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Research Article

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Effect of Breathing Exercises via Joint mobilization on the Lung Function and Spinal Alignment of Straight-necked Women

Byung-Sun Kong[1] · Beom-Cheol Jeong[2] · Kyung-Tae Yoo†

Department of Physical Therapy, Namseoul University,
[1]Graduate School of Integrative Medicine, Cha University,
[2]Rehabilitation Center, Noble Care Hospital

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| Abstract |

PURPOSE: This study examined the effects of breathing exercises via joint mobilization on the lung function and spinal alignment of 30 straight-necked women in their 20 s and 30 s.

METHODS: The participants were divided into two groups: an experimental group who performed breathing exercises via joint mobilization, and a control group who performed general stretching exercises. The differences between the two groups were measured and compared at three points in time: during the pre-examination, after four weeks of intervention, and after a four-week maintenance period. The changes in each group were measured before and after the intervention and after a one-month maintenance period and compared. For data analysis, the SPSS 22 was used to obtain the mean and standard deviation with a significance level of $\alpha = .05$.

RESULTS: Eight weeks of breathing exercises via joint mobilization and general stretching exercises positively impacted the lung function and spinal alignment in straight-necked patients. In particular, the experimental group showed more significant differences in spinal alignment after four weeks period of intervention and four weeks of maintenance.

CONCLUSION: Breathing exercises via joint mobilization can be considered an effective intervention that can improve the respiratory volume and spinal alignment for patients with straight necks.

Key Words: Alignment, Postural, Respiratory, Spinal, Straight neck

†Corresponding Author : Kyung-Tae Yoo
taeyoo88@nsu.ac.kr, https://orcid.org/0000-0001-7956-819X

Ⅰ. Introduction

Work has continued to become highly specialized, leading to an increasingly sedentary working environment that requires people to engage in a set pattern of movements. This has resulted in difficulty in the balanced development of muscles in modern-day workers [1]. If the postural imbalance, postural asymmetry, and nervous system damage caused by occupations, postures, and habits persist, their bodies will age faster, along with a gradual degeneration and weakening of their vertebral joints [2]. In addition, a limit on the operational range of the neck can cause inconvenience and decrease an individual's concentration as well as cause psychological problems, which can lead to social problems [3]. Proper stimulation of the long-damaged nerves and musculoskeletal system is the first step to correcting these issues. Therefore, it is essential to conduct postural correction exercises that utilize breathing to maintain and further strengthen the nerves and musculoskeletal system [4].

A straight neck, one of the inappropriate postures, refers to a state in which the head is placed forward relative to the trunk and where there is a gap of more than 5cm between the ear and the humerus head [5]. If this posture is held consistently, the muscles that lift the head, such as the levator scapulae muscle and splenius capitis muscle behind the neck, will be under constant tension. In addition, the extensor muscles behind the neck bones that lift the head up will always be tense to maintain the eye position level at all times. Eventually, this leads to localized pain over the entire cranial bone, neck bone, mouth, and jaw joints, along with muscle cramps and pain-trigger points that can cause headaches and radiating pain [6]. This makes it difficult to maintain good posture, leading to breathing issues and causing breathing to change in a manner that relies on the upper thoracic bone, thereby increasing the tension in the shoulder. This causes difficulty in using proper breathing techniques that equally utilize the lower thoracic bone and the diaphragm [7].

Unlike normal breathing, which properly utilizes the diaphragm and its functions, abnormal breathing occurs only in the upper thoracic bone, excluding the lower thoracic bone. This breathing is often observed in patients complaining of musculoskeletal problems. Therefore, it is recommended that these patients incorporate adequate breathing exercises that use the upper thoracic bone, lower thoracic bone, and abdomen [8]. Improving diaphragm movement can increase the pressure in the abdomen to a proper amount, help stabilize the lumbar vertebrae and trunk, and aid in the correction of unstable postures. The diaphragm is attached to the six lower ribs and the xiphoid process of the lumbar vertebrae L1-3 [9]. As a result, the diaphragm plays a role in maintaining posture and breathing. A dysfunction in any of these elements can have negative effects.

Previous studies reported that posture maintenance using breathing techniques could help stabilize the core area. Spinal segmentation exercises were also found to positively affect posture maintenance, pain reduction, equilibrium, and lung capacity [10]. Correcting posture and stabilizing the pelvis through breathing exercises positively affected muscle strength, equilibrium, and respiratory activity [11].

