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Research Article

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Effects of a Combination of Scapular Stabilization and Thoracic Extension Exercises on Respiration, Pain, Craniovertebral Angle and Cervical Range of Motion in Elementary School Teachers with a Forward Head Posture: A Randomized Controlled Trial

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| Abstract |

PURPOSE: This study examined the effects of an exercise program for the thoracic spine and scapula rather than the neck, which is the primary site of pain.

METHODS: Thirty-two elementary school teachers with a forward head posture (FHP) were assigned randomly to either the experimental group (n = 16) or the control group (n = 16). The experimental group performed scapular stabilization exercise (SSE) and thoracic extension exercise (TEE), and the control group performed cervical self-myofascial release exercise and stretching exercise. The pulmonary functions, pain, craniovertebral angle (CVA), and cervical range of motion (CROM) were measured before the intervention and six weeks after.

RESULTS: The within-group comparisons showed that the VAS and CROM (except for extension) in both groups were significantly different before and after the intervention ($p < .05$). The changes in the maximum inspiratory pressure (MIP), maximum expiratory pressure (MEP), forced vital capacity (FVC), forced expiratory volume at 1 sec (FEV1), and CVA were significant only in the experimental group ($p < .05$). The between-group comparisons showed a significant difference in the FVC, FEV1, VAS, CVA, and left lateral flexion ($p < .05$).

CONCLUSION: The combination of SSE and TEE in the experimental group was more effective in improving the FHP and breathing ability. Moreover, the experimental group and control combination appeared to be effective in reducing pain and improving the CROM. The combination of SSE and TEE, which are exercises that do not target the cervical spine directly, was effective in improving the posture, respiration, neck pain, and CROM in elementary school teachers with FHP.

Keywords: Cervical spine, Exercise, Forward head posture, Neck pain

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Ⅰ. Introduction

Approximately 50% of the global population experiences clinically significant neck pain because of the excessive use of smartphones and electronic devices [1]. Schoolteachers may be exposed to conditions in the work environment that cause physical health problems. The common health complaints of teachers include shoulder pain (73.4%), neck pain (68.9%), headache (67.1%), and lower back pain (59.2%) [2]. Owing to the advancements in information technology have led to the increasing adoption of modern teaching methods in traditional classes, such as the use of the internet, projectors, computers, and smart classrooms [3]; therefore, teachers are spending more time with computers than before. Working on a computer for prolonged periods means that a stationary posture is maintained for an extended length of time [4]. This change can lead to poor posture that can cause neck pain. Continuous pressure on the cervical alters the spinal curve, leading to degenerative changes in the joints, a straight cervical spine, and forward head posture (FHP) [5, 6].

FHP is characterized by hyperextension of the upper cervical spine (C1–C3), flexion of the lower cervical spine (C4–C7) [7], an increase in the cranial rotation angle, and a decrease in the craniovertebral angle (CVA) [6]. A change in the curvature of the cervical spine leads to upper-crossed syndrome because of a muscle imbalance [8], resulting in a round shoulder posture (RSP). An RSP refers to the anterior displacement of the acromion process of the scapula with respect to the vertebra prominens (C7) and is characterized by a shoulder angle formed with a protracted, anteriorly tilted, and internally rotated scapula and a shortened pectoralis minor muscles [9]. In FHP and RSP, the normal relationship between the muscles and bone structure [10] is altered, causing muscle imbalance and pain in the head, chin, neck, back, shoulders, and arms [11]. In this situation, pain and the importance of the relationship between poor posture and respiratory dysfunction should be considered [12]. FHP can worsen kyphosis and inhibit the mobility of the thoracic spine, particularly regarding thoracic extension. Therefore, individuals with FHP may experience neck pain, and sinking of the ribs owing to a flexed thorax, which may limit the ability to perform exercises and negatively affect breathing [13, 14]. For example, poor posture due to FHP may physically restrict the thoracic cage from expanding [15]. In addition, breathing problems occur because the mobility of the back is reduced owing to increased tension in the sternocleidomastoid muscle, which decreases the ventilation function of the diaphragm [16].

Research on a variety of therapeutic exercises and rehabilitative interventions is being actively performed to alleviate neck pain and functional disorders and improve posture. Examples include stretching and strength training, deep cervical flexor muscle training, myofascial release, and Kinesio Taping. Some of the approaches for treating FHP focus on the neck indirectly rather than directly. The therapeutic evidence for these approaches is based on regional interdependence, which refers to the concept that pain in one body region can cause injury to another region [17, 18]. Accordingly, symptoms can be reduced by indirect treatment, i.e., by treating the region that is causing injury to another region rather than by treating the injury directly [19]. A study suggested that scapular stabilization exercise (SSE) may improve neck pain and posture by improving and correcting muscle activities and may enhance the quality of life of patients with FHP [20]. Other studies showed that the loading mechanism in the cervical spine, which is an important factor in neck pain [21], is determined by the thoracic spine [22]. Based on these findings, many studies focused on the thoracic spine in patients experiencing neck pain [23] and reported that thoracic extension exercise (TEE) was effective in improving the FHP [24].

Many studies have evaluated the cervical spine of patients with FHP. On the other hand, few studies have assessed the effect of exercises that target the thoracic spine instead of the cervical spine. Furthermore, the effect of exercises on pulmonary functions was rarely investigated. This study compared cervical spine exercises used in previous studies with thoracic spine and scapular exercises. The specific study objective was to determine the combined effects of SSE and TEE on improving breathing, neck pain, CVA, and cervical range of motion (CROM) in elementary school teachers with FHP. The authors hypothesized that the combination of SSE and TEE would effectively improve breathing, neck pain, CVA, and CROM in patients with FHP.

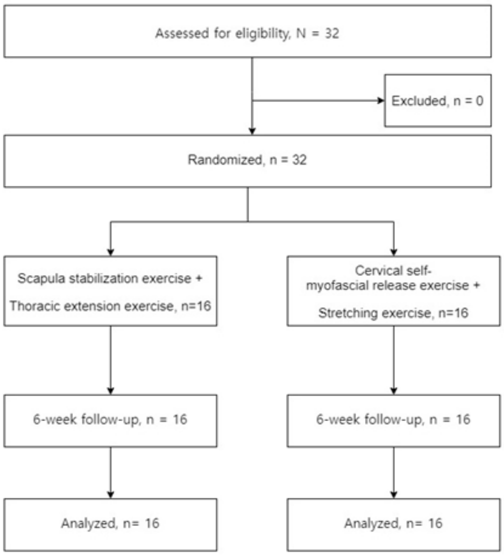

Fig. 1. Flowchart of the recruitment, randomization, and follow-up of the participants.

Ⅱ. Methods

1. Participants

This prospective, randomized-controlled study included school teachers (13 males and 19 females; mean age 36.44 ± 11.44 years; mean height 167.59 ± 8.00 cm; mean weight 64 ± 11.36 kg) with FHP aged between 20 and 60 years who were working at two elementary schools in Ulsan, the Republic of Korea between March 2018 and June 2018. Each participant heard and understood the purpose of the study and the experimental process, and provided written consent to participate. The selection criterion of the participants was FHP and a score of ≥4 for the Visual Analog Scale (VAS). A forward head posture was evaluated using photogrammetry. Participants with a centerline of external auditory meatus deviated from the centerline of scapula acromion > 2.5 cm [25] and a CVA < 53º [26] were included in this study. The exclusion criteria included serious pathological conditions, such as a tumor, whiplash injury within the past three months, congenital type of deformity, history of cervical and thoracic spine surgery, and neurological signs compatible with nerve root pressure. The study protocol was approved by the Institutional Review Board of Daegu University (1040621-201801-HR-009-02). The study was conducted in accordance with the principles of the Declaration of Helsinki.

2. Procedure

All participants underwent a physical examination, and their demographic data were collected. Using the sealed envelope method, the participants drew cards on which group numbers were written and were assigned randomly to either the experimental (n = 16) or control group (n = 16). The experimental group performed SSE and TEE, and the control group performed cervical self-myofascial release exercise (CSRE) and stretching exercise (SE) using massage balls. Both groups performed exercises for 40 min per day, three times per week for six weeks. The respiratory pressure (PImax), respiratory function, VAS, NDI (Neck Disability Index), CVA, and CROM measurements at pre- and post-intervention were compared (Fig. 1). All interventions were supervised and managed by a single physiotherapist with more than five years of clinical experience in musculoskeletal physical therapy.

1) Scapula Stabilization Exercise and Thoracic Extension Exercise

The SSE [27] and TEE [28] used in previous studies were modified and supplemented for use in this study. The SSE consisted of four exercise programs. The participants sat on their knees in the 90° flexion position, and a Swiss ball was propped up between the chest and stomach. Looking from the side, the earlobe, acromion of scapula, and pelvis made a straight line.

(1) Scapula retraction exercise: While retracting both the scapula, both arms are raised backward.

(2) Scapula mobilization exercise: With the thumbs up, both arms are raised sideways, making a straight line with the shoulders.

(3) Scapula dynamic stabilization exercise Ⅰ: One arm beside the ear is raised, and the other arm is pushed out behind the back. The same is done for the opposite side.

(4) Scapula dynamic stabilization exercise Ⅱ: Both arms are raised beside the ears and then pushed down, bending and maintaining the elbows at 90°. Both the arms are raised beside the ears again and then put down.

Each exercise was performed with two sets of 15 reps, 10 sec per rep. After four weeks, the exercise intensity was increased by adding weight with dumbbells (Fig. 2).

The TEE was comprised of three exercise programs as follows:

(1) TEE Ⅰ: The restricted thoracic spinal segment is located on a foam roller, and the patient lies on it with their knees flexed. Both hands are crossed on the chest, and the buttocks are lifted slightly from the floor. The foam roller is rolled slowly up and down the thoracic spinal segment.

(2) TEE Ⅱ: Sitting with the knees flexed, a Swiss ball is placed in front. The ball is pushed forward to a distance with both hands on it.

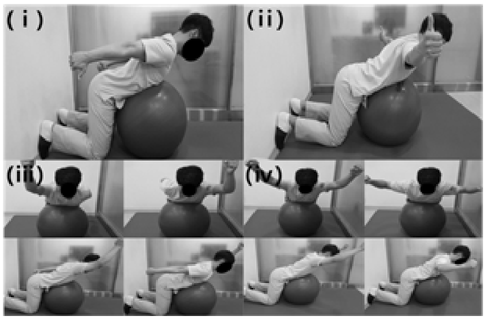

Fig. 2. Scapula stabilization exercise program.

Fig. 3. Thoracic extension exercise program.

(3) TEE Ⅲ: In the prone position, the lifting up and putting down of the upper body is repeated while supporting the body with both elbows.

Each exercise was performed with two sets of 15 reps, 10 sec per rep (Fig. 3).

2) Cervical self-myofascial release exercise and stretching exercise

The CSRE [29] and SE [30] used in previous studies were modified and supplemented to be used in this study.

