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Cranial Electrical Stimulation for Mitigation of Some Mental Problems

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ABSTRACT

The aim of this article is to present own obtained results in a pilot study performed with the use of cranial electrotherapy stimulation (CES).

The evaluated sample comprised patients with a) anxiety and depression, b) cystic fibrosis, c) moderate hypertension, as well as d) ADHD children. Each group is containing of 10 patients. All problems were diagnosed according DSM-IV criteria.

For measuring behavioral issues Child Depression Inventory (CDI), Scale for Anxiety for Adolescents (SCAN) and Beck Depression Inventory (BDI) were applied.

Quantitative electroencephalography (qEEG) is performed for evaluation the brain spectra before and after treatment. Spectrum weighted frequency was calculated in CZ to measure general mental arousal.

Obtained results confirm the efficacy of CES treatment in different psycho physiological disorders such as general anxiety, moderate depression and hypertension but in nonlinear dependences.No significant results are obtained for ADHD children. However, for ADHD children neurofeedback is more effective.

KEYWORDS : cranial electrostimulation therapy, depression, anxiety, moderatehypertension.

Background

Although the effect of electrical current on living tissues has been known for centuries, systematic research in this field was performed-mostly in the last years of 20-th century. It was proved that a week scalp direct current can influence prolonged changes in brain excitability. Conventional neural networks are characterized by many neurons coupled together through synapses. The activity, synchronization, plasticity and excitability of the network are then controlled by its synaptic connectivity. Cranial electrotherapy stimulation could change synaptic activity by fluctuations in specific ionic or neurotransmitters concentration and in this way to modulate neuronal excitability (Durand, 2010).

It is known from the basic neurophysiology that direct current shifts membrane potential of neurons toward either hypo or hyper polarization, depending on the direction of the current. Week direct current placed on the scalp changes membrane potentials of cortical neurons only slightly.

Controlled studies provide evidence that CES is effective for anxiety (Kirsch,2007; Winick, 1999), depression (Millet, 2009; Gilula, 2005), headaches (Tarasova,2008), fibromyalgia (Smith,2000), smoking cessation (Wing, 2013), drug withdrawal symptoms (Lori,2010), post-traumatic stress disorder (Novakovic, 2011), obesity (Bolotova, 2010), pain (Jung, 2012), hypertension (Podzolkov, 1992), for neuroenhancement in aging patients (Zimerman, 2013; Fujiyama, 2014), for ameliorate sustained attention (Chen, 2011) as well as in Alzheimer disease (Scherder, 2006).

It remains not quite clear how the electrical current from CES may alter brain activity. It is supposed that abouta half of the applied CES current enters the brain, with the highest levels of current recorded in the thalamus. One theory suggests that the cranial alternating current stimulation interferes with ongoing brain wave oscillations by introducing cortical noise (Zaghi,2010). In vitro studies of rat brain slices show that high-frequency (50–200 Hz) sinusoidal current stimulation suppresses activity in cell bodies and axons (Jensen and Durand, 2007). Perhaps the most investigated effects to date of CES have come from electroencephalographic studies, which have found recordings to be altered during and after treatment with CES. Applying CES at 0.5- and 100Hz resulted in simultaneous EEG downward shift in mean alpha frequency, with greater effect for 100 Hz stimulation (Schroeder and Barr cited in Higgins 2009).

Changes in EEG pattern could be obtain also with neurofeedback training, which is additional non-invasive and cost-effective tool used widely in psychophysiology (Pop-Jordanova2009). Neurofeedback is a technique in which a person uses information about a normally unconscious body functions (blood pressure, muscle tension, heart rate, electrical brain activity etc.) to gain conscious control over these functions.

The aim of this article is to present the results of our pilot study of the use of CES, used for the first time in our region.

Subjects and method

In this study following subgroups of patients were included: a) adolescents with depression and high anxiety; b) adolescents with cystic fibrosis (CF) supposing to have anxiety and depression, both groups with mean age 20,77 ± 5.5 years; c) children with ADHD, mean age 8.5 ± 1.2 years, d) adults with moderate hypertension, mean age 65.2 ± 7.5 years. Each subgroup includes 10 patients, both gender.

All patients obtained 10 sessions of cranial electrotherapy (5+5 with weekend pause), using Alpha StimR modality, with 350 mA current power during 20 minutes. The electrodes were placed on both ear lobes.

Behavioral measurement comprised: Child Depression Inventory (CDI) and Scale for anxiety for adolescents (SCAN) as well as Beck Depression Inventory (BDI) for adults. Patients with moderate hypertension were checked for arterial tension and pulse before and after each session of CES.

QEEG analysis using Mizar equipment with 19 electrodes placement was made before and after all CES sessions. Spectrum weighted frequency (brain-rate parameter) is calculated in CZ using the following formula(introduced in 2005 by Pop-Jordanova N. and Pop-Jordanov J.)

$$f_b = \sum_i f_i P_i = \sum_i f_i \frac{V_i}{V} \quad \text{with} \quad V = \sum_i V_i$$

where the index idenote the frequency band, and Vi is corresponding mean amplitude of the electric potential.

For statistics the descriptive method (mean values and standard deviation) as well as Student's t-test were used. Results are presented in tables and graphics.

Results

Obtained results for SCAN and CDI are presented on Fig. 1.

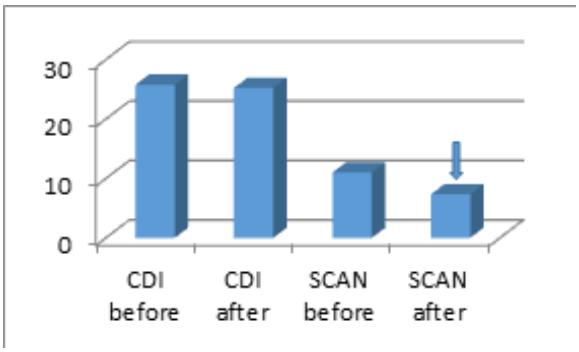

Fig.1 Results obtained with CDI and SCAN before and after treatment

For the group of adolescents, as can be seen, only scores on SCAN showed significant diminishing after CES treatment. Depression scores are also diminished, but without statistical significance.

In adults, mean BDI scