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Research Article

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Effects of Cervical Stabilization and Scapular Stabilization Exercise on the Proprioception and Craniovertebral Angle and Upper Trapezius Muscle Tone of People with Forward Head Posture

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| Abstract |

PURPOSE: This study examined the effects of the craniovertebral angle, proprioception (joint error test), and the upper trapezius on the muscle tone when comparing cervical stabilization and scapula stabilization exercises and when two exercises were performed together.

METHODS: The participants in this study agreed in advance, and this study was carried out by recruiting 27 university students in their twenties with mild frontal posture. The subjects were assigned randomly to three groups that performed cervical stabilization exercises, scapular stabilization exercises, and both cervical and scapular stabilization exercises. One-way repeated ANOVA was used to analyze the evaluation values of the 1st, 3rd, and 6th weeks of exercise intervention within the group, and one-way ANOVA was used to compare the difference in the effects of exercise intervention among the three groups.

RESULTS: Proprioception was significantly different in the cervical stabilization exercises (CSE) group and the cervical stabilization exercises + Scapular stabilization exercises (CSE+SSE) groups at three weeks, and there was a significant difference between the scapular stabilization exercises (SSE) group and the CSE+SSE group ($p < .05$). At six weeks, there was a significant difference between the CSE group and the CSE+SSE group, and there was a significant difference between the SSE group and the CSE+SSE group ($p < .05$). There was a significant difference between three and six weeks in the CSE group ($p < .05$). In the SSE group, there was a significant difference between pre and six weeks, and between three and six weeks ($p < .05$). In the CSE+SSE group, there was a significant difference between pre and three weeks, and between pre and six weeks ($p < .05$). On the other hand, there were no significant differences between CVA and muscular tone in all three groups ($P > .05$).

CONCLUSION: In all groups, the proprioception (joint error test) showed significant improvement, and the CSE+SSE group showed greater improvement than the other groups. As a result, the appropriate combination of neck stabilization exercise and scapular stabilization exercise

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effectively improved proprioception in the presence of forward head posture (FHP).

Key Words: Cervical Stabilization Exercise (CSE), CVA, Forward head posture, Muscle tone, Proprioception, Scapular Stabilization Exercise (SSE)

Ⅰ. Introduction

The use of VDTs (Visual Display Terminals) in daily life, such as computers and smartphones, is almost universal [1]. The excessive use of the VDT and long-standing sedentary lifestyles can lead to musculoskeletal disorders, of which forward head posture (FHP) is the most common [1]. During adolescence, a high incidence of incorrect postures appears due to prolonged sitting postures and heavy school bags [2-5].

The FHP generally features a horizontal distance of more than 5 cm between the external auditory canal and the posterior angle of the acromion, increased flexion of the lower cervical and upper thoracic vertebrae, an increased larynx from the first cervical vertebrae, and increased upper cervical vertebrae [6]. The neuromuscular proprioceptive reflex regulates the movement of the spine. FHP weakens the proprioceptive reflexes and increases spinal instability and the risk of injury [7]. The persistence of FHP can be a potential factor in reducing proprioceptive sensation and inducing cervical pain [8]. The craniovertebral angle (CVA) can be used to evaluate the state of FHP. CVA can be used as an important index to determine cervical dysfunction, with a smaller angle implying a more severe degree of FHP [9].

Proprioception is the ability to determine the position of a joint [10]. A method for measuring motor sensation and joint position sense is to reposition the joint as accurately as possible at a predetermined position [11]. Proprioception is the information obtained from joints, tendons, ligaments, and skin. If FHP damages the proprioception, it may be difficult to respond appropriately based on coordination with the related muscle [12].

FHP causes thoracic kyphosis, reduced thoracic mobility, and changes in the function of the rotator cuff muscle, resulting in round shoulders. Round shoulders refer to a posture induced by cervical hyperextension, thoracic lordosis, anterior scapular tilt, scapular downward rotation, and internal scapular rotation [13]. Round shoulders weaken muscles, such as the neck flexor, lower and middle trapezius muscle, serratus anterior muscle, and infraspinatus muscle. In contrast, the upper trapezius muscle, pectoralis major muscle, and levator scapulae muscle develop an imbalance pattern in the body, such as shortening [14]. Therefore, FHP can lead to postural imbalance, resulting in decreased proprioception.

A previous study reported that cervical stabilization exercises (CSE) and scapular stabilization exercises (SSE), which are performed to resolve postural imbalances and increase proprioception around the head and neck, have significant effects. CSE can enhance balance and function through neck joint movement regulation in patients with neck movement disorders, and the role of muscles in cervical stability is emphasized [15]. Recently, CSE has been used to improve the strength and endurance of neck muscles attached to the cervical [15]. Based on Chiu's work, CSE was established as a movement that could increase the activity of deep neck flexors by retraining deep neck flexors and improving the ability of the cervical to maintain a correct neutral posture [16].

Scapular stabilization exercise (SSE) is a method designed to secure the scapula in the neutral position of the thoracic cage through the interaction of the muscle that makes up the shoulder [17]. SSE is an exercise to position the scapula between the 2nd and 7th ribs, which is the neutral point of the chest, through the interaction of the muscles around the shoulder joint that connects the upper limbs and trunk [18-20]. It has recently been viewed as the most likely exercise method for correcting posture in FHP patients [21]. According to the results of previous studies, both CSE and SSE increase the angle of the CVA, strengthen the surrounding muscles, and increase proprioception in the neck. Many studies compared SSE and McKenzie extension exercise, but relatively few papers have compared SSE and CSE.

This study examined the effects of CSE, SSE, and CSE+SSE on CVA, proprioception (joint error test), and upper trapezius muscle tone.

Ⅱ. Methods

The pre, mid, and post-changes in CVA, proprioceptive, and muscle tone in the upper trapezius were compared when CSE and SSE were performed separately and when CSE and SSE were together. Table 1 presents the research process.

1. Participants

This study was conducted on 15 healthy adult males and 12 healthy adult females aged 20 or over enrolled in S University located in A city, for a total of 27 persons. All subjects were given a thorough explanation of the purpose and methods of the study before participating. The number of subjects was calculated using a sample size calculation program (G Power, 3.1.9.). The inclusion criteria were those without a history of neck and shoulder injuries, those without neurological damage to the upper extremities, inflammatory, degenerative joints, and connective tissue. The study design used the pre-, mid-, and post-outcome values to compare the groups. The research subjects were selected from people with a CVA of less than 60°, and the experiment proceeded without knowing which group they belonged to. The Sunmoon University IRB (Institutional Review Board) approved the study (SM-202204-008-2). All subjects were provided written notification, were explained the purpose of the experiment and the method of study subjects, and had their height, body weight, CVA, proprioception, and upper trapezius muscle tone measured before starting the experiment. Table 1 shows the characteristics of the subjects.

2. Experiment Procedures

Fig. 1 presents the research process. The subjects were divided into the CSE group, SSE group, and CSE+SSE group. Before all experiments, the study subjects were set to single-blind, and the experiment was conducted without knowing which group they belonged to. The study design was a pre, mid, and post-test control group design (randomized), with pre, mid and post-test comparisons among the three groups. All study subjects measured the

Table 1. General characteristics of the participants

	CS group (n = 9)	SS group (n = 9)	CS+SS group (n = 9)
Age (years)	21.77 ± 1.34	21.11 ± .99	21.22 ± 1.13
Height (cm)	165.3 ± 4.49	169.2 ± 7.72	170.5 ± 8.07
Weight (kg)	60.8 ± 4.88	64.8 ± 9.30	72.7 ± 13.9
CVA (degree)	55.22 ± 4.55	53.64 ± 4.76	52.88 ± 4.55
Proprioception (Cm)	5.35 ± 1.74	5.23 ± 2.30	4.8 ± 1.53
Upper trapezius muscle tone (Hz)	18.38 ± 1.15	17.3 ± 1.81	17.85 ± 1.07
Upper trapezius muscle tone (N/m)	338.6 ± 32.5	313.2 ± 51.9	332.2 ± 29.9

Values indicate mean ± standard deviation

CSE; Cervical Stabilization Exercise, SSE; Scapular Stabilization Exercise

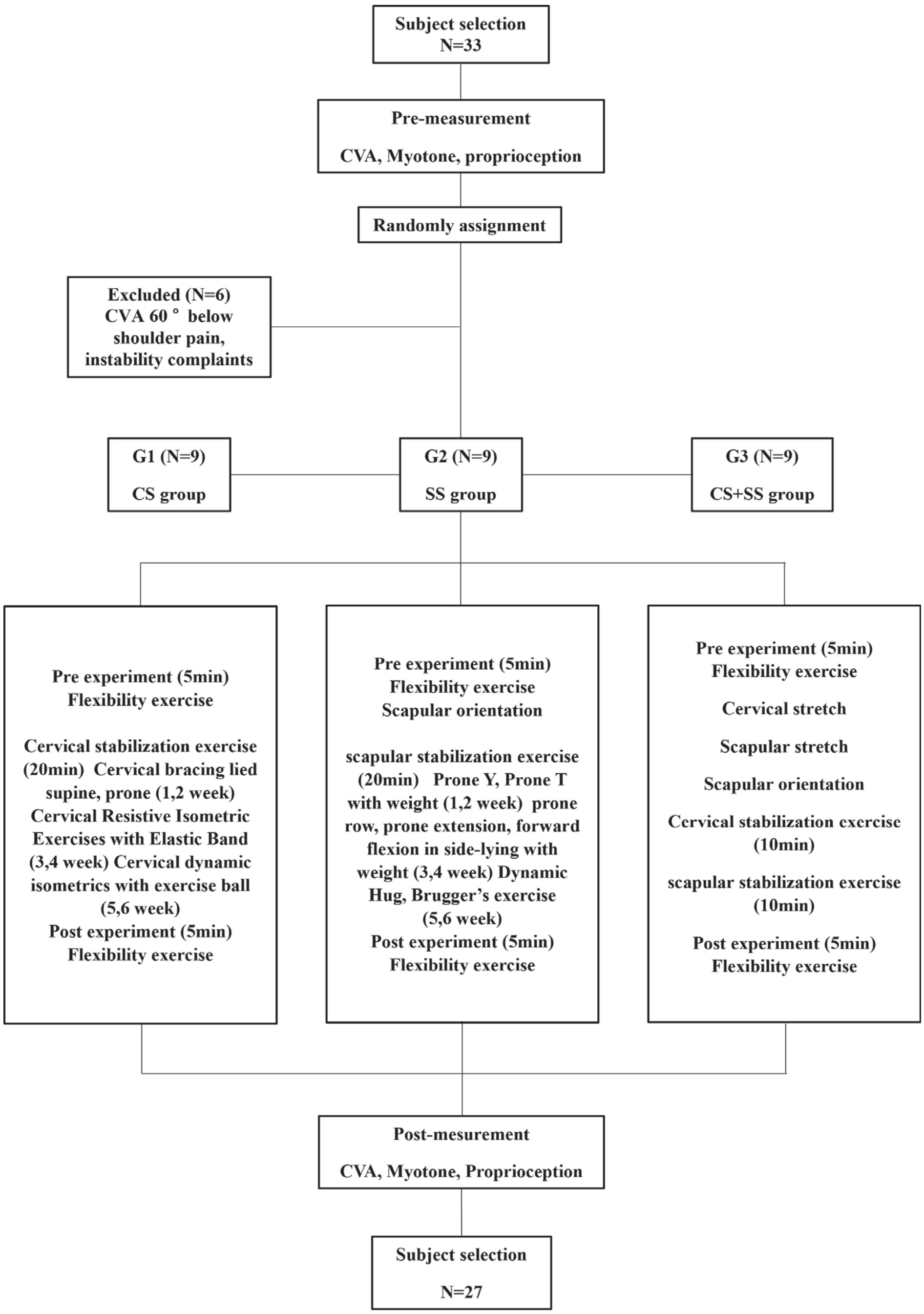

Fig. 1. Flow diagram of the study selection process.

proprioception, CVA, and upper trapezius muscle tone. Three measurements were taken before the exercise intervention, after three weeks of exercise intervention, and after six weeks of exercise intervention. The exercise intervention was performed three times a week for six weeks.

3. Intervention

1) Cervical Stabilization Exercise (CSE)

All subjects performed neck muscle stretching before and after the exercise for six weeks, three times a week. All subjects exercised for 20 minutes and stretched for 10 minutes for 30 minutes in total.

In the first and second week, the first exercise was to take the supine and prone position to strengthen the flexor muscles located at the front of the subject's neck and to resist gravity with the head lifted from the bed.

In the third and fourth weeks, for neck stabilization of the subject, the subject sat on a chair and performed an isometric exercise of the neck using an elastic band.

In the fifth and sixth exercises, for cervical stabilization of the subjects, an isometric exercise of the neck using an exercise ball was performed at the standing position (Fig. 3).

2) Scapular Stabilization Exercise (SSE)

All subjects underwent shoulder stretches before and after exercise three times a week for six weeks, and scapular rearrangement before exercise. All subjects exercised for 20 minutes and stretched for 10 minutes for 30 minutes. In the first and second weeks, the first exercise was for the subject to make a 90 and 120° shoulder abduction in the prone position, followed by a thumb pointing up.

In the third and fourth weeks, the first exercise was a shoulder horizontal abduction dumbbell exercise with the elbow flexion at 90° in the prone position to strengthen the subject's trapezius and rhomboid rotator cuff muscles. The second exercise was elbow and shoulder extensions using a dumbbell in the prone position to strengthen the subject's lower trapezius and rotator cuff muscles. For the third exercise, a side-lying posture was taken to improve the cooperation and muscle strength of the subject's trapezius muscle. The dumbbell exercise was then carried out by elbow extension and shoulder flexion. The fourth exercise used dumbbells in a side-lying position for elbow flexion to 90° and shoulder external rotation to strengthen the infraspinatus and teres minor of the subject's rotator cuff muscles.

In the fifth and sixth weeks, the first exercise was to hold an elastic band around the back in a standing position to the subject's scapular stabilization, extend the upper arm forward with the elbow extension, and then hold that position for two seconds and release the force slowly. The subjects were instructed to return slowly to their original postures. The second exercise placed a ball between the wall and the scapular in a standing position with an elastic band to improve the balance and posture of the subject's shoulder muscles (Fig. 4).

3) Cervical and Scapular Stabilization Exercise (CSE+SSE)

The exercise was appropriately mixed with the above two exercises, differing only in the number of repetitions.

In weeks one and two, the cervical stabilization exercise was repeated six times for 10 seconds each and was performed three times a week. The scapular stabilizing exercise was repeated for two sets of 10 repetitions and was carried out three times a week. In weeks three and four, the cervical stabilization exercise was repeated five times for 10 seconds each and was performed three times a week. The scapular stabilizing exercise was repeated in one set of 10 repetitions and was carried out three times a week. In weeks five and six, the cervical stabilization exercise was repeated five times for 10 seconds each and was performed three times a week. The scapular stabilizing exercise was repeated for two sets of 10 repetitions and was carried out three times a week.

4. Outcome Measurements

1) Craniovertebral Angle (CVA)

The measurement tools used were a mobile phone camera and an electronic goniometer (Goniometer digital, Baseline, USA). After having the subject sit in a chair, a camera was placed 1 m from the chair where the subject was sitting. The subject's external auditory canal was placed in the center of the camera grid, and the side of the subject was photographed. A line was drawn from the subject's C7 vertebrae spinous process to the middle of the external auditory canal; a line horizontally was drawn with the C7 vertebrae spinous process, and the angle between them was measured.

2) Proprioception

A helmet, laser point, and target paper were used to measure the subject's positional sensation of proprioception (joint error test). After taking the helmet, the subject was asked to stand at shoulder width and maintain a distance of one meter from the target. After the subject looks to the front, activate the laser point to place the laser point at the center point of the target paper. Have the subject memorize the current head and laser point positions. With their eyes closed, neck flexion to the maximum was performed and held for three seconds. The subjects were then asked to return to the starting head position at the desired speed. Three measurements were taken to measure the distance away from the midpoint of the target. Then record the average of the distances of the two points located at similar points about how far away from the center point of the target paper.

3) Muscle tone

The subject was instructed to be in a comfortable position after looking forward while seated in a chair, and the muscle tone of the upper trapezius of the subject was measured. Subsequently, the muscle tone of the upper trapezius was measured at the subject's clavicle 1/2 position using a Myoton (Myoton, Myoton AS, Estonia).

5. Statistical Analysis

SPSS statistical software (version 28.0.1; IBM Corp, Armonk, NY) was used to calculate the mean and standard deviation for each measure. One-way ANOVA was used to check for differences between the groups, and one-way repeated ANOVA was used to check for changes within groups over time (one week, three weeks, six weeks). A p-value $< .05$ was considered significant. Post hoc tests were performed with a Bonferroni test.

Ⅲ. Results

This study measured and compared the position sensation, CVA, and upper trapezius muscle tone among proprioceptive of the neck before, during, and after SSE and CSE. One-way ANOVA was performed to compare the differences between groups before, immediately after, and after three weeks of intervention, and after six weeks of intervention. There was no significant difference in CVA among the three groups ($p > .05$).

The proprioceptive was significantly different in the CSE group and the CSE+SSE groups at three weeks and between the SSE group and CSE+SSE group ($p < .05$). At six weeks, there was a significant difference between the CSE group and CSE+SSE group, and between the SSE group and CSE+SSE group ($p < .05$). There was no significant difference among the three groups of pre-test ($p > .05$), as presented in Fig. 2.

Myotone (Hz) revealed a significant difference between the CSE group and SSE group in Week 3. There was a significant difference between the CSE group and CSE+SSE group ($p < .05$). In Week 6, there was a significant difference between the CSE group and SSE group ($p < .05$) but not between the three groups in the pre-test ($p > .05$). Myoton (N/m) revealed a significant difference between the CSE and SSE groups at three weeks ($p < .05$) and among the three groups in the pre-test and after six weeks ($p > .05$) are presented in Table 2.

