International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 7, 2020
ISSN: 1475-7192

# Effect of Sling Neck Flexion Exercise on Concentration and Brain Activity of Subjec ts with Forward Head Posture

**Won-Sik Bae[1], Dong-Yeop Lee*[2], Keon-Cheol Lee[3]**

*[1]Professor, Dept. of Physical Therapy, Kyungnam College of Information & Technology, 45, Jurye-Ro, Sasang-gu, Busan, Korea*

*[*2] Professor, Dept. of Physical Therapy, Sun Moon University, 70, Sunmoon-ro 220 beon-gil, Tangjeong-myeon Asan-si, Chungcheongnam-do, Korea*

*[3] Professor, Dept. of Physical Therapy, Kyungnam College of Information & Technology, 45, Jurye-Ro, Sasang-gu, Busan, Korea*

*f452000@naver.com[1], kan717@hanmail.net[*2], kitpt2002@nate.com[3]*

*Corresponding author[*]: +82-010-4421-7177*

**Abstract**

**Background/Objectives:** The purpose of this study was to investigate the effect of sling neck flexion exercise o n attention and brain activity in subjects with forward head posture (FHP).

**Method/statistical Analysis:** The study group comprised 30 students who were randomly divided into two grou ps. One group(15 students) took part in sling neck flexion exercise for 6 wk, and the other group(15 students) se rved as the control. FHP was determined using a global postural system (GPS 400) device. An electroencephalo gram (EEG) was performed using EEG 3000 to assess left and right brain activity.

**Findings:** A homogeneity test revealed that the general characteristics of the subjects in the two groups did not significantly differ. A paired t-test and independent t-test were performed to analyze differences between and within two groups. The change in concentration according to the experiment duration showed a significant difference in the experimental group ($p<.05$). By contrast, the control group showed no significant difference ($p>.05$). While the change in the left brain activity showed a significant difference in the experimental group ($p<.05$), the control group did not show a significant difference ($p>.05$). The mean at each time period showed no significant difference between the two groups ($p>.05$). While the experimental group showed a significant difference in the change in the right brain activity according to the experiment duration ($p<.05$), no significant difference was observed in the control group ($p>.05$). The between-group difference of the mean at each time period showed no significance ($p>.05$).

**Improvements/Applications:** In conclusion, sling neck flexion exercise can improve brain function. Regular po stural correction exercise is required. We expect the results to be used in clinical trials.

***Keywords***: Brain activity, Concentration, Electroencephalogram, Forward head posture, Global postural system, Sling neck flexion exercise

## 1. Introduction

The number of patients with forward head posture is increasing due to the prevalence of smartphone and computer use. Furthermore, the affected age group of forward head posture is becoming younger because people are gaining access to smartphones earlier than before. As a result, the social interest in this topic is increasing, and many related studies are in progress.

According to [1], the amount of blood flowing toward the head decreases when the extent of forward head posture

is severe. This change subsequently affects the α brain wave that appears when a person shows concentration (which forms the basis of their learning ability), α brain wave that appears when a person is in a mentally stable condition, and β brain wave that is activated when a person is mentally focused.

Brain waves, which measure changes in the electronic signal exchanged among brain cells, are assessed by attaching an electrode on the head surface, which in turn allows the activation of the cerebral cortex to be objectively measured in a noninvasive manner[2]. Brain waves record the extracellular current developed by the electronic action of the excitatory postsynaptic potential (EPSP) and inhibitory postsynaptic potential (IPSP), which occurs in the cerebral cortex; thus, they contain important information about the brain activity and activation state. Brain waves are broadly used as data indicating the current movement of the brain.

Concentration is a general term that refers to the brain processing procedure where a person performs a certain task by focusing on the relevant stimulus while ignoring other stimuli[3]. The concentration process selects stimulus information coming from the environment and processes this information efficiently. Concentration is therefore the ability to choose only the necessary stimulus among numerous stimuli and process it through the visual and auditory senses, tactile sensation, and motion perception. Concentrating on a certain object or person by paying close attention is an important element of improving the learning behavior.

In general, the neck flexion exercise, which uses a sling that provides an unstable supporting ground, is performed to improve the proprioceptive sensibility of neck muscles that have a high muscle spindle density[4]. Proprioceptive sensibility is stimulated by exercises performed on unstable surfaces, which "wake up" the brain. As a result, the information processing speed increases to further improve body coordination, reflexes, and agility.

The cervical vertebra is geographically in a close relation with the brain, and forward head posture can diminish brain function and concentrating power. This study examined the attentive concentration and brain activity of subjects with forward head posture by applying exercises and measuring their brain activity.

## 2. Materials and Methods

### 2.1. *Participants*

In this study, subjects with forward head posture were chosen among the students enrolled in University K, Busan Metropolitan City, by implementing posture evaluation. Forward head posture was defined as any deviation of more than 2.5 cm of the center of the acromion from the center of the mastoid[5]. The subjects participated in this experiment after sufficiently understanding the purpose and method of this study and voluntarily agreeing on the participation. Thirty students were chosen and then evenly and randomly allocated between an experimental group (15 students) and a control group (15 students). The inclusion criteria of the subjects are summarized below.

1) Those who sufficiently understood the purpose and method of the study and voluntarily agreed to participate;

2) Those who promised not to receive additional therapy or exercise during the research duration that can affect the research outcome; and

3) Those without surgical or neurological illnesses in the neck and shoulder.

### 2.2. *Study design*

A pretest was conducted on the forward head posture, concentration, and left and right brain activity before the intervention. A post hoc test was implemented six weeks after the intervention.

### 2.3. *Measurement method*

A whole body posture measurement system (GPS 400, Chinesport, Italy) was used to select individuals with forward head posture, and a brain wave measurement instrument (CANS3000, LAXTHA, Korea) was used to investigate the concentration and the left and right brain activity. The measurements were conducted by an experienced researcher.

The GPS 400 was used to measure the forward head posture. With a computer, this instrument photographs the body using a camera and measures the extent of forward head posture using horizontal, vertical, and center lines. In accordance with the New York Posture Rating, a case was classified as "normal" when the external auditory

canal, humerus, and talus were in a vertical alignment; “mild” when the vertical line of the external auditory canal was shifted 0.5–1.0 cm to the front from the center line; and “severe” when the shift was over 1 cm. Students whose vertical distances between the humerus and the external auditory canal exceeded 1 cm were chosen as subjects in this study in Figure 1[6].

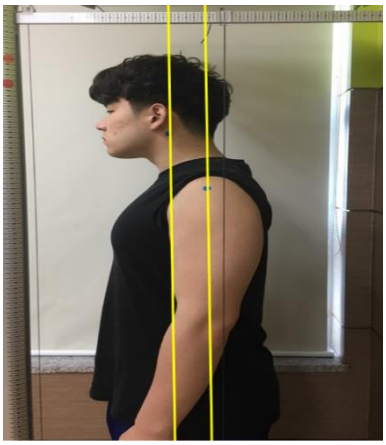

**Figure 1: Measurement of the forward head posture**

In this study, the CANS3000 electroencephalogram (EEG) instrument was used to examine how the left and right brain activity changed. EEG is a noninvasive test method that can objectively and continuously assess the function of the cerebrum, and it is broadly used in many research fields.

A cream-type EEG paste, which has better accuracy and economy than pads, was chosen for the use of the CANS3000[1]. The measurement was implemented before the exercise, three weeks after the exercise, and six weeks after the exercise. Each measurement took 5 min, and the distance between the screen and the subject was maintained at 60 cm. With the EEG paste, two electrodes were attached to the forehead (frontal lobe), and two electrodes were attached to the back of each ear (temporal lobe). Here, the electrodes were attached to the forehead right above the pupil with the subject standing still and looking straight ahead. Mildly dim blue light was used for illumination around the testing area to create a sense of stability in the atmosphere[7].

### 2.4. *Exercise methods*

The sling neck flexion exercise produces therapeutic effects by stabilizing the neck muscles, increasing muscle strength, improving muscle endurance, and promoting relaxation. The subjects assumed the prone position on a table, with their head over the edge of the table, and touched a sling with their forehead. In this position, the subjects performed the neck flexion exercise. A 30-second exercise combined with a 10-second rest consisted one set, and a total of three sets were implemented in Figure 2[8].

**Figure 2: Sling neck flexion exercise**

### 2.5. *Data analysis*

The program SPSS (version 25.0 for Windows) was used for the statistical treatment of the data. An independent t-test was conducted to check the homogeneity of the experimental and control groups. A paired t-test and an independent t-test were used to analyze the difference of the mean of the exercise group according to the time change and the between-group difference of the mean, respectively. The statistical significance level α was set

as .05.

### 3. Results and Discussion

**1. General characteristics of the subjects:** A homogeneity test revealed that the general characteristics of the subjects in the two groups did not significantly differ. The average ages of the experimental and control groups were 21.8 and 23.5, respectively. The experimental group had an average height and weight of 167.2 cm and 62.7 kg, respectively. The control group had an average height and weight of 170 cm and 63.2 kg, respectively in Table 1.

**Table 1: General characteristics of the subjects**

| Variables | EG (n=15) | CG (n=15) | t | *p* |
|---|---|---|---|---|
| Age (year) | 21.80±2.88 | 23.53±3.82 | −1.404 | .171 |
| Height (cm) | 167.20±9.36 | 170.00±8.01 | −.880 | .386 |
| Body weight (kg) | 62.67±15.73 | 63.20±18.07 | −.086 | .932 |

EG: experimental group; CG: control group

**2. Change in concentration following the experiment:** Table 2 summarizes how the concentration in the experimental and control groups changed following the six-week sling neck flexion exercise. The change in concentration according to the experiment duration showed a significant difference in the experimental group ($p<.05$). By contrast, the control group showed no significant difference ($p>.05$). The mean at each time period also showed no significant difference between the two groups ($p>.05$).

**Table 2: Change in concentration following the experiment**

| | Pre | Post | Difference | t | p |
|---|---|---|---|---|---|
| EG | 47.80±13.02 | 55.17±11.51 | −7.37 | −4.253 | 0.001 |
| CG | 50.13±10.29 | 51.15±10.22 | −1.02 | −.484 | 0.636 |
| t | −.545 | 1.011 | | | |
| p | 0.590 | 0.255 | | | |

Unit: score; EG: experimental group; CG: control group

**3. Change in left brain activity following the experiment:** Table 3 summarizes how the activity of the left brain changed in the experimental and control groups according to the sling neck flexion exercise for six weeks. While the change in the left brain activity showed a significant difference in the experimental group ($p<.05$), the control group did not show a significant difference ($p>.05$). The mean at each time period showed no significant difference between the two groups ($p>.05$).

**Table 3: Change in left brain activity following the experiment**

| | Pre | Post | Difference | t | p |
|---|---|---|---|---|---|
| EG | 45.95±5.78 | 48.96±1.65 | 3.01 | −2.346 | 0.034 |
| CG | 47.40±2.39 | 48.05±2.56 | 0.65 | −.943 | 0.361 |
| t | −.896 | 1.161 | | | |
| p | 0.382 | 0.255 | | | |

Unit: %; EG: experimental group; CG: control group

**4. Change in right brain activity following the experiment:** Table 4 summarizes how the activity of the right brain changed in the experimental and control groups according to the sling neck flexion exercise for six weeks. While the experimental group showed a significant difference in the change in the right brain activity according to the experiment duration ($p<.05$), no significant difference was observed in the control group ($p>.05$). The between-group difference of the mean at each time period showed no significance ($p>.05$).

**Table 4: Change in right brain activity following the experiment**

| | Pre | Post | Difference | t | p |
|---|---|---|---|---|---|
| EG | 54.04±5.78 | 51.05±1.64 | 3.01 | −.647 | 0.035 |
| CG | 52.60±2.39 | 51.95±2.56 | 0.65 | .647 | 0.361 |
| t | 0.892 | −1.146 | | | |
| p | 0.384 | 0.261 | | | |

Unit: %; EG: experimental group; CG: control group

Conservative therapy (such as physical agent and traction therapy) and exercise therapy (such as posture-correcting, extension, muscle-strengthening, and stabilization exercises) are being applied in clinics as main therapy programs for the rehabilitation of the neck.

[9] examined the effect of a sling exercise program and stretching on the forward head posture with the participation of healthy adults in their twenties with forward head posture as research subjects. Their study reported significant differences in the CVA and CRA before and after their experiment, which implemented the sling exercise and stretching for twice a week for four weeks. In their study, the surface electromyography test results of the experimental group showed a significant improvement in activity. Furthermore, the vertical head and upper neck angles decreased after the stretching and sling exercises. [10] applied dynamic neuromuscular stabilization, neck stabilization, neck extension, and extensor-strengthening exercises for six weeks (each exercise) to 45 subjects with forward head posture. These individuals were divided into experimental groups A and B and a control group. The authors reported an improvement in forward head posture, vertebra structure, and respiratory function. The current study also applied the sling neck flexion exercise on subjects who had forward head posture and confirmed a significant difference in the results.

Brain waves provide important information about brain activity and the brain activation state; it changes in certain ways depending on one's consciousness and mental activity. Brain waves have been used for improving cognitive functions, such as concentration, reaction time, behavior modification, accuracy, relaxation, and decision-making ability[11]. [1] determined changes in the α brain wave that appears when a person is concentrating, α brain wave that appears when a person is in a mentally stable condition, and β brain wave that is activated when a person is in a mentally concentrated condition using a sample consisting of men and women in their twenties who had forward head posture. In their study, the correlation between forward head posture and brain wave was examined using a nerve feedback system.

[12] suggested that asymmetry of the left and right brain activity is a characteristic of depression. According to [13], the difference between the left and right brain is called functional differentiation of the brain in brain science; they argued that asymmetry of the left and right cerebral hemisphere can be generally measured through brain analysis. According to their study, all individual human brains have distinguished characteristics, and the overall development of the brain and the balance between the left and right brain are necessary conditions for the optimization of brain functions. [14] implemented action observation training on subjects who showed forward head posture to measure the cerebral cortex activity; they reported a difference in the cerebral cortex activity in the experimental group but not in the control group.

