Pol. J. Appl. Sci., **2018**, *4*, 72-77

THE EFFECT OF EMG-BIOFEEDBACK IN THE TREATMENT OF TENSION-TYPE HEADACHE: A PILOT STUDY

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Abstract: Introduction: aim, primary thesis. A tension-type headache (TTH) is the most common type of idiopathic headache. EMG-biofeedback is a non-invasive rehabilitation technique in which the measurements of muscle tension are monitored in order to improve muscle control and reduce health disorders. The aim of the study was to assess the potential effectiveness of EMG-biofeedback therapy on the course of tension-type headache in young adults.
Materials and methods. The uncontrolled study included 21 patients (11 men, 10 women) aged 20-27 years (mean = 23.05 ± 1.93 years) with episodic tension-type headaches diagnosed based on ICHD-II. Each of the patients underwent 15 EMG-biofeedback training sessions lasting 22 minutes aimed at reducing trapezius muscle tension. The measured parameters were muscle tension registered before and after the biofeedback training sessions. Additionally, pain intensity and frequency along with subjective dorsal muscle tension on a 5-point scale were assessed.
Results. After the series of 15 EMG-biofeedback training sessions, headache intensity decreased in 52% of the patients. These results correlated with reduced muscle tension ($p < 0.012$) and decreased subjective assessment of dorsal muscle tension ($p < 0.05$). Headache frequency decreased in 66% of the patients, but these results were not statistically significant ($p=0.055$).
Conclusions. This study confirms the effectiveness EMG-biofeedback training as an additional therapy technique in the treatment of tension-type headache in young adults.

Key words: tension-type headaches, EMG-biofeedback, biofeedback, TTH, therapy.

DOI: 10.34668/PJAS.2018.4.2.06

Introduction

A tension-type headache (TTH) is the most common type of idiopathic headache in adults as well as children; it occurs in 40-78% of the population [1, 2]. According to the International Classification of Headache Disorders-2 [3], a tension-type headache is a bilateral, mild-to-moderate headache. It is described as blunt, pressing, tightening but non-pulsating pain [4]. Its intensity does not increase due to usual physical activity, nor does it limit daily activities. The pain is usually without additional symptoms such as nausea, vomiting, photophobia or phonophobia, which differentiates it from a migraine [3–5]. Despite this, it is a serious social and therapeutic problem due to the frequent work breaks and sick days sufferers are forced to take as well as the costs of headache treatment [6, 7].

Two types of tension-type headaches can be distinguished in terms of duration: episodic TTH (lasting no more than 15 days a month) and chronic TTH (lasting at least 15 days a month).

The most common TTH-inducing factors include mental stress, improper and irregular meals, excess caffeine, dehydration, sleep disorders, fatigue, anxiety, depression, prolonged muscle tension, and drug-induced headaches [8, 9]. The pathomechanisms of TTH are not yet fully understood. Peripheral mechanisms play a main role in episodic TTH and central mechanisms in chronic TTH. Environmental factors seem to be more involved in the pathogenesis of episodic TTH, whereas genetic factors play an important role in the development of chronic TTH [10–13]. It is always necessary to identify and eliminate triggers responsible for inducing and maintaining headaches [14, 15].

The results of recent studies indicate that lowered threshold of nociceptor excitability in the pericranial muscles (head, neck and shoulder muscles) as well as increased sensitivity of pain pathways play a significant role in the pathomechanism of TTH [16–19].

Treatment of TTH episodes involves the use of paracetamol and nonsteroidal anti-inflammatory drugs. Chronic TTH therapy involves the use of antidepressant agents: amitriptyline as a first-line drug, and mirtazapine and venlafaxine as second-line drugs. All the above-mentioned substances cause a number of adverse effects and must be used reasonably, so as not to exceed the maximum doses. The use of tryptanes, opioids and agents to reduce muscle tension is not recommended [20]. Pharmacotherapy should always be supported by behavioral therapy (regular lifestyle, healthy eating, keeping a headache diary, psychotherapy, cognitive therapy, and relaxation techniques) [20–22]. Recently, more and more often neurophysiological methods such as EMG and EEG biofeedback are used as additional TTH treatment [23, 24]. These techniques increase treatment efficacy, gradually enabling sufferers to reduce the drug dosage and thus reduce the risk of adverse effects and overdose [25].