One-way repeated ANOVA was performed to compare the differences among groups before, immediately after, after three weeks of intervention, and after six weeks of intervention. There was no significant difference in CVA

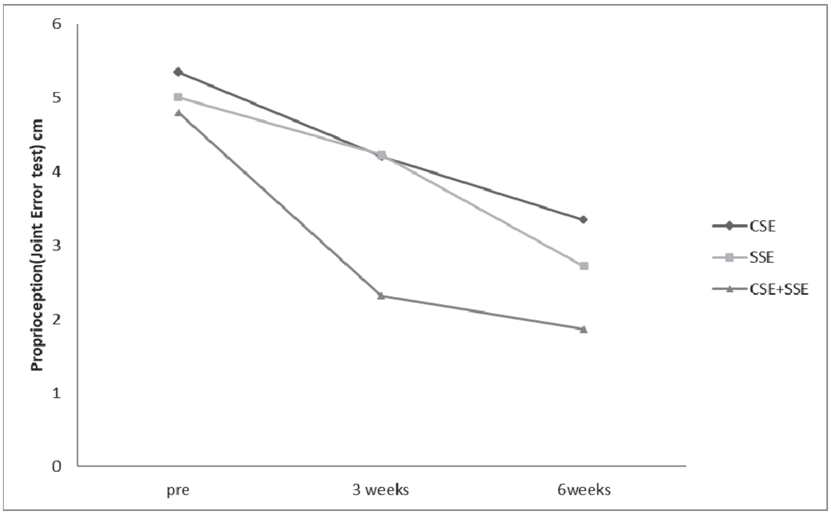

Fig. 2. Comparison of proprioception over time.
Cervical Stabilization Exercise; CSE, Scapular Stabilization Exercise; SSE, Cervical and Scapular Stabilization Exercise; CSE+SSE

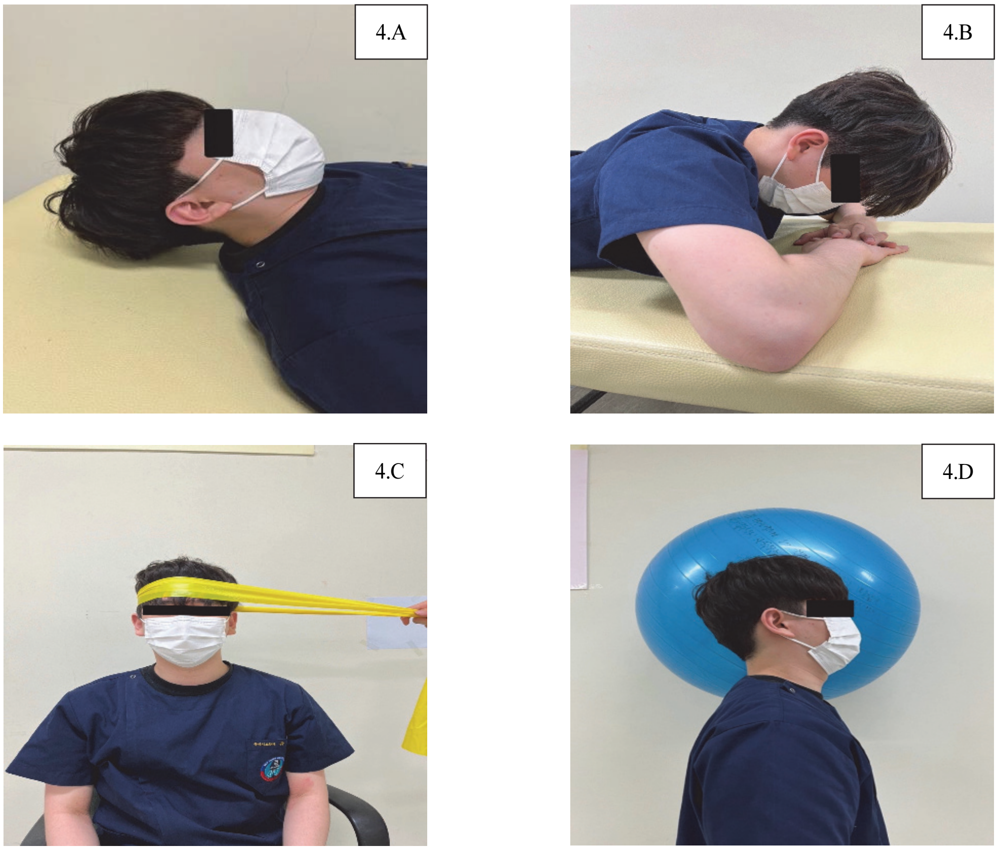

Fig. 3. Cervical Stabilization Exercise (CSE) (A). Supine cervical bracing, (B). Prone cervical bracing, (C). Cervical resistive exercises with an elastic band, (D). Cervical dynamic isometrics with an exercise ball.