The common treatment for straight neck includes massage, electrical stimulation, heat application, and neck extension exercises, all of which are directed at reducing pain. They differ from treatments that focus on posture, which aim to reduce the tension in joints, muscles, and connective tissues [12]. Patients suffering from neck pain due to straight neck syndrome are more likely to suffer from weakened respiratory functions than others. Weakening of the muscles surrounding and supporting the neck bone limits the diaphragm movement and causes respiratory excursion [13].

Thus, breathing exercises are required to increase the patients oxygen intake, reduce their pain, and improve the function of the nerve system [14]. Exercises for this include neuromuscular facilitation to stimulate the proprioceptor, feedback-based breathing exercises for posture control, exercises for expanding the thoracic bones via diaphragm stimulations, exercises for expanding the thoracic bones, proprioceptive neuromuscular facilitation, and abdominal breathing exercises using postural changes [14-18]. A common feature of these exercises is that they aim to aid recovery of the nervous system function by stimulating the sensorial receptors.

Although there have been many studies on respiratory muscles thus far, little attention has been paid to examining the effects of breathing exercises via mobilization of the joints on posture correction, despite its significance. Furthermore, there is a lack of research examining the positive effects of joint mobilization on the lung function and spinal alignment. Therefore, this study examined the effects of breathing exercises via joint mobilization on the lung function and spinal alignment of working women in their 20s and 30s with straight neck syndrome. The sustained effects of the exercises were analyzed for eight weeks following the program.

Ⅱ. Methods

1. Participants

For this study, 30 women who had been diagnosed with functional straight neck syndrome by a neurosurgeon were selected as participants. All were free of neurosurgical and orthopedic issues and did not suffer from significant joint degeneration. The participants' ages ranged from 20 to 30 years, and all were workers at the 'C' Hospital located in Seoul. This study was carried out from February to April 2020, and was conducted with the approval of the Namseoul University Bioethics Institute (NSU-202002-005). The participants were selected based on excluding those with neurological, neurosurgical, and orthopedic diseases; those who are pregnant or possibly pregnant; those participating in other research or rehabilitation programs; and those undergoing musculoskeletal treatment such as manual therapy or chuna therapy. Thirty patients with straight neck syndrome were enrolled in this study [19]. Measures were taken to guarantee the validity of the clinical trials. Microsoft Excel was used to assign participants into groups using randomly generated numbers. Doing so would allow maximum comparability of the experimental group and ensure that the allocation of the participants would not reflect any bias on the researcher's part to the experimental group. Participants were allocated to two groups: an experimental group of 15 people who performed breathing exercises by joint mobilization and a control group of 15 people who conducted general stretching exercises.

2. Experimental Method

The experiment was carried out after the participants received a sufficient explanation of the methods and procedures and provided written consent. Information on their general characteristics and medical traits was collected after they signed the consent forms. The experimental group and control group both had their general health traits, lung function, and spinal alignment measured before the experiment. The same person took the measurements using the same method in both groups. Two weeks before the experiment, educational and training sessions on using the pre-research equipment for intervention and measurement were conducted for the research assistants. During the experiment period, one participant in the experimental group and four participants in the control group were eliminated due to personal injuries and health issues. Thus, 25 people, 14 in the experimental group and 11 in the control group, participated in the experiment until the end. After the measurements were taken, the experimental group was assigned to carry out breathing exercises via joint mobilization, while the control group was assigned general stretching exercises. The intervention was conducted three times a week for 30 minutes each, for four weeks, for both groups. The first measurement was taken before the intervention; the second measurement was taken after four weeks of intervention to observe its effect on the participants; the third measurement was taken after another four weeks to observe its sustained effect. Each intervention was performed by two physical therapists with more than three years of experience The research involved four assistants for the intervention: two per group and two assistants for the measurements. The research was carried out over eight weeks. The 30-minute intervention sessions were performed three times a week for the first four weeks.