The most significant abnormality found in patients with TTH is palpable tenderness of the skull and head muscles. During examination, doctors often observe increased tension in the head, neck and shoulder muscles, which could also be the result of improper posture, fear or anxiety [26–28]. In addition, increased tension can indicate the body's response to headaches [29–31].

Biofeedback (BFB) is the process of providing subjects with feedback information on physiological processes that take place in their bodies [32]. BFB training involves the measurement of parameters such as heart rate (HR), respiratory sinus arrhythmia (RSA), respiratory parameters, blood pressure, skin conductance known as electrodermal response (EDR), peripheral body temperature and muscle tension (EMG) [33, 34]. Our previous experiences with a BFB methods include the treatment for patients with cerebral palsy, head injuries, autism and ADHD [32, 35–37].

Various forms of BFB have been used in TTH therapy since the 1970s [38,39]. Electromyographic biofeedback (EMG-BFB), during which patients are provided with feedback on their muscle activity and learn how to identify and control muscle tension, is an important factor in TTH therapy [38, 40]. During EMG-BFB training sessions, electrodes are applied to the skin surface over the appropriate muscles and register the bioelectric activity of these muscles [41]. A single EMG-BFB training session usually lasts 10 to 30 minutes. It begins with a 1-3 minute measurement of baseline parameters, based on which thresholds for the analyzed parameters are set. During subsequent training sessions, the patient works to achieve training goals which are provided with sound and visual feedback on developing the desired muscle tension [42, 43].

The literature data indicate that three muscle groups are potentially used during EMG-BFB training sessions in TTH therapy: 1) frontal, 2) neck, 3) nape and dorsal [40, 44–46]. The aim of the study was to assess the effectiveness of EMG-biofeedback trapezius muscle therapy on the course of tension-type headache in young adults – volunteers students.

Materials and methods

Materials.
The study was conducted in 2014-2015 at the Department of Pediatric Neurology and Rehabilitation, Medical University of Bialystok. The study began with 32 student volunteers who had been diagnosed with episodic tension-type headaches according to ICHD-II criteria. Eleven of them dropped out, and 21 students finished the research (11 men, 10 women) aged 20-27 years old (mean age 23.05 ± 1.93 years). At the start of recruitment, patients completed a questionnaire providing data on headache characteristics, previous treatment, the course of the disease, as well as other medical data. For the duration of the entire study, the participants did not receive prophylactic pharmacological treatment, and no one confessed to take analgesic medications. From one month prior to the intervention up to a month after, patients completed diaries every day describing headache characteristics such as intensity, symptoms, triggers and medications.

Procedure.
Patients underwent 15 EMG biofeedback training sessions lasting 22 minutes each on average 3 times a week between headache episodes. The BFB therapy used a multichannel device (Procomp Infiniti from Thought Technology, Canada) with MyoScan-Z. Two SEMG sensors with triode electrodes which were placed on the upper parts of the left (EMG A) and right (EMG B) trapezius muscle. Electrode impedance was ¡10k? and SEMG signals were calibrated. The scheme of biofeedback training sessions involved the measurement of parameters (pre-baseline, 60 sec), 5 EMG biofeedback training rounds (180 sec each) with the rest period between rounds (60 sec each) as well as a post-baseline measurement (60 sec). The training protocol was based on our previous experience and modified for this study.

Parameters.
We assessed averaged muscle tension values SEMG RMS (μV) recorded from baselines before EMG-BFB training sessions and immediately after their completion (Table 1). In addition, patients assessed the following on a 5 – point scale (0-4; Table 2):

I. subjective dorsal muscle tension (0 – very relaxed muscle, 4 – strongly tensed muscle).

II. headache frequency (0: less than once a month, 1: less than once a week, 2: once a week, 3: several times a week, 4: every day).

III. pain intensity (0: no pain, 1: minimal pain, 2: medium pain, 3: high pain, 4: maximum pain).

Headache frequency and pain intensity were assessed according to daily diaries.

Statistical methods.

A level of $p < 0.05$ was considered statistically significant. The normal distribution was verified using the Shapiro-Wilk test. The t test and Pearson's correlation were used for variables with normal distribution; and the Wilcoxon test and Spearman's correlation were used for non-parametric variables. The Statistica 10 software was used for statistical analysis.

The Bioethics Committee of the Medical University of Bialystok approved the study; the studied patients gave their informed consent.

Results

After EMG-BFB training sessions, a statistically significant reduction in trapezius muscle tension was observed in 76% of the patients, whereas an increase in muscle tension was observed in 24% patients. Measurements observed for EMG A and EMG B sensors (Table 1) were similar for the whole group with differences below 5%, which indicates muscle tension symmetry. The pre-therapy mean value of muscle tension for EMG A sensor was 8.34 [μV] $\pm$ 2.12, whereas the post-baseline mean value was 6.55 [μV] $\pm$ 1.59 after 15 EMG-BFB training sessions (p=0.0010). The results for EMG B sensor were 8.06 [μV] $\pm$ 2.21 before therapy and 6.25 [μV] $\pm$ 1.63 after the training sessions (p=0.0006).

Table 1: Results of measuring trapezius muscle tension (left – EMG A, right – EMG B), pre and post EMG-biofeedback training session.

		Mean	Median	min.	max.	SD	p
EMG A [μV]	PRE	8.35	8.16	4.61	14.00	2.13	0.0010 *
	POST	6.56	6.73	4.19	10.92	1.60	
EMG B [μV]	PRE	8.06	7.75	4.28	13.96	2.21	0.0006 **
	POST	6.25	6.22	3.68	10.26	1.64	

Based on the surveys, a reduction in headache intensity was reported by 52% of patients, whereas there were no changes in the remaining 48% (Table 2). Headache frequency decreased in 66% of patients, did not change in 29% and increased in 5%.

Muscle tension reduction was statistically correlated with headache intensity reduction (p=0.0012 for EMG A sensor

Table 2: Questionnaire results pre and post EMG-biofeedback training sessions: assessment of headache intensity, frequency, and subjective muscle tension.

		0 N	0 %	1 N	1 %	2 N	2 %	3 N	3 %	4 N	4 %	Changes	p
HEADACHE INTENSITY (0 - no pain, 1 – minimal pain, 2 – medium pain, 3 – high pain, 4 - maximum pain)	PRE	-	-	6	28.6	13	61.9	2	9.5	-	-	- 10 reduced from 2 to 1; - 1 reduced from 3 to 1; - 7 no change	**0.0020***
	POST	-	-	16	76.2	4	19.0	1	4.8	-	-		
HEADACHE FREQUENCY (0 - less than once a month, 1 - less than once a week, 2 - once a week, 3 - several times a week, 4 - every day)	PRE	-	-	-	-	2	9.5	9	42.9	10	47.6	- 5 reduced from 4 to 3; - 2 reduced from 4 to 2; - 5 reduced from 3 to 2 - 2 reduced from 2 to 1 - 1 reduced from 3 to 1; - 7 no change	**0.0026***
	POST	-	-	3	14.3	7	33.3	8	38.1	3	14.3		
SUBJECTIVE MUSCLE TENSION (0 – very relaxed muscle, 1 – relaxed muscle 2 – slightly tensed muscle 3 – tensed muscle 4 – strongly tensed muscle)	PRE	-	-	-	-	3	14.3	7	33.3	11	52.4	- 7 reduced from 4 to 3; - 1 reduced from 4 to 2; - 7 reduced from 3 to 2; - 6 no change	**0.0002***
	POST	-	-	-	-	11	52.4	7	33.3	3	14.3		

and p=0.008 for EMG B). No statistically significant changes in headache frequency reduction were reported (p=0.07 for EMG A and p=0.055 for EMG B; Table 3).

During the subjective assessment of dorsal muscle tension both prior to and after the sessions, 57% of patients declared a feeling of increased relaxation, whereas 43% did not notice any changes. Increased muscle tension and more frequent headaches were reported by one individual. The reported changes were statistically correlated with reduced muscle tension (p=0.44 for EMG A, p=0.33 for EMG B; Table 3).

Table 3: Table of correlations of changes in trapezius muscle tension with headache frequency, intensity, subjective muscle tension, pre and post EMG-biofeedback training sessions.

	HEADACHE FREQUENCY (PRE – POST)	HEADACHE INTENSITY (PRE – POST)	SUBJECTIVE MUSCLE TENSION (PRE – POST)
EMG A (PRE – POST)	p = 0.070	**p = 0.012 ***	**p = 0.044 ***
EMG B (PRE – POST)	p = 0.055	**p = 0.008 ****	**p = 0.033 ***

Discussion

Our findings suggest the validity of using EMG-BFB in TTH therapy. The obtained reduction in muscle tension correlates with decreased headache intensity as well as a not statistically significant reduction in frequency. We should emphasize that the changes were obtained without combining with any pharmacotherapy. Tornoe and Skov evaluated the effect of computer animated relaxation therapy (EMG-BFB) in nine children between 7 and 13 years with TTH and the children's experiences with the therapy [47]. The conducted therapy consisted of an uncontrolled nine-session course in modified progressive relaxation therapy assisted by computer animated surface EMG provided from the trapezius muscles and with the physiotherapist as a participant observer. The results showed a mean improvement of 45% for headache frequency at a 3-month follow-up versus baseline and a significant reduction in headache frequency for all participants and in Total Tenderness Score for children with frequent episodic tension-type headache. Similar data were presented in a meta-analysis on BFB efficacy, in which Nestoriuc et al. evaluated 53 studies conducted from 1973 to 2001, on 1532 patients [44, 45]. The obtained results indicate a higher efficacy of EMG-BFB compared with relaxation therapy, keeping a headache diary and placebo. The authors found that combination therapy involving EMG-BFB and relaxation techniques was more efficacious and had long-lasting effects. The authors indicated that the greatest changes were noted in the reduction of headache frequency. The differences between our results and the meta-analysis could be due to our small study group and differences in the questionnaire scales.

Also in 2001, a group of specialists from the International Society for Neurofeedback and Research (ISNR) and the Association of Applied Psychophysiology and Biofeedback (AAPB) evaluated BFB as effective and specific to tension-type headache therapy in adults, qualifying it as level 4 effectiveness (scale 1-5, 5 is the highest) [48]. During the assessment, the specialists took into consideration the results of many studies, analyzed cases as well as randomization [44, 49].

During headache episodes, we registered increased tension in the shoulder, neck and head muscles in our patients. These measurements were not taken into the study. There are only a few papers in the literature assessing the efficacy of EMG-BFB training of nape and dorsal muscles, which was suggestion for us to evaluate these muscle group in the study [40, 44–46]. Our results indicate that the measured trapezius muscle tension values after EMG-BFB therapy significantly reduced subjective muscle tension according to the patients. Patients reported greater awareness of their body's reactions and learned to counter negative reactions. Similar results presented Tornoe and Skov also using trapezius muscle tension in their study [47]. The children expressed a growing understanding of body reactions and an acquired ability to deactivate and regulate these reactions. Simple relaxation techniques and education about pain theory may also be included in TTH therapy. The obtained results enable us to continue EMG-biofeedback therapy during which we will compare the effectiveness of other electrode locations as well as include children.

Limitations.

The main limitation of this study is the lack of a no-treatment control group. Without the use of a control group, it is difficult to determine if the results were caused solely by the EMG-Biofeedback intervention or by other factors. Another limitation of this study was the lack of comparison of other alternative methods or conditions to test, for example whether the site which was used for providing feedback had any advantages over other sites.

Future Research.

The limitations of the present study are not surprising given the pilot nature of this research; thus, it will be important for future studies to confirm the findings by employing more rigorous designs that include larger sample sizes and random assignment to intervention and control groups. In addition, future research will benefit from the inclusion of different electrodes placement within one study. It will also be important for future studies to further examine long-term changes in headaches as a result of Biofeedback trainings.

Conclusions

The results confirm the potential of EMG-Biofeedback and to use EMG-biofeedback training as an additional therapy technique in the treatment of tension-type headache in young adults. The EMG-BFB training sessions reduced trapezius muscle tension in over half of the patients significantly correlating with decreased headache intensity. This was a preliminary study, and research is being continued in children.

Compliance with Ethical Standards

Conflict of Interest.

All authors declares no conflict of interest.

Ethical approval.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The Bioethics Committee of the Medical University of Bialystok approved the study.

Informed consent.

Informed consent was obtained from all individual participants included in the study.

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Received: 2018
Accepted: 2018