



Original Article

Effects of neurofeedback training on the cervical movement of adults with forward head posture

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Abstract. [Purpose] The purpose of the present study was to examine the effects of neurofeedback training on postural changes in the cervical spine and changes in the range of motion of the neck and in the Neck Disability Index in adults with forward head posture. [Subjects and Methods] The subjects of the study were 40 college students with forward head posture, randomly divided into a neurofeedback training group (NFTG, n=20) and a control group (CG, n=20). The neurofeedback training group received six sessions of pottery and archery games, each for two minutes, three times per week for four weeks, using the neurofeedback system. [Results] There were no significant effects within and between groups in terms of the absolute rotation angle, anterior weight bearing, and range of extension and flexion by x-ray imaging. There were significant effects in the neurofeedback training group pre- intervention and post-intervention in Neck Disability Index. There were significant effects between groups in Neck Disability Index. [Conclusion] It is thought that neurofeedback training, a training approach to self-regulate brain waves, enhances concentration and is therefore an effective intervention method to improve neck pain and daily activities.

Key words: Neurofeedback, Forward head posture, Neck Disability Index

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INTRODUCTION

Forward head posture (FHP) pushes the center of the head forward and upwards which, in turn, increases the head weight supported by the neck, triggering relative compensatory mechanisms, such as increased cervical lordosis and abnormal and sustained contractions in the suboccipital muscle and muscles in the neck and shoulders. As this posture causes changes in the head and neck area¹⁾, it is thought to be one of the most well-known postures that result from poor posture. In this posture, posterior cranial rotation occurs to adjust the eyes by rotating the head backwards and in the end, there is an increase in the cervical extensor; if sustained for long enough, there will be a loss of the normal cervical lordosis²⁾. Such increases in the lordosis and muscles in the suboccipital region, neck, and shoulders—in other words, such muscle contractions cause changes in the head and neck area³⁾. Humans are greatly influenced by physical, structural, and functional changes that result from posture. Therefore, it is highly likely that they experience a decline in learning performance, concentration, and memory with poor postures. Ultrasound therapy, therapeutic exercise, electrical stimulation therapy, and a combination of therapeutic interventions are often used as treatments for FHP. Neurofeedback is a brain-training program that self-regulate one's own brain waves by providing feedback on the status of brain waves induced using the biofeedback technique⁴⁾. The underlying principle of neurofeedback is that it improves brain plasticity by enhancing the self-regulation of brain homeostasis with brain waves. In other words, people self-train their brains by looking, hearing, and feeling their own brains. Neurofeedback does not merely involve increasing specific brain waves, but also maintaining and optimizing the health of brain functions by bringing balance and harmony of brain waves. Because the brain self-teaches and self-trains in accordance with the given

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information, a strong network of nerve fibers that connect brain cells develops, leading to improvements in blood circulation, which in turn increases the supply of oxygen and stimulates the delivery of information, greatly improving the brain functions⁵). As the self-training program of brain waves⁶, neurofeedback training aims to normalize cerebral functions by either decreasing or increasing specific brain waves when a patient receives visual or auditory feedback on the activities in the cerebral cortex during a brain wave measurement⁷. Therefore, the training is being used in various fields of study, such as sports training, that require concentration⁸).

Since it is thought that cervical spine misalignment not only affects FHP, but also concentration, the present study aims to investigate the effects of neurofeedback training on the postural changes, range of motion (ROM), and Neck Disability Index. (NDI) of the cervical joints while tracking changes using x-ray imaging.

SUBJECTS AND METHODS

The subjects of the present study were students of University G in North Gyeongsang province whose cervical lordosis angle was below 21 degrees⁹), whose anterior weight bearing (AWB) of the head was above 15 mm¹⁰), and whose cervical extension ROM was below 70 degrees (Neuman). They were adequately informed of the purpose and methods of the study and took part in the study after voluntarily signing the consent form. The subjects who regularly took medications or therapies to ease pain until recently and who had neurological problems were excluded from the study. Table 1 shows the general characteristics of the study subjects (Table 1). All parents of the enrolled participants provided written informed consent prior to this experiment in accordance with the ethical standards established in the Declaration of Helsinki.