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

3. Outcome measures

The primary outcome was PImax, respiratory functions, VAS, and NDI. The respiratory pressure test was performed in the sitting position using the MicroRPM (Care Fusion, Basingstoke, UK), and maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) were measured (Fig. 4). Before the measurement, several training sessions were provided so that the participants would be aware of the measurement method. The average of three measurements was calculated. In the respiratory function test, the forced vital capacity (FVC), forced expiratory volume at 1 sec (FEV1), and the ratio of FEV1/FVC were measured using the CardioTouch 3000 (Bionet, Seoul, Korea) (Fig. 4). The average of three measurements was calculated. The participants sat upright on a chair with a nose plug over their nose. In the mouthpiece connected to the sensor of the measuring device, starting from inhalation, normal breathing was performed three times. When the notification sound was heard from the measuring device, exhalation was performed three times at the maximum speed. The amount from the maximum inhalation was measured three times, and the average value was used.

The intensity of the participants' subjective neck pain was measured using the VAS. A horizontal line of 10 cm was shown to the participants, and the left side indicated a pain-free state (0). The right end was assumed to be a very severe pain state (10) to indicate the degree of pain. The numbers were not marked on the horizontal line to remove the effect of the participants' preconceived notions, and the results were measured by measuring them with a ruler up to the points marked by the participants. The intraclass correlation coefficient (ICC) of the VAS measurement for neck pain was 0.97, which is a highly reliable measurement method [31]. Using NDI, this study evaluated how restrictive everyday life is due to neck pain. The higher the total score of all questions added, the higher the neck disorder [32]. The NDI is a widely used and reliable measurement method with an ICC of 0.98 [33].

Fig. 4. Respiratory pressure measuring instrument (MicroRPM), Lung capacity measuring instrument (Cardiotouch 3000).

The CVA and CROM were measured as secondary outcomes. The CVA was assessed by taking photographs with a digital camera, and the angle was measured using Photoshop CS2 [34]. The digital camera was placed at a height of 33 inches and a distance of 104 inches away from the participant. The participants maintained a comfortable posture and stood straight with their arms on the side while looking into a mirror positioned in front of them. They were photographed in the most comfortable position after repeating continuous movements involving the maximal flexion and extension of the head three times. CVA is the angle formed by a horizontal line passing through C7 and a line connecting the tragus to the C7 spinous process [35, 36]. Each participant was photographed three times, and the average CVA value was used in the analysis. In one study, CVA was reported to have high reliability [10].

CROM, a tertiary outcome, was assessed with a tape measure [37]. The CROM was assessed with the participants seated in a chair and the cervical and thoracic regions of their spine 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. The CROM was measured twice, and the average was used in the analysis. In neck flexion–extension, the 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. The 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 the neck flexed laterally without straining. The participants were not allowed to raise the shoulder girdle toward the ears. In neck rotation, the 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.

4. Statistical analysis

Power analysis and sample size calculations were performed using the G*Power version 3.1.9.4 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). The Cohen's d formula was used for the effect size corresponding to the detected effect to compare the experimental group with the control group within and between groups. The 0.2 of effect size d of 0.2, 0.5, and 0.8 represent a small, medium, and large effect size, respectively. The sample size was calculated using an effect size d of 0.91, 80% power (1-β error probability), and 0.05 significance level. Therefore, 32 participants were needed in this study.

Statistical analysis was performed using the IBM SPSS for Windows version 22.0 software (IBM Corp., Armonk, NY, USA). The descriptive data are 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. An independent sample t-test and chi-square test were conducted as a homogeneity test of the experimental and control groups. A matching sample t-test was used to compare the pre- and post-intervention measurements within the two groups. An independent t-test was used to confirm the curative effect between the two groups. A p-value < 0.05 was considered significant. An independent t-test was performed to confirm the therapeutic effect between the experimental and control groups.

Ⅲ. Results

1. Participants' general characteristics

Thirty-two participants were assigned to either the experimental group (SSE and TEE) or 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).