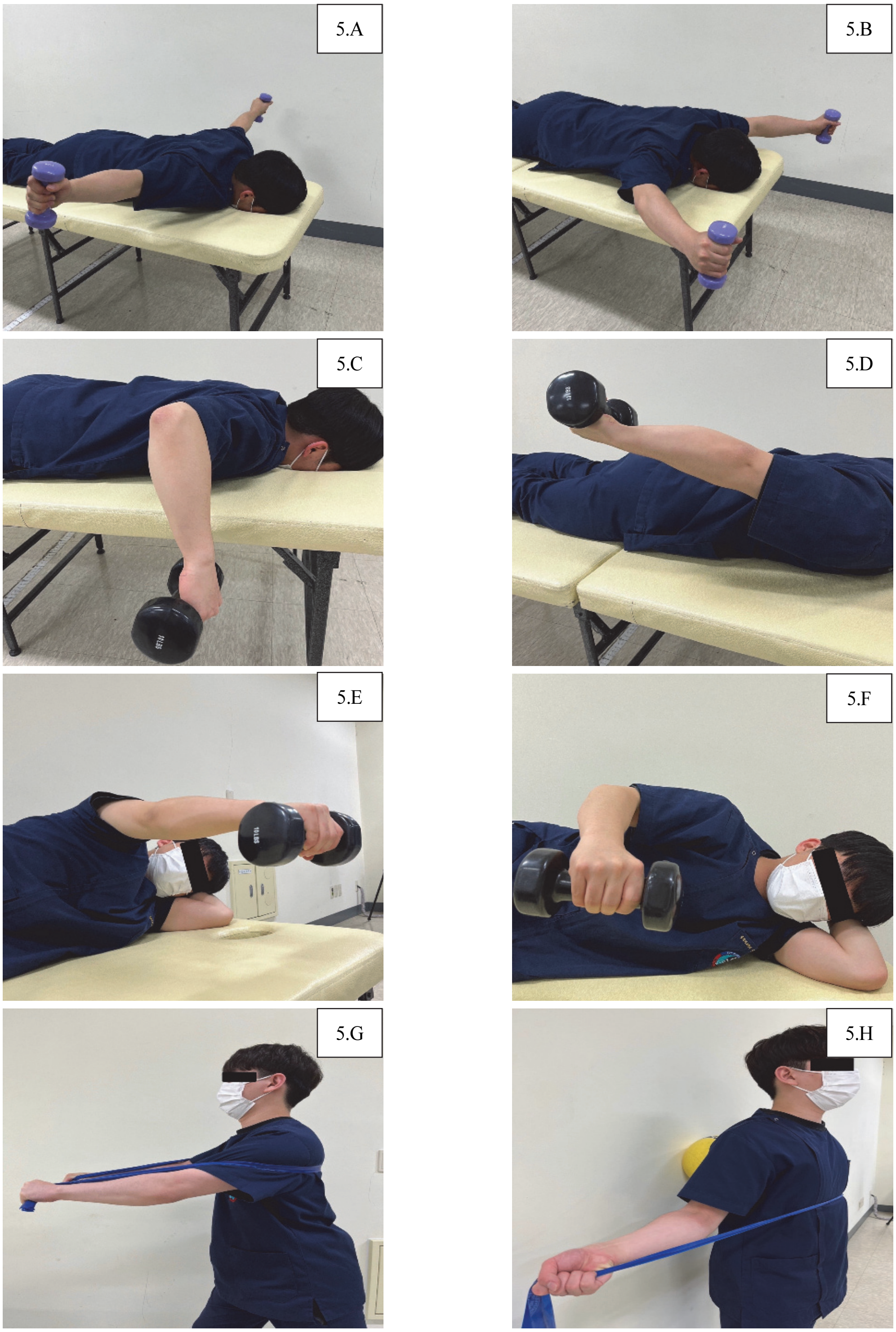

Fig. 4. Scapular Stabilization Exercise (SSE) (A). Prone ‘T’, (B). Prone ‘Y’, (C). Prone row, (D). Prone extension, (E). Forward flexion in side lying, (F). Side-lying external rotation, (G). Dynamic Hug, (H). Brugger’s exercise.