Table 1. Exercise Program of the Experimental Group

Order (time)	Detailed Contents	Intensity
Warm-up (5 min)	Breathing Rhythm	
Main Exercise (20 min) (2 min / program)	1) Direct stimulation of muscle the open and close the jaw 2) Weaken extension muscle stimulation 3) Atlas stimulation that is twisted inversely to the TMJ 4) Stretching the diaphragm directly while stimulating the sternum. 5) Raise the pelvic of the short leg and raise the other side of the ischial tuberosity 6) Stimulating the talus of the foot on the shorter side.	1~4 week: Easy same Intensity Program × 2 set Rest Rest between program: 1 min
Cool-down (5 min)	Check the Breathing Rhythm	

1) Breathing Exercise Group

The breathing exercise regimen that mobilizes the joints was developed by a physical therapist for the purpose of this research. The regimen was based on modifying the exercises in Walther's Applied Musculoskeletal Neurology [20], the main teaching material for this field. The jaw joints, upper cervical, sternum tubercle, sacroiliac articulation, and talus, which are the key joints for breathing, were mobilized gently. Regarding the relationship between breathing and posture, the jaw joints and the shoulders must be balanced for the type of breathing that affects the posture the most. Thus, the masseter and temporalis, which are muscles used to open and close the jaw, were rubbed as a form of direct stimulation. In the case of the ears and shoulders, the head-neck reflexes make it so that one ear is on a higher level with weaker extensor muscles than the other. To address this, the masseter and the muscle spindle of the temporalis were mobilized because they are the extensor muscles of the higher ear, with the ear and the jaw joint being on the same level. In the case of the upper cervical, the cervical vertebra No. 1 usually twists in the opposite direction of the jaw joints, so mobilization was applied to reverse the direction of the twist. In addition, the sternum tubercle was mobilized directly with motions stretching the diaphragm. In sacroiliac articulation, the posterior superior iliac spine was raised via the SOT Wedge (sacro-ocipital technique: SOT block), where the leg was shortened, and the arch of the foot was lowered. The SOT Wedge was also used to stimulate and raise the opposite ischial tuberosity. The talus bone was stimulated to correct the lowered arch of the foot. The intervention was performed for 30 minutes. The session consisted of five minutes of warm-up, 20 minutes of the main exercise regimen, and five minutes of cooling down. Table 1 lists the experimental method in the experimental group.

2) Control Group

Before the general stretching regimen in the control group, the participants were checked to determine if their head, trunk, and pelvis were aligned while lying down straight. This is because proper alignment of the spine is essential for stretching. Next, the breathing of the participants was checked to determine if their upper diaphragm, lower diaphragm, and abdominal diaphragm were functioning well. The exercise regimen used in previous studies [21] was modified for this research. Back arching stretches, such as the cat pose and the camel pose, were performed 10 times, with each pose held for six seconds. The trunk rotations were then conducted 10 times and held for six seconds each. Hip joint circling to the right and to the left was performed 10 times for five seconds each. Subsequently, calf stretching was done twice, for 30 seconds each, followed by shoulder joint circling five times, for 5 seconds each. The intervention lasted 30 minutes, consisting of five minutes of warm-up, 20 minutes of the main exercise regimen, and five minutes of cooling down.

Table 2. Exercise Program of the Control Group

Order (time)	Detailed Contents	Intensity
Warm-up (5 min)	Upper and Lower limb, Trunk Stretching	
Main Exercise (20 min) (3 min / program)	1) Cat and camel 6 sec / 10 times 2) Trunk rotation and hold 6 sec / 10 times 3) Hip joint circling / Rt. 5 sec & Lt. 5 sec / 10 times 4) Calf stretching / 30 sec / 2 times, 5) Shoulder joint to circling 5 sec / 5 times	1~4 week: Easy same Intensity Program × 2 set Rest between Program: 1 min between Set: 1 min
Cool-down (5 min)	Upper and Lower Limb, Trunk Stretching	

Table 2 lists the experimental method in the control group.

3. Measurement Apparatus

In this study, the participants' age, height, weight, and foot size were measured and compared with their general physical traits. Fit mate Med was used to measure the participants' lung function. The Cervical Lateral View of their X-ray and Intelroid were used to measure their spinal alignment.

1) Lung Function Test

A Clinical desktop metabolic system (Fit mate Med, COSMED, Italy) was used to test the forced expiratory vital capacity (FVC), the slow vital capacity (SVC), and the maximum voluntary ventilation (MVV) to examine the lung function of the participants. A licensed physical therapist conducted each test as the research leader. A disposable mouthpiece was used, considering the safety of each participant. In the forced expiratory vital capacity (FVC) test, the subject was asked to breathe normally roughly three times and then try to inhale, exhale, and inhale as much air as possible for each breath in succession. In the slow vital capacity (SVC) test, the subject was asked to breathe normally more than four times, inhale slowly to breathe in as much air as possible, exhale slowly, and then return to normal breathing. The max voluntary ventilation (MVV) test was performed for a set time, during which the subject was made to breathe as quickly and as much as possible. Each measured value was recorded as a percentage.

2) Measurement of the Cranial Rotation Angle (CRA) and Cranial Vertebral Angle (CVA)

The cervical lateral view was filmed using X-rays (Dong Gang Med, Korea) to measure the cranial rotation angle and cranial spine angle. The measurement was taken while the subjects were standing. As such, the position of the feet was marked to control gravity, which could affect the position. This way, the subjects' positions could be held identically for each measurement. To identify the changes to the front of the head on the cervical lateral view of the X-ray, the angles were measured for the side of the eye, the canthus and the ear's tragus, and the spinous process of the C7 spine. These were then analyzed to determine if the cranial rotation angle had decreased. To calculate the curve of the neck, the angle connecting the ear and the horizontal line of the C7 spine were measured and analyzed to determine if the cranial vertebral angle had increased.

4. Data Analysis

In this study, the SPSS 22.0 (IBM, USA) was used to analyze the data measured. The Schapiro-Wilk test was performed on all the data to verify their normality. A repeated two way-ANOVA was conducted for two variables (group and time) to compare the differences in the lung function and the spinal alignment for each group (a group that performed breathing exercises via joint mobilization and a group that conducted general stretching exercises) over time (before the intervention, after four weeks, and after eight weeks). One-way ANOVA was carried out to check the main effects on time and the interaction effects between the two factors. A Scheffe test was run for post verification. An independent sample T-test was conducted to examine the differences between the two groups according to time. The statistical significance level was set at $\alpha = .05$.

Ⅲ. Results

1. General Characteristics of the Participants

The experiment started with 30 women in their 20s and 30s with straight neck syndrome. One participant in the experimental group and four in the control group dropped out from the experiment for personal reasons and health issues. Thus, 25 subjects participated until the end of the experiment. Table 3 lists the general characteristics of the participants.

2. Comparison of Changes in the Lung Function by Intervention

1) Forced Expiratory Vital Capacity (FVC) Test

Table 4 lists the changes in the forced expiratory vital capacity test. No interaction effects between group and time in the FVC were observed after the intervention, whereas a significant main effect was observed with time. A post-hoc test of the time where the significant main effect occurred indicated that both the experimental and control groups showed significant differences after four weeks of intervention and four weeks of maintenance, compared to that before the intervention. There were no differences between the groups according to time.

2) Slow Vital Capacity (SVC) Test

Table 4 lists the changes in the slow vital capacity test. There were no significant interaction effects observed between the group and time regarding the changes in SVC after the intervention. There appeared to be a significant main effect on time. A post-hoc test of the time where there was a significant main effect revealed more statistically significant differences in the experimental group after four weeks of intervention and four weeks of maintenance, compared to that before the intervention.

3) Maximum Voluntary Ventilation (MVV) Test

Table 4 lists the changes in the maximum voluntary ventilation test. No significant interaction effects were observed between the group and time regarding changes in MVV after the intervention. A significant main effect for the group with time was noted. A post-hoc test of the group and time, where a significant main effect appeared,

Table 3. General Characteristics

	G1 (n = 14)	G2 (n = 11)	*P*
	Mean ± SD	Mean ± SD	
Age (years)	36.29 ± 5.32	32.55 ± 5.52	.102
Height (cm)	162.21 ± 4.28	163.73 ± 3.63	.350
Weight (kg)	57.28 ± 9.96	55.90 ± 7.75	.701
Foot Size (mm)	239.29 ± 11.06	229.36 ± 35.83	.394

SD: Standard deviation, $*p < .05$
G1: Breathing + Joint mobilization
G2: Stretching Exercise

Table 4. Statistical Analysis and Comparison of the FVC, SVC, MVV, CRA, and CVA in Each Group (Unit)