In this study, the concentration score in the experimental group, as measured by the Dynavision, also confirmed such improvement over time. Brain wave measurement indicated an improvement in the symmetry of the left and right brain activity. These results imply that the sling exercise effectively improves the forward head posture. Through such improvement, the concentration and symmetry of the left and right brain activity increased, which

not only produced a posture-correcting effect but also induced an enhancement in brain function.

This study has two limitations. The daily activities of the subjects could not be controlled, and the results cannot be generalized to people in all age groups.

## 4. Conclusion

This study examined the effect of the sling neck flexion exercise aimed at correcting the forward head posture on brain function over the research duration of six weeks. The following conclusions were drawn from the results of this study. First, the concentration of the experimental group improved with time through the forward head posture-correcting exercise. Second, in the experimental group, the ability of the left and right brain gradually became balanced with time through the forward head posture-correcting exercise.

These results suggest that the correction of the forward head posture is an important factor for improving brain function, and regular posture-correcting exercise is necessary. The findings of this study are expected to be used in clinics, and continued research will be required in diverse areas to correct the forward head posture more effectively.

## 5. References

1. Lee YM, Gong WT, Jeon JY. Correlations between forward head posture, range of motion of cervicospinal area, resting state, and concentrations of the brain. J Phys Ther Sci. 2011 Aug;23(3):481-4.
2. Wing K. Effects of neurofeedback on motor recovery of a patient with brain injury: a case study and its implications for stroke rehabilitation. Top Stroke Rehabil. 2001 Sep;8(3):45-53. DOI:10.1310/4G2F-5PLV-RNM9-BGGN.
3. Baker F, Tamplin J, Kennelly J. Music therapy methods in neurorehabilitation : a clinician's manual. Philadelphia: J. Kingsley; 2006.
4. Liu JX, Thornell LE, Pedrosa-Domellof F. Muscle spindles in the deep muscles of the human neck: a morphological and immunocytochemical study. J Histochem Cytochem. 2003 Feb;51(2):175-86. DOI: 10.1177/002215540305100206.
5. Salahzadeh Z, Maroufi N, Ahmadi A, Behtash H, Razmjoo A, Gohari M, et al. Assessment of forward head posture in females: observational and photogrammetry methods. J Back Musculoskelet Rehabil. 2014 Apr;27(2):131-9. DOI:10.3233/BMR-130426.
6. Harman K, Hubley-Kozey CL, Butler H. Effectiveness of an exercise program to improve forward head posture in normal adults: a randomized, controlled 10-week trial. J Man Manip Ther. 2005;13(3):163-76. DOI: 10.1179/106698105790824888.
7. Heo JS, Choi WS, Bae NY, Ryu YH, Dong KR, Yeo HY. The effects of the light stimulus in accordance with background light of EEG laboratory room. Journal of Advanced Engineering and Technology. 2014 Jun;7(2):79-84.
8. Kim SY, Kwon JH. Lumbar stabilization exercises using the sling system. Journal of Korean Academy of Orthopaedic Manual Therapy. 2001 Jun;7(2):23-39.
9. Kim EJ, Kim JW, Park BR. Effects of sling exercise program on muscle activity and cervical spine curvature of forward head posture. The Journal of the Korea Contents Association , 2011 Nov;11(11):213-20. DOI:10.5392/JKCA.2011.11.11.213.
10. Bae WS, Lee HO, Park DJ. Effects of breathing methods on neck muscle activation in subjects with a forward head posture. PNF and Movement, 2017 Aug;15(2):159-66. DOI:10.21598/JKPNFA.2017.15.2.159.
11. Evans JR, Abarbanel A. Introduction to quantitative EEG and neurofeedback. San Diego: Academic Press; 1999.
12. Davidson RJ. Cerebral asymmetry and emotion: Methodological conundrums. Cognition and Emotion. 1993;7(1):115-38. DOI:10.1080/02699939308409180.

13. Bak KJ, Park PW, Ahn SK. A study on the effects of prefrontal lobe neurofeedback training on the correlation of children by timeseries linear analysis. Journal of the Korea Academia-Industrial Cooperation Society. 2009 Jul;10(7):1673-9. DOI:10.5762/KAIS.2009.10.7.1673.

14. Yang HS, Kang HJ. Comparison of electroencephalographic changes during mental practice and action observation in subjects with forward head posture. J Korean Soc Integrative Med. 2019 Sep;7(3):171-80. DOI:10.15268/ksim.2019.7.3.171.