Table 1. General Characteristics of the Participants (Mean ± SD)

	Experimental Group (n = 16)	Control Group (n = 16)	p
Gender (male, %)	6 (37.5)	7 (43.7)	.719†
Age (years)	37.50 ± 10.60	35.38 ± 12.47	.312‡
Height (cm)	167.31 ± 7.12	167.88 ± 9.03	.312‡
Weight (kg)	62.31 ± 9.21	65.69 ± 13.26	.089‡
BMI (kg/m^2)	22.19 ± 2.36	23.08 ± 2.63	.340‡

*P < .05

†chi-square test, ‡Independent t-test

EG: Experimental group, CG: Control group

Table 2. Comparison of the Primary Outcomes According to the Within-group and Between-group (Mean ± SD)

Measure	Within-group								Between-group	
	Experimental Group (n = 16)				Control Group (n = 16)					
	Pretest	Posttest	MD	p (d)	Pretest	Posttest	MD	p (d)	t	p(d)
MIP	69.98 ± 23.87	77.32 ± 20.62	7.34 ± 10.53	.014*(0.7)	69.10 ± 19.10	71.07 ± 18.05	1.97 ± 5.99	.207	1.77	.087
MEP	77.21 ± 23.80	83.57 ± 30.74	6.37 ± 10.85	.033*(0.6)	82.91 ± 22.35	83.91 ± 23.72	1.00 ± 3.64	.289	1.86	.073
FVC	2.72 ± .85	3.16 ± .56	.44 ± .58	.008*(0.8)	3.11 ± .99	3.20 ± .9	.09 ± .29	.224	2.20	.036*(0.8)
FEV1	1.74 ± .59	2.42 ± .63	.68 ± .59	.000*(1.2)	2.37 ± 1.02	2.49 ± .91	.12 ± .37	.214	3.20	.003*(1.1)
FEV1/ FVC	65.99 ± 17.13	76.59 ± 12.67	10.59 ± 21.31	.065	76.34 ± 24.02	77.76 ± 18.57	1.42 ± 11.71	.635	-1.51	.144
VAS	5.69 ± 1.58	1.81 ± 1.33	-3.87 ± 0.62	.000*(1.2)	5.63 ± 1.78	2.44 ± 1.59	-3.19 ± 0.75	.000*(1.2)	-2.83	.008*(1.0)
NDI	12.75 ± 7.44	5.06 ± 6.48	-7.68 ± 1.99	.000*(1.1)	11.63 ± 5.71	2.94 ± 3.80	-8.69 ± 3.36	.000*(1.1)	1.02	.316

*p < .05, d: effect size d

MIP: Maximum inspiratory pressure, MEP: Maximum expiratory pressure, FVC: Forced Vital Capacity, FEV1: Forced Expiratory Volume at one second, VAS: Visual Angle Scale, NDI: Neck Disability Index, MD: Mean Differences

1) Comparison of primary outcomes according to within- and between-group differences

Table 2 lists the primary outcomes in the experimental and control groups. Regarding the MIP, MEP, FVC, and FEV1, the within-group differences were significant only in the experimental group ($p < .05$) and showed moderate-to-large effect sizes ($d = .6$ to 1.2). The between-group difference was significant in the FVC and FEV1 ($p < .05$) with large effect sizes ($d = .8$ to 1.1). FEV1/FVC was not significant in either the within- or between-group comparisons ($p > .05$). The VAS showed significant within-group differences in both groups ($p < .05$) and large effect sizes ($d = 1.2$, 1.2). The between-group difference was also significant ($p < .05$) and showed a large effect size ($d = 1.0$). Regarding the NDI, the within-group difference was significant in both groups ($p < .05$) and had large effect sizes ($d = 1.1$, 1.1). On the other hand, the between-group difference was not significant ($p > .05$).

2) Comparison of secondary outcomes according to within- and between-group differences

Table 3 compares the secondary outcomes between the groups. Regarding CVA, the within-group difference was significant in the experimental group only ($p < .05$) and showed a large effect size ($d = 1.2$). The between-group difference was significant ($p < .05$) and showed a large effect size ($d = 1.3$). Except for extension, the CROM of both groups showed significant within-group differences, specifically in flexion, left lateral flexion, right lateral flexion, left rotation, and right rotation ($p < .05$).