		T1	T2	T3		F	P	Post-hoc
		Mean ± SD	Mean ± SD	Mean ± SD				
FVC (%)	G1	58.78 ± 25.97	87.78 ± 10.98†	86.71 ± 10.46‡	Group	.510	.477	
					Time	19.001	.000*	T1 > T2,T3
	G2	63.63 ± 24.65	91.36 ± 13.64†	87.18 ± 15.09‡	Group*time	.098	.906	
SVC (%)	G1	65.64 ± 19.41	81.24 ± 12.32†	85.28 ± 8.11‡	Group	.510	.477	
					Time	6.889	.002*	T1 > T2,T3
	G2	72.54 ± 16.32	83.00 ± 17.75	83.09 ± 17.21	Group*time	.535	.588	
MVV (%)	G1	33.92 ± 14.45	63.64 ± 21.59†	70 .92 ± 13.69‡	Group	5.123	.027*	
					Time	22.277	.000*	T1 > T2,T3
	G2	45.90 ± 22.21	75.36 ± 21.40†	78.36 ± 24.65‡	Group*time	.103	.902	
CRA (˚)	G1	143.11 ± 8.64	136.47 ± 6.58†	133.98 ± 5.00‡	Group	.293	.590	
					Time	12.252	.000*	T1 < T2,T3
	G2	142.57 ± 7.93	130.60 ± 8.80†	131.69 ± 5.37‡	Group*time	.187	.830	
CVA (˚)	G1	73.28 ± 4.49	73.03 ± 2.41	74.39 ± 2.34	Group	1.520	.222	
					Time	2.665	.077	
	G2	73.72 ± 4.64	73.61 ± 2.61	76.27 ± 3.02	Group*time	.340	.713	

FVC: Forced expiratory vital capacity, SVC: Slow vital capacity, MVV: Max voluntary ventilation, CRA: Cranial rotation angle, CVA: Craniovertebral angle * $p < .05$,

Post hoc test by time: T1, T2 = †, T2, T3 = ††, T1, T3 = ‡, T1, T2, T3 = ‡‡

Post hoc test by Group: G1, G2 = a

G1: Breathing + joint mobilization
G2: Stretching Exercise

T1: Pre-test
T2: Post-4 weeks
T3: Post-8 weeks

revealed both groups to show significant differences in time after four weeks of intervention and after four weeks of the maintenance period, compared to that before the intervention. There was no difference in time between the two groups.

3. Comparison of the Changes in Spinal Alignment by Intervention

1) Cranial Rotational Angle (CRA)

Table 4 lists the changes in cranial rotational angle. There were no significant interaction effects between the group and time. A significant main effect was observed with time, but there was no significant difference in the group. The post-hoc test of the time in which a significant main effect occurred showed significant differences in both groups after four weeks of intervention and four weeks of maintenance, compared to that before the intervention. No difference was observed between the two groups.

2) Craniovertebral Angle (CVA)

There were no significant interaction effects on the craniovertebral angle between the groups and time (Table 4).

Ⅳ. Discussion

This study examined the effects of breathing exercises via joint mobilization on the lung function and spinal alignment of straight-necked women.

A forced expiratory vital capacity (FVC) test, slow vital capacity (SVC) test, and max voluntary ventilation (MVV) test were performed to determine the changes in the respiratory capacity between the two groups. There were no significant interaction effects observed between the group and time regarding changes in FVC after the intervention. When a significant main effect appeared, statistically significant differences in both the experimental and control groups were observed after the four-week intervention and the four weeks of maintenance, compared to that before the intervention.

In the slow vital capacity (SVC) test, while no statistically significant difference was noted in the interaction between the group and time, a significant main effect was observed with time. Compared to before the intervention, significant differences were noted in the experimental group after the four weeks of intervention and after the four weeks of maintenance. No differences were observed in the control group. This means that the intervention in the experimental group was more effective in the SVC test than the control group.

The maximum voluntary ventilation and respiratory rate were measured in the max voluntary ventilation (MVV) test. While no significant interaction effects were observed between the group and time, there was a significant main effect for the group with time. Significant differences emerged in both the experimental and control groups after four weeks and after the four weeks of maintenance compared to that before the intervention.

This is because straight-necked women have excessive tension in their upper trapezius muscle and upper thoracic bone, resulting in improper use of the diaphragm caused by the weakening of their lower thoracic bones. This leads to weakening of the abdominal diaphragmatic muscle, the spinal cord muscle, and the pelvic muscle, leading to poor abdominal pressure. This is consistent with the previous study results showing that the lack of adequate breathing weakened the forced expiratory vital capacity, slow vital capacity, and maximum voluntary ventilation [22]. To improve this, it is necessary to restore the function of the spinal cord muscle, which supports the vertebrae in posture maintenance. Moreover, it is necessary to normalize the muscle serratus posterior superior and inferior, which are connected to the ribs that activate the spine and breathing.

