

Effect of Neuro-Feedback Training and Transcutaneous Electrical Nerve Stimulation (TENS) in Stress, Quantitative Sensory Threshold, Pain on Tension Type Headache

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Purpose: The objective of this study is to evaluate the effect of neuro-feedback training and transcutaneous electrical nerve stimulation (TENS) on stress, quantitative sensory threshold and pain in patients suffering from tension type headache.

Methods: 22 participants who passed the preliminary evaluation were enrolled in the study and 11 participants were randomly assigned to each group. The control group (n=11) was subject to the TENS treatment of which was composed of a 20-minute session for 5 times a week during 4 weeks, and the experimental group (n=11) was subject to both neuro feedback training and TENS treatment for 10 minutes a day and 5 days a week during 4 weeks.

The Perceived Stress Scale (PSS) was used to measure a level of stress and the quantitative sensory testing (QST) was used for the measurement of cold pain threshold (CPT) and heat pain threshold (HPT); A degree of pain was evaluated through the headache impact test-6 (HIT-6).

Results: In comparison of all dependent variables between the control and subject groups, there were significant differences in stress, quantitative sensory threshold and pain after the treatment ($p < 0.05$), and the experimental group showed significant differences in stress, CPT, HPT and pain ($p < 0.05$) and the control group showed only a significant difference in HPT ($p < 0.05$).

Conclusion: Findings of this study demonstrate that the concomitant administration of the TENS treatment and neuro feedback training is effective on alleviation of stress, quantitative sensory threshold and pain in patients with tension type headache.

Key Words: Neurofeedback, Pain, Sensory threshold, Stress, TENS, Tension type headache

I. Introduction

Headache is one of the most common diseases that most people have it at some time in their life.¹ The most common form of headache is tension-type headache with prevalence of 86%.² There are two types of tension-type headache; frequent episodic tension-type headache and chronic tension-type headache.³ The causes of headache are various including

genetic and neurophysiological causes such as stress, anxiety and depression and it is challenging to make a definite diagnosis.⁴

Especially, the 20s is usually under a great deal of stress due to anxiety over adaptation to a new environment and employment and show a danger signal of the mental health.⁵ Stress is a significant cause of various diseases.⁶ It could develop vascular complications by causing the neck muscle atrophy and arise and/or aggravate a headache by generating substances triggering headaches.⁷

As for a headache, it is important to treat a disease and/or malfunction, its fundamental cause.⁸ Most people usually take medication for alleviating pain.⁹ Still, medication has a risk of side effects and overdose of painkillers could cause

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rebound headaches and make a symptom rather chronic.¹⁰ Transcutaneous electrical nerve stimulation (TENS) is a non-pharmacologic and non-invasive treatment for pain alleviation and it could be administered in a simple manner without risks of side effects.¹¹ It has been widely adopted since it is able to reduce pain by stimulating the nerves without worries about side effects caused by long-term administration of medication,¹² but not a sufficient radical treatment. In addition, there is a neuro feedback training using a biofeedback.¹³ This neuro feedback training enables patients to control their brainwaves, in turn alleviating migraine, tension-type headache, depression and stress.¹⁴ Moreover, there is a report that the neuro feedback training could elevate the compliance and effect of medication.¹⁵

To measure a degree of pain, there should be reliable data on conditions of a patient that could help the patient and an operator have a smooth conversation. The interpretation of subjective data could vary with different evaluators.¹⁶ Thus, the importance of the quantitative sensory testing (QST) has been emphasized for collecting subjective and detailed data and making a reliable evaluation. Moreover, it would be necessary to consider mental aspects of headaches as well.¹⁷ There are a number of studies on the objectification of pain and sense through the TSA-II for the cerebral infarction sensory testing, trigeminal nerve damage and orofacial region, but only few studies on headaches.^{18,19}

Thus, this study aims to reveal the effect of the TENS treatment and neurofeedback training on stress, sensory threshold and pain.

