., 2012). Similarly, in this study, it is thought that combined CSE and SE strengthened the muscles around the neck and aligned the cervical vertebrae to improve CVA. The increase in CVA indicates the improvement of FHP, suggesting that the combination of CSE and SE had positive effects on FHP. In agreement with our findings, Noh et al. (2013) also reported that CSE regulates FHP. Therefore, to improve neck and shoulder posture, it would be necessary to maintain cervical stability (Lee et al., 2013).

The inspiratory function test showed that FEV_1 improved significantly post-intervention only in the experimental group ($p<.05$, $d=.74$). Inspiratory variables were not significantly different between the experimental and control groups post-intervention; however, the increase in the variables tended to be higher in the experimental group. In previous studies, CSE reduced FHP to correct biomechanical changes in the cervical and thoracic spine and improve respiratory muscle strength. In turn, this led to improved thoracic and abdominal mobility and diaphragm efficacy (Pawaria et al., 2019). In addition, patients who performed cervical CSE with respiratory retraining showed greater improvement in respiratory function (Nam et al., 2015). However, although CSE had positive effects on FHP and FEV1 in this study, no significant relationship on overall respiration was observed. Dimitriadis et al. (2013) reported that FHP was a predictor of expiratory muscle weakness but not of inspiratory strength. Therefore, it is thought that the combination of CSE and SE had minor effects on respiratory muscles by improving FHP, which subsequently positively aligned the cervical vertebrae to improve respiratory function.

2. Inter-group and intra-group comparisons between secondary outcomes

In both the experimental and control groups, VAS and NDI were significantly decreased post-intervention ($p<.05$, $d=2.37$ to 2.92). PBU training and stretching helps to stretch shortened muscles and strengthen weakened ones to achieve optimal muscle length and strength to improve muscle performance (Nezamuddin et al., 2013). Therefore, this may have reduced pain, improving the VAS and NDI. In a study by Kim & Hwangbo (2019), it was reported that neck stabilization exercise using PBU not only improved neck alignment but also reduced pain by activating deep neck muscles. These findings are consistent with our results. Our findings demonstrated that the combination of CSE and SE, which are stabilization exercises, was effective in alleviating pain. In other previous studies, DCF exercise significantly reduced the pain associated with neck movements and joint palpation (Gupta et al., 2013; Iqbal et al., 2013). It has been reported that cervical stabilization exercise is effective in reducing neck pain, forward head posture, depression, and anxiety in individuals with non-specific chronic neck pain (Akodu et al., 2018).

Additionally, these exercises improved imbalanced neck muscle activation and reduced neck pain (Kang et al., 2018; Noh et al., 2013).

3. Inter-group and intra-group comparisons between tertiary outcomes

In the experimental group, all ROM variables were significantly improved post-intervention. In contrast, in the control group, all ROM variables except for extension were significantly improved post-intervention ($p<.05$, d=.53 to 1.02, .59 to 1.90). The inter-group comparison showed significant differences in left lateral flexion, right lateral flexion, and left rotation between the two groups ($p<.05$, d=.81 to .99). Abdel-aziem and Draz (2016) reported that the combination treatment of DCF exercise plus physical therapy agents is the most effective intervention for the management of neck pain, with some advantages in pain, disability, and ROM. The main action of DCFs is cervical flexion. The combination of CSE and SE reduces the contraction and tension of the DCFs through muscle stabilization, and the combination of CSRE and SE increases the flexibility of the fascia, which appears to have a positive effect on CROM. DCF exercise improved the ability of deep cervical flexors such as longus capitis and longus colli as the main stimulus for flexion movement (Suvarnnato et al., 2019), so there was no significant difference in extension in this study.

Activation of DCF is important because it regulates posture in the cervical spine region and stabilizes the spinal unit (Jun & Kim, 2013). It is suggested that DCF training using PBU promotes muscle contraction to improve muscular endurance, and that stretching exercise increases mobility of shortened muscles in subjects with FHP (Kang, 2015). Additionally, Based on the evidence from previous studies, in patients with chronic neck pain, exercise using PBU and neck stabilization exercise using sling exercise reported significant effects on neck pain and joint range of motion (Lim, 2015). Therefore, it is thought that the combination of CSE and SE applied in this study has a positive effect on pain reduction by strengthening the DCF and stabilizing the movements of the cervical spine, thereby increasing the range of motion of the cervical spine.

Several limitations must be considered in the interpretation of this study's findings. First, a relatively small number of participants were included in this study, and the participants were only office workers with specific occupations. Therefore, the findings of this study cannot be generalized to everyone. Moreover, the intervention period was relatively short at 6 weeks; therefore, we could not evaluate how long the effects lasted. Lastly, the participants had moderate FHP rather than severe FHP. As a result, the interventions did not have significant effects on the participants. Future studies must be conducted on larger groups of participants across various occupations to determine how long the effects of the intervention last.

Ⅴ. Conclusion

The combination of CSE and SE, which were stabilization exercises for the cervical spine, significantly improved CVA, respiration, disability, and joint ROM in office workers with FHP. Therefore, the combination of the two exercises may be an effective option to reduce symptoms and prevent postural problems in office workers with FHP. In particular, the method may be useful for those who cannot perform direct exercises of the cervical spine.

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