Table 2. Comparison of CVA, proprioception, and muscle tone between the groups according to exercise intervention

	Group	CSE	SSE	CSE+SSE	F	p
CVA (degree)	pre	56.33 ± 1.91	54.42 ± 4.21	53.66 ± 4.05	1.347	.279
	3week	56.37 ± 4.11	54.84 ± 4.42	54.28 ± 4.72	.539	.590
	6week	57.28 ± 3.72	55.62 ± 5.04	54.55 ± 5.33	.756	.480
Proprioception (joint error) (cm)	pre	5.35 ± 1.84	5.01 ± 1.98	4.80 ± 1.62	.207	.814
	3week	4.21 ± 1.25[c]	4.23 ± 1.28[c]	2.38 ± .61[ab]	8.490	.002*
	6week	3.34 ± .84[c]	2.72 ± .98[c]	1.86 ± .65[ab]	7.128	.004*
Myotone (1) (Hz)	pre	18.38 ± 1.15	17.30 ± 1.81	17.85 ± 1.07	1.383	.270
	3week	18.73 ± .85[bc]	17.25 ± 1.88[a]	17.22 ± 1.57[a]	3.646	.041*
	6week	18.84 ± 1.15	17.36 ± .84	17.71 ± 1.35	3.294	.054
Myotone (2) (N/m)	pre	338.67 ± 34.52	313.22 ± 55.09	332.22 ± 31.78	.902	.419
	3week	346.11 ± 32.29[b]	297 ± 52.88[a]	318.11 ± 16.99	3.970	.032*
	6week	327.78 ± 47.03	296.22 ± 37.94	317.74 ± 43.36	1.260	.302

*p < .05; (Mean±SD); [a] Statistically different from pre; [b] Statistically different from 3week; [c] Statistically different from 6week, Cervical Stabilization Exercise; CSE, Scapular Stabilization Exercise; SSE, Cervical and Scapular Stabilization Exercise; CSE+SSE.

Table 3.1. Comparison of CVA over time

Group	Pre	Three weeks	Six weeks	F	p
CS (cm)	55.33 ± 4.79	56.38 ± 4.11	57.29 ± 3.72	.918	.419
SS (cm)	53.64 ± 5.05	54.61 ± 4.82	55.62 ± 5.02	1.152	.341
CS+SS (cm)	53.66 ± 4.05	54.28 ± 4.72	54.55 ± 5.33	.259	.775

Cervical Stabilization Exercise; CSE, Scapular Stabilization Exercise; SSE, Cervical and Scapular Stabilization Exercise; CSE+SS.

Table 3.2. Comparison of proprioception over time

Group	Pre	Three weeks	Six weeks	F	p
CS (degree)	5.35 ± 1.84	4.21 ± 1.25[c]	3.34 ± .84[b]	6.84	< .007*
SS (degree)	5.01 ± 1.9[c]	4.23 ± 1.28[c]	2.72 ± .98[ab]	12.80	< .001*
CS+SS (degree)	4.80 ± 1.62[bc]	2.32 ± .69[a]	1.86 ± .65[a]	19.67	< .001*

*p < .05; (Mean±SD); [a] Statistically different from pre; [b] Statistically different from 3week; [c] Statistically different from 6week; Cervical Stabilization Exercise; CSE, Scapular Stabilization Exercise; SSE, Cervical and Scapular Stabilization Exercise; CSE+SSE.

Table 3.3. Comparison of myotone over time

Group	Pre	Three weeks	Six weeks	F	p
CS (Hz)	18.39 ± 1.15	18.73 ± .85	18.84 ± 1.15	.362	.702
CS (N/m)	338.67 ± 34.52	346.11 ± 32.29	327.78 ± 47.03	.512	.609
SS (Hz)	17.30 ± 1.81	17.25 ± 1.88	17.22 ± 1.57	.040	.961
SS (N/m)	313.22 ± 55.09	297.00 ± 52.88	296.22 ± 37.94	1.816	.195
CS+SS (Hz)	17.85 ± 1.07	17.36 ± .84	17.71 ± 1.35	.620	.55
CS+SS (N/m)	332.22 ± 31.78	318.11 ± 16.99	317.22 ± 43.34	1.051	.399

Cervical Stabilization Exercise; CSE, Scapular Stabilization Exercise; SSE, Cervical and Scapular Stabilization Exercise; CSE+SSE.

within the three groups ($p > .05$), as listed in Table 3.1. A significant difference in proprioception was observed in all three groups ($p < .05$). A significant difference in the CSE group was noted between three and six weeks ($p < .05$). In the SSE group, there was a significant difference between pre and six weeks and between three and six weeks ($p < .05$).

In the CSE+SSE group, there was a significant difference between the pre-test and three weeks and between the pre-test and six weeks ($p < .05$), as listed in Table 3.2.

None of the three groups of Myoton showed a significant difference within the group ($p > .05$), as presented in Table 3.3.