The subjects in the present study who had signed the consent form were randomly divided into a neurofeedback training group (NFTG) and a control group (CG) and took x-ray images. In accordance with their NDI measurements, each group underwent a four-week intervention program of three sessions per week. After four weeks, the subjects again took x-ray images and measured their NDIs. The NFTG performed the program using a neurofeedback system developed by Braintech Corp. in Korea. The neurofeedback training took place in a light-blocking and noise-cancelling space. After a 10-minute break, the subjects wore headbands while adjusting the midline electrode site, FPz to be over the center of the forehead, which is the prefrontal region and connecting the reference electrode to the left earlobe. The training methods included pottery and archery games as part of the concentration training. First, for the pottery game, the subjects would score the most points when they made most cups out of broken pieces of glass. When the stability of brain waves met the satisfactory level of stability for training, a signal was sounded and a cup was made, but when the brain waves became unstable, the training stopped. The game was repeated six times for two minutes per session. Second, for the archery game (mind arrow) where the subjects shot arrows with their brain waves, when the brain waves met the training conditions, a signal was sounded. If an arrow was shot when the signal was sounded, the subjects had a high probability of hitting the bullseye. The game ended when 15 arrows were shot within two minutes, showing the brain training performance in terms of scores. The game was repeated six times within a period of 12 minutes. We measured the subject's cervical position using x-ray imaging. The absolute rotation angle (ARA)¹¹ was measured to calculate a cervical lordosis angle, and the anterior weight bearing (AWB)⁴ was measured to assess FHP. And to find the neck flexion and extension angles, the range of flexion and extension motion (RFEM)¹² was examined by x-ray imaging. We also checked the NDI. The NDI was comprised of a total of 10 questions to measure the neck pain and functional disorder of respondents. The respondents were asked to choose one option out of six (0–5 points) in 10 survey items, namely neck pain, daily activities, lifting objects, reading, headache, concentration, work, driving, sleep, and leisure activities. The higher the score, the greater the neck dysfunction. The score range was between zero and 50, indicating 0–4 for no disability, 5–14 for mild disability, 15–24 for moderate disability, 25–34 for severe disability, and above 35 for complete disability¹³). For the data analysis, SPSS 14.0 for Windows was used to process the statistics, and independent t-tests were carried out to compare differences within and between the groups. Statistical significance was set at 0.05.

Table 1. General characteristics of each group (Mean ± SD)

	NFTG (n=20)	CG (n=19)
Male/Female	9/11	9/10
Age (years)	20.9 ± 3.3	22.8 ± 4.4
Height (cm)	168.5 ± 9.2	167.6 ± 8.7
Body weight (kg)	59.3 ± 11.5	59.5 ± 11.4

NFTG: neurofeedback training group, CG: control group

RESULTS

There were no significant within-group differences in the AWB, ARA, cervical flexion and extension angles, and RFEM ($p>0.05$). Moreover, there was no significant within-group difference in the NDI pre-intervention ($p>0.05$). However, post-intervention, a significant difference in the NDI was found within the NFTG ($p<0.05$) (Table 2).

In addition, no significant between-group differences were found in the AWB, ARA, cervical flexion and extension angles, and RFEM, both pre- and post-intervention ($p>0.05$). Moreover, there was no between-group difference in the NDI pre-intervention ($p>0.05$). However, post-intervention, a significant between-group difference in the NDI was found ($p<0.05$) (Table 2).

DISCUSSION

Modern people suffer problems in the cervical spine due to continuous stress and poor posture, as they overwork and overpressure their cervical spines by sitting at a computer for a long period of time, using a smartphone, and lacking exercise. Such postural change in the cervical spine causes dysfunction and imbalance in the head and neck and is accompanied by limitations in the ROM and pain¹). Neurofeedback training is a comprehensive training system that spurs the growth of and change in brain cells as a part of biofeedback training¹³). Biofeedback training involves a patient learning to control his or her physical activities while effecting changes in his or her own physiological activities as various physiological signals that occur in the human body are converted into easy-to-understand visual signals by a computer¹⁴). Brain waves, one of the physiological signals that occur in the human body, reflect specific mental statuses in humans. Therefore, changes in mental status can be observed with brain waves. In the present study, after college students with FHP underwent the neurofeedback training, a comparative analysis of changes in x-ray images (AWB, ARA, RFEM) and NDIs was conducted to investigate whether there were any postural and functional changes in the cervical joints. No significant increases were found in the AWB and cervical flexion angle of the NFTG and CG. Hence, to improve posture in the cervical spine, physical therapy interventions, such as direct joint mobilization and direct improvement in the muscle strength of stabilizers that maintain joint alignments, are important¹⁵). However, such direct interventions were excluded from the present study, and only neurofeedback training, an internal biofeedback system of brain waves, was used, which is thought to have made it difficult to directly cause postural change and increase the ROM in the cervical spine. Such research findings suggest that when joint mobilization, exercise therapy, and neurofeedback training are applied in combination to people with poor posture of and pain in the cervical spine, it will have a greater impact on improving their neck pain and functional recovery in the future. Gong et al.¹²) reported that after patients who had neck pain associated with acute whiplash performed exercise, there was a reduction in the NDI in chronic neck pain patients. In the present study, a significant increase was observed in the NFTG. This is thought to be the result of neurofeedback training, which maintained stable and effective brain functions in the NFTG. Moreover, with the improvement in the dynamic functions in the cervical spine, the group's daily activity function improved partially. With the postural improvement in the neck, the stress in the muscles around the neck was reduced, leading to a lower NDI, which in turn improved concentration. In addition, pain reduction in the NDI was found both in the study¹⁵) of neurofeedback training on patients with chronic pain and by Ibric and Dragomirescu¹⁶), who applied neurofeedback training to patients who complained of neck and temporomandibular pain as well as a sleep disorder. Teaching self-regulation to either reduce or alleviate pain sensations by stabilizing the pain in the central nervous system is the core of neurofeedback training. From the aforementioned results, it is expected that the subjects in the NFTG experienced pain reduction in the cervical spine. Moreover, the finding in which scores in the NDI indicating functional disorders improved is in line with the research findings of Yu Yeon-Ho⁸) who reported improved physical movement abilities, such as static coordination ability,

Table 2. Comparison of the change of neck position and Neck Disability index (NDI) between the neurofeedback training group and the control group (mean \pm SD)

	NFTG		CG	
	Pre-test	Post-test	Pre-test	Post-test
AWB	22.5 \pm 5.4	21.9 \pm 4.9	22.2 \pm 4.7	23.7 \pm 6.5
ARA	11.1 \pm 4.1	11.8 \pm 4.2	10.6 \pm 3.6	11.7 \pm 3.5
Flexion	16.6 \pm 9.5	16.3 \pm 5.0	18.1 \pm 7.8	18.6 \pm 4.9
Extension	50.6 \pm 7.2	51.7 \pm 5.4	51.3 \pm 7.9	50.8 \pm 6.8
RFEM	67.2 \pm 12.7	68.0 \pm 7.2	69.4 \pm 9.8	69.3 \pm 7.5
NDI	7.2 \pm 1.5	6.7 \pm 1.7 ^{*a}	7.5 \pm 1.8	7.7 \pm 1.9

*Significant difference from the pre-test at $p<0.05$. ^aSignificant difference in gains between the two groups. $p<0.05$. NFTG: neurofeedback training group, CG: control group. AWB: anterior weight bearing, ARA: absolute rotation angle, RFEM: range of flexion and extension motion, NDI: neck pain and disability index

hand movement coordination ability, general movement coordination ability, and the ability to perform simultaneous movement and single movement. Furthermore, Yu Saeng-Yeol¹⁷⁾ reported that concentration training with biofeedback enhanced pitching performance and partially improved attention, while Chang Jae-Geun¹⁸⁾ found that concentration training with brain wave regulation had a positive impact on sprint performance. Therefore, the findings of the present study can be seen in the same light.

In the present study, although neurofeedback training could not be confirmed to directly cause change in the postural alignment of patients with FHP, it is thought to have improved their overall ability to carry out daily activities and their physical functions. Building on the findings of the present study, it is hoped that there will be continuous research on neurofeedback training to investigate its effects on improving concentration and direct changes in brain waves.

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