Breathing exercises via joint mobilization aim to restore the spinal cord function to which these muscles are attached. It does so by mobilizing the main joints in the ankles, pelvis, trunk, and head, which are important for breathing, such as the jaw joints, upper cervical, sternum tubercle, sacroiliac articulation, and talus. Such exercises can lead to an increase in abdominal pressure, which is the basic requirement for breathing. This is similar to a previous study that mobilized the joint receptors of the entire vertebrae and stabilized the body's superficial muscles, leading to the upper and lower thoracic bones being balanced, which in turn enabled proper breathing [16].

In addition, significant changes were also observed in the general stretching group. This shows that the forced expiratory vital capacity and maximum voluntary ventilation can increase following the subjects engaging in more aerobic exercises regardless of the exercise type. This is consistent with the results of a previous study [23] that reported an increase in the maximum intake of oxygen following experiments with a group with breathing exercises and a group with a gradually increasing exercise load. On the other hand, the lack of interaction effects between the two groups may be partly because the general stretching group also saw significant changes in their lung function capacity as the stretches stabilized the pelvis and the trunk. The short period of intervention is also considered one of the reasons.

The experimental group showed significant differences in the slow vital capacity (SVC) test, which measures the expiratory reserve volume, inspiratory reserve volume, single respiratory volume, and the expiratory and inspiratory capacity, after four weeks of intervention and also showed the sustained effects of the regimen after four weeks of maintenance, compared to that before the intervention. This is similar to the results of previous studies [24-27], which concluded that stimulation of the deeper joints and muscles improved the body's simultaneous contraction capacity, abdominal pressure, and body rigidity, which in turn led to a decrease in the level of dynamic stress in the subjects' daily life and enhanced their stable breathing ability. Therefore, breathing exercises via joint mobilization is a goal-oriented and effective regimen for improving the lung function of straight-necked women.

In this study, to identify the changes in spinal alignment between the experimental and control groups, the cranial rotational angle (CRA) and cranial vertebral angle (CVA) were measured using the X-ray cervical lateral view test. While there were no significant interactions between the groups and time in the cranial rotational angle, a significant main effect was observed with time. Compared to that before the intervention, both the experimental group and control group showed a significant decrease after four weeks. The changes in the cranial rotational angle were similar in both groups in terms of the interaction effects and the main effects between the group and time. As shown in a previous study [28], where both breathing exercises via joint mobilization to treat straight neck syndrome and general stretching were found to relax the muscles and increase the operating range of the joints, the cranial rotation angle was increased by increasing the range of operation of the neck bone joint. Unlike the significant differences seen in the cranial rotation angle, there were no significant differences in the cranial vertebral angle. This is because the short period of intervention made it difficult for the subjects to recognize the correct posture despite the designated feet position and X-ray posture. Thus, they did not recover the dorsal spinocerebellar tract, which is the unconscious sensorial transmitted to the spinal cord muscle, vertebra, and cerebellum. A previous study [29] concluded that the treatment of straight neck syndrome was closely linked to relaxing the subjects' abnormal physical structure and muscles to normalize the body's frame to its proper state. Therefore, to improve the spinal alignment of straight-necked women in their 20s and 30s suffering from shoulder pain, exercise regimens that include breathing exercises via joint mobilization and general stretching can be understood to have a positive impact on posture control and functional improvement. Moreover, a more effective way of treating patients diagnosed with functional straight necks would be for them to carry out a systematically organized treatment program that includes breathing exercises via joint mobilization and general stretching under the guidance of a qualified physical therapist.

Future studies will be needed to provide more insights into breathing exercises by examining the negative aspects of breathing exercises via joint mobilization. In addition, research that compares the two groups with a third, a group that is designated both the breathing exercises via joint mobilization and general stretching, will be needed.

Ⅴ. Conclusion

This study examined the effects of breathing exercises via joint mobilization and general stretching on improving the lung function and spinal alignment of women in their 20s and 30s, who were diagnosed with straight neck syndrome. The results showed that the four-week intervention positively affected both the experimental and control groups in terms of improving the lung function and spinal alignment of straight-necked patients. This suggests that both exercises may be combined for an even more effective treatment of straight neck syndrome.

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