Ⅳ. Discussion

This study revealed changes in CVA, proprioception, and upper trapezius of muscle tone over time (one, three, and six weeks) when CSE, SSE, and CSE+SSE were performed on 27 adult males and females with mild FHP. Many previous studies have compared the effects of SSE and Mckenzie Stretch exercise, and CSE and Mckenzie Stretch exercise, on people with FHP [22, 27]. Few studies compared the effects of applying these exercises to each group of people with FHP, and even fewer papers applied both SSE and CSE. Therefore, this study designated three groups: two groups performed SSE and CSE separately, and one performed both SSE and CSE.

There was a significant improvement in proprioception in this study. The stabilizing exercise was effective against all groups, but the degree of improvement after three and six weeks of exercise differed between the groups. The group who underwent both SSE and CSE showed the most significant improvement among the three groups after three and six weeks of exercise. After three weeks of exercise, the CSE group showed greater improvement than the SSE group. After six weeks of exercise, the SSE group showed greater improvement than the CSE group.

A previous study found that performing the joint repositioning task in FHP resulted in more significant errors than when it was maintained correctly [8]. As a result, there was a significant improvement in proprioception in all groups, which was consistent with previous studies showing that stabilization exercises were effective in improving proprioception in the neck [21,26]. FHP and round shoulder position occurred due to structural characteristics, and SSE was recommended as a recovery treatment for unbalanced shoulder muscles caused by FHP and round shoulder position [25]. Evidence from these studies suggests that SSE significantly improved neck proprioception. The group that performed both SSE and CSE showed the greatest improvement since both SSE and CSE effectively enhanced the proprioception in the neck. It is considered that the group that performed both CSE and SSE showed the greatest improvement.

There was no significant difference in CVA in the three groups of this study. Several studies have shown that CSE relaxes the shortened muscles by extending the neck and strengthens the neck muscles [22,23]. The SSE strengthens the weakened serratus anterior muscle and relaxes the stronger upper trapezius muscle [28], which was said to be effective against FHP by improving CVA. There was no statistically significant difference in CVA in this study. The reason for this result is that first, the previous study was conducted with subjects with an FHP of less than 44–53°s [22,23,28]. The present study, however, was conducted with subjects with mild CVA of less than 60°, so no significant difference was found. Second, it is likely that the improvement in CVA was hampered by inducing FHP [1-5] when used to study time, sedentary life, and electronic devices because of the inability to control the subjects' daily life while not exercising. As a result, there was no statistically significant difference in all groups, and it was found that the three exercise groups of this study showed no improvement effect on CVA. A study of subjects with a CVA of less than 44 to 53° with severe FHP and controlling the environmental factors will be needed to see a statistically significant change in CVA.

There was no significant improvement in muscle tone in all the groups. CSE and SSE were performed in this study to improve FHP and decrease muscle tone according to previous studies [13,14], and the muscle tone of the upper trapezius was increased in people with FHP. A previous study observed decreased muscle tone, stiffness, and elasticity of the upper trapezius during SSE [28], but there were no significant differences during SSE in the present study. In previous studies, there was insufficient evidence that upper trapezius muscle tone was reduced during CSE [29], and no significant difference was found when CSE was performed in this study. There was no significant difference in this study because, first, this study applied the exercise 18 times for six weeks and evaluated the research results over a relatively short period. Therefore, a study of the effects of this exercise on muscle tone for periods longer than six weeks is needed. Second, the upper trapezius muscle tension was increased from sedentary habits or hobbies because the subjects could not control their daily life during the experiment.

This study had some limitations. First, the sample size was small, with 27 subjects, and the study was conducted on healthy men and women in their 20s. Therefore, care should be taken when generalizing to all age groups. Second, the intensity and duration of the exercise in the groups could not be matched perfectly because the types of exercise in the three groups were different. Third, when measuring CVA and high receptivity, there was a limitation on the measurement part because there was no professional equipment. Therefore, future studies will be needed to correct these limitations.

Ⅴ. Conclusion

CSE and SSE were performed on 27 mild FHP adult males and females for six weeks. The CVA, proprioception, and upper trapezius muscle tone were measured according to the duration, and the following conclusions were obtained.

First, the proprioception of the neck was improved in the CSE group, SSE group, and CSE+SSE group. Second, there was more significant improvement in neck position sense of proprioception in the CSE+SSE group than in the CSE and SSE groups.

The exercise was effective in enhancing the position proprioception of the head and neck in all groups, but no effect could be confirmed with CVA and muscle tone.

Based on the results of this study, the effect was more significant in the CSE + SSE groups, so it is expected to be used as basic data for patients with FHP.

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