II. Methods

1. Subjects

In the study, undergraduate students, in their 20s, of G

University were required to complete HIT-6. The inclusion criteria for this study was the HIT-6 score of 50 or above. In accordance with the classification of the international headache society,²⁰ 22 undergraduate students were found to have tension-type headache since they answered that they have two of the following four characteristics: headache for more than 10 times in less than 12 days a year, headache lasts for 30 minutes to 7 days, headache of bilateral, non-pulsatile, or minor or moderate degree, headache not aggravated by physical activities (Table 1). Episodic headache, headache with loss of consciousness or epileptic seizure, paralysis or hypoesthesia on a side of the body opposite to the side experiencing a headache, administration of medication for last 4 weeks and non-suitability for electronic treatment were the exclusion criteria for the study.³ Every participant voluntary agreed to participate in the study and the study was conducted in compliance with the code of ethics.

2. Instruments and measurement

For the scale of stress, the perceived stress scale (PSS) is used and it is made of 10 questions – 0=never, 1= almost never, 3= sometimes, 4= very often.²¹ TSA-II (Medoc, Israel, 2001) was used to measure the degree of the QST. TSA-II is a non-invasive device delivering quantitative assessment of pain sensory by measuring small caliber fibers, which compose the pain pathway. Cold pain threshold (CPT) is a degree of pain felt at 10°C and it usually evaluates complex functions of C fiber and A-delta fiber, and heat pain threshold (HPT) is a degree of pain felt at 45°C and it assesses functions of C fiber.^{18,19} Based on a previous study that applied a sensor on the peripheral areas sensing pain,²² a sensor was located on the temporal region on the head side with headache. With temperature of 32°C as baseline, change the temperature at a speed of 1°C/s and participants were required to press a button as soon as

Table 1. General characteristics of subjects

Variable	Control group (n=11)	Experimental group (n=11)
Age (year)	26.8 ± 5.7	24.3 ± 4.7
Gender (M/F)	5 / 6	4 / 7
Height (cm)	167.9 ± 5.6	166.3 ± 7.1
Weight (kg)	64.8 ± 4.8	62.8 ± 7.5

they felt a change in the temperature as pain.¹⁹ It was measured three times and the average score was calculated.

To assess a subjective degree of pain considering a psychological aspect, Headache Impact Test-6 (HIT-6) was conducted. It is a questionnaire designed to measure the impact headaches have on a patient's ability. IT includes 6 questions for assessment of pain, social function, role function, cognitive function, psychological pain and vitality. A question answered "Never" = 6 points for 'Never'; A questions answered 'Almost Never'= 8 points; A question answered 'Sometimes'=10; A question answered 'Often'=11 points; A question answered 'Always'=13. If the score is 50 to 55, headache has a substantial impact on a life, and if the score is 60 or above, headache has a very severe impact on a life.²³

3. Intervention

The study was conducted from the 1st of June to 30th of June 2014. 22 participants were randomly assigned to two groups. The control group (n=11) was subject to the TENS treatment on the upper trapezius, of which was composed of a 20-minute session for 5 times a week for 4 weeks, and the experimental group (n=11) was subject to both neuro feedback training and TENS treatment for 10 minutes a day and 5 days a week for 4 weeks. The intervention was made 5 times a week for 4 weeks in total.

The baseline amplitude, frequency and amplitude of the TENS (Dynamec 301, Dae Yang Medical, Korea) were 200 μ s, 150 Hz and 5 mA, respectively. It was conducted for 20 minutes without causing any displeasure to patients.²⁴ By using the triangular placement method, it was attached on the upper trapezius and region occipitalis on both sides.¹¹

Neuro feedback was conducted using the Procomp Infiniti(SA7951 version 5.1, Thought Technology, Canada) to train brainwaves. In a quiet space with no interference, the train was made one on one. To prevent the inflow of artifacts, a participant was required to have a comfortable posture and keep the movement minimum. In accordance with the international 10-20 system, an electrode was attached onto Cz. A ground lobe and a negative lobe were attached on each ear. EEG-Z Sensor was used after the impedance check.¹⁴ After setting the reward threshold and inhibit threshold to

Alpha(α , 8 - 12 Hz) and sensory motor rhythm(SMR, 12-15 Hz), respectively,²⁵ 3 games were conducted. When the α -wave and SMR-wave get activated, a helicopter starts to fly, bowling pins gets fell over and coins starts to get flipped on the monitor and sounds go on through speakers. On the other hand, all the motions get stopped when the α -wave and SMR-wave start to get slowed. This training helps raise an interest and alleviate stress. After being acquired with the training, one random program was conducted for 10 minutes in one day.

4. Statistical analysis

SPSS 20.0 program was used to compute the mean and standard deviation of data of the study. The test of normality on general properties of participants showed that they are normally distributed. The independent t-test was used to demonstrate statistically significant differences between the two groups and the paired t-test was for assessment of statistically significant differences between participants across groups. The statistical significance level was $\alpha=0.05$.

III. Results

1. Comparison of PSS, HIT-6 between Control and Experimental group

The perceived stress scale of the control group was 23.83 points prior to the intervention, but changed to 22.75 points after the intervention. Also, of the experimental group was 26.83 points prior to the intervention and changed to 18.42 points after the intervention. In the experimental group, there was a significant difference ($p<0.05$). The comparison of two groups also demonstrated that there was a significant difference between the control and experimental groups ($p<0.05$) (Table 2).

A score of the HIT-6 of the control group was 57.38 points prior to the intervention, but reduced to 55.08 points after the intervention. In addition, a score of the HIT-6 of the control group was 55.91 points prior to the intervention, but reduced to 45.27 points after the intervention. In the experimental group, there was a significant difference ($p<0.05$); There was a significant difference between the control and experimental

Table 2. Comparison of PSS, HIT-6 between Control and Experimental group (Score)

		Control group (n=11)	Experimental group (n=11)	t
PSS	Pre	23.83 ± 2.98	26.83 ± 4.28	1.992
	Post	22.75 ± 3.36	18.42 ± 4.87	-2.537 †
	t	1.744	4.069*	
HIT-6	Pre	57.38 ± 4.87	55.91 ± 3.05	-0.869
	Post	55.08 ± 6.28	45.27 ± 3.85	-4.504 †
	t	1.646	6.478*	

PSS: Perceived stress scale, HIT-6: Headache Impact Test-6

*p<0.05; significant difference compared with the pretest

†p<0.05; significant difference compared with the Control group

Table 3. Comparison of Quantitative sensory threshold between Control and Experimental group

		Control group (n=11)	Experimental group (n=11)	t
CPT(°C)	Pre	15.30 ± 2.08	16.29 ± 2.71	1.368
	Post	13.94 ± 2.87	10.20 ± 2.82	-3.217 †
	t	1.668	8.260*	
HPT(°C)	Pre	34.53 ± 4.31	34.68 ± 2.78	0.101
	Post	37.91 ± 2.64	40.31 ± 2.83	2.150 †
	t	-2.295*	-4.637*	

CPT: Cold pain threshold, HPT: Heat pain threshold

*p<0.05; significant difference compared with the pretest

†p<0.05; significant difference compared with the Control group

groups after the intervention ($p < 0.05$)(Table 2).

2. Comparison of pre and post intervention Quantitative sensory threshold

The CPT of the control group was 15.30°C prior to the intervention, but changed to 13.94°C after the intervention. Also, of the experimental group was 16.29°C prior to the intervention and changed to 10.20°C after the intervention. In the experimental group, there was a significant difference ($p < 0.05$). The HPT of the control group was 34.53°C prior to the intervention, but changed to 37.91°C after the intervention. Also, of the experimental group was 34.68°C prior to the intervention and changed to 40.30°C after the intervention. There were significant differences ($p < 0.05$) in both groups. The comparison of two groups also demonstrated that there was a significant difference between the control and experimental groups in terms of both CPT and HPT ($p < 0.05$) (Table 3).

IV. Discussion

Tension type headache usually causes pain that radiates in a band-like fashion bilaterally from the forehead to the occiput.²⁶ In addition, improper posture causes muscular imbalance and in turn causes a musculoskeletal issue.²⁷ Moreover, central sensitization caused by prolonged tension type headache could develop it to chronic tension-type headache,² and especially stress, deteriorated concentration and depression have substantial impacts on the 20s.²⁸ There is a high risk of relapse of a disease with a high prevalence.¹⁰ Thus, it should be treated at an early stage. Medication is only affective for momentary pain alleviation, and not a radical treatment and rather lead to the secondary headache.²⁹ Thus, a physical therapy, a non-invasive treatment, has received a lot of attention.³⁰ The TENS has almost no risks of side effects and can be administered in a simple fashion; It is widely used as intervention for pain alleviation, but not a sufficient radical treatment.³¹ On the other hand, neuro feedback training leads an increase in reward threshold and a decrease in inhibit threshold through biofeedback.³² It could enhance performance of the brain to the optimum level and reduce mental and

physical strain and stress, resulting in refreshment of both body and mind.¹³

Thus, the study aimed to investigate a non-invasive treatment effective for tension-type headache. Moreover, effects of the experimental treatments were evaluated through objective assessment and life evaluation.

Through the comparison with changes in PPS, it was revealed that there was a significant decrease in stress in the experimental group. Othmer et al³³ claimed that neuro feedback training is effective on reducing a stress level in patients suffering from a post traumatic stress disorder (PTSD) by controlling; Walker et al³⁴ reported the effects of neuro feedback training on stress and memory, assessment items of the self-rating scale, in PTSD patients. Also, Hammond³⁵ reported the alleviation of stress by resolving chronic fatigue. Findings of these studies also supported by the study demonstrating the effect of the TENS and neuro feedback training on stress reduction.

There is a report that the referred pain, caused by activation of a trigger point of myofascial pain, is matched with a pain area for tension-type headache.³⁶ The trapezius could be a cause of tension type headache due to stabilization of the head, visual strain, concentration and fatigue.³⁷ Thus, the TENS was applied on the trapezius.

In the study, the CPT of the control group was reduced by 1.36°C and of the experimental group was also reduced by 6.09°C. Also, the control and experimental groups show increases in the HPT by 2.38°C and 5.63°C, respectively. TENS is credited with analgesia through various mechanisms, and the most probably mechanism evaluated in this study was the blockage or the increase in threshold of nervous fiber depolarization.^{12,28} Especially, considering a significant difference shown in the experimental group, it would be reasonable to assume that a proper neuro feedback training could influence sensory threshold. Kwon et al²² reported changes in the CPT and HPT by -4.07°C and +4.98°C, respectively, after the administration of acupuncture. This finding corresponds with of the study.

Moreover, Cramp et al²³ and Hooten et al³⁸ also demonstrate that there are an increase in muscle tone on a body part with pain and a decrease in temperature on a peripheral part and

the higher the pain intensity, the lower the cold/hot pain threshold. Findings of this study reveal that the TENS and neuro feedback training prevent excitotoxicity of the C fiber and A-delta fiber and results in relaxation, leading to stress alleviation, pain alleviation and sensory threshold increase.

Howe et al³⁹ also reported that the SMR (sensory motor rhythm) training could inhibit a somatosensory information process and reduce muscle tone through the GABA (Gamma-aminobutyric acid). A non-invasive neuro feedback training is considered to have a positive effect on muscle tone alleviation and influence pain threshold consequently.¹³

To properly evaluate headaches, it would be necessary to consider psychological conditions.¹⁷ The experimental group of the study showed a significant decrease in headaches. Moreover, the study demonstrated effects of neuro feedback training on tension alleviation and psychological aspects. Scott et al⁴⁰ claimed that neuro feedback training is effective on psychological issues such as difficulties with concentration, perception and impulse control. In addition, a finding of β -SMR training is effective on emotion relaxation supports a result of this study.

The limitation of this study is a small number of samples. Accordingly, research on a diversity of subjects will be necessary. Further, this study concerned adults in their 20s and research on a wide range of age groups is needed for objectifying the result.

Based on these findings, it would be reasonable to assume that the concomitant administration of the TENS and neuro feedback training is effective on alleviation of stress, sensory threshold and pain. In the future study, it would be necessary to expand age ranges of participants and to monitor its persistent effects through a follow-up study.

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