Table 3. Comparison of the Secondary Outcomes According to the Within-group and Between-group (Mean ± SD)

Measure	Within-group								Between-group	
	Experimental Group (n = 16)				Control Group (n = 16)					
	Pretest	Posttest	MD	p (d)	Pretest	Posttest	MD	p (d)	t	p(d)
CVA	49.43 ± 2.64	53.12 ± 1.82	3.68 ± 2.99	.000*(1.2)	50.34 ± 1.74	50.75 ± 2.61	.41 ± 2.13	.450	3.47	.002*(1.3)
Flexion	4.19 ± 2.27	1.73 ±1.45	-2.45 ± 1.78	.000*(1.4)	4.63 ± 1.91	2.31 ± 2.11	-2.31 ± 2.24	.000*(1.0)	-.20	.845
Extension	19.09 ± 1.38	19.41 ± 1.17	.31 ± .97	.216	18.17 ± 1.67	18.47 ± 1.75	.30 ± 1.92	.546	-.02	.986
Left lateral flexion	17.06 ± 1.61	15.44 ± 1.23	-1.63 ± 2.15	.008*(.8)	16.41 ± 2.33	13.38 ± 2.19	-3.03 ± 1.60	.000*(1.9)	2.10	.044*(.7)
Right lateral flexion	17.33 ± 1.23	15.66 ± 1.74	-1.67 ± 1.89	.000*(.9)	15.38 ± 1.72	12.84 ± 1.76	-2.53 ± 2.03	.000*(1.2)	1.24	.225
Left rotation	15.25 ± 2.17	13.88 ± 1.58	-1.38 ± 2.35	.033*(.6)	14.13 ± 2.22	11.63 ± 2.28	-2.50 ± 2.76	.000*(.9)	1.24	.224
Right rotation	15.41 ± 1.57	13.94 ± 1.38	-1.47 ± 1.92	.008*(.8)	14.50 ± 1.80	10.53 ± 6.35	-3.97 ± 6.67	.000*(.6)	1.18	.249

*p < .05, d: effect size d

CVA: Craniovertebral Angle, MD: Mean Differences

Furthermore, the effect sizes were moderate to large (d = .6 to 1.4, .6 to 1.9). In the between-group comparison, a significant difference was observed in the left lateral flexion only (p < .05), and the effect size was moderate (d = .7).

Ⅳ. Discussion

Neck pain is one of the most significant work-related health problems that are linked to various factors, including physical and mental stress [3, 4], and teachers are among the occupational groups in whom neck pain has a high prevalence [38]. School teachers frequently hold a “head-down” position when they read, mark assignments, and write on a blackboard [39]. The poor posture continues to stress the cervical structure, resulting in FHP [40], neck pain, and musculoskeletal dysfunction [10]. In addition, FHP is strongly correlated with breathing problems [13]. Thus, the current study examined the combined effects of SSE and TEE on breathing, pain, CVA, and CROM in elementary school teachers with FHP.

1. Comparison of primary outcomes according to within- and between-group differences

Among the outcomes regarding respiration, within-group comparisons showed that MIP, MEP, FVC, and FEV1 were significantly different in the experimental group only (p < .05, d = .6 to 1.2). In the between-group comparisons, only FVC and FEV1 were significantly different (p < .05, d = .8, 1.1). One study indicated that an abnormal structural change in the cervical and thoracic regions of the spine causes dysfunctional movement in the rib cage, affecting the respiratory function and reducing lung volume, vital capacity, and pulmonary muscle strength [41]. Another study reported that FVC, FEV1, and FEV1/FVC tended to decrease in subjects with FHP compared to the control subjects [42]. Therefore, the combination of SSE and TEE in the current study improved the pulmonary functions by correcting pulmonary muscle imbalances due to FHP and had a positive effect on the alignment of the cervical and thoracic regions of the spine. Kang et al. [27] reported that SSE improved the FHP by activating the neck muscles, lower trapezius, and serratus anterior; this result supports the current findings. The SSE/TEE combination (i.e., exercises targeting the thoracic spine and performed by the experimental group) was more effective in improving breathing than the CSRE/SE combination (i.e., exercises directly targeting the neck structure and performed by the control group).

The VAS and NDI decreased significantly at pre- and post-intervention in both groups (p < .05, d = 1.2). After the muscle function improves, neck pain decreases, and the ability to maintain a neutral cervical position improves [43,44]. The muscle imbalance is expected to decrease when tension and fatigue in superficial muscles, such as the upper trapezius and sternocleidomastoid, are reduced. Hence, the pain decreases, which positively affects the VAS and NDI. McDonnell et al. [45] reported that NDI significantly decreased after a three-month intervention program that included a scapular exercise to reposition a misaligned scapula, which supports the findings of the current study. The findings of the current study showed that the combination of SSE and TEE, i.e., exercises that do not directly target the neck, is effective in reducing pain.

2. Comparison of the secondary outcomes according to the within- and between-group differences

The CVA increased pre- and post-intervention significantly in the experimental group only ($p < .05$, $d = 1.2$), and a significant difference was observed between the experimental and control groups ($p < .05$, $d = 1.3$). Previous studies reported that a stretching and strength training program improved the CVA in subjects with FHP [46] and that exercises for the chest area (specifically, chest stretching using a foam roller, scapula protraction, and chin-in exercise) were effective in FHP and RSP [47]. Furthermore, the combination of SSE and TEE increased the CVA by strengthening the muscles around the thoracic spine and by realigning it. An increase in CVA means that FHP improved; hence, the combination of SSE and TEE appears more effective in FHP compared to the combination of CSRE and SE. Cho et al. [48] reported that mobilization and mobility exercises for the upper thoracic region increased the CVA, which supports the findings of the current study.

In both the experimental and control groups, CROM, except extension, statistically significantly decreased pre- and post-intervention ($p < .05$, $d = .6$ to1.9). McDonnell et al. [49] reported that CROM improved greatly after a three-month intervention program that included a scapular exercise to reposition a misaligned scapula. Won et al. [50] reported that region-by-region gradual strength training for four weeks affected the realignment of the head to the normal anatomical position and increased CROM. These findings are consistent with the findings of the current study. Considering that muscles in the cervical spine and the shoulders are structurally connected, it is speculated that the mobility of the neck improves as pain decreases because of the increase in muscle strength and the stabilization of neck alignment. In the current study, the combination of CSRE and SE (i.e., exercises targeting the neck and performed by the control group) and the combination of SSE and TEE (i.e., exercises aimed at scapular stabilization and performed by the experimental group) were effective in increasing the CROM.

3. Limitations

This study had the following limitations. The study sample was small, and the participants' age had a wide range because age was not restricted in the recruitment of study subjects. Considering the characteristics of the study subjects, only one occupational group participated in the study, making it difficult to generalize the study findings. In addition, the duration of the intervention (six weeks) was relatively short. Moreover, the duration of the effect of the intervention was not investigated because of time limitations in funding. Lastly, the individual effects of SSE and TEE were not examined. Therefore, to investigate the duration of the intervention effect in detail, future research should be performed with a larger sample and with subjects from diverse occupational groups.

Ⅴ. Conclusion

The combination of SSE and TEE, which involves exercises for the shoulders and thoracic spine, was effective in improving posture, breathing, neck pain, and CROM in elementary school teachers with FHP. The combination of CSRE and SE in the control group was effective in reducing neck pain and improving CROM but had no significant effect on posture and breathing. Therefore, among various therapeutic interventions, SSE and TEE may be used to improve posture, reduce pain during work, and prevent physical and mental fatigue in elementary school teachers with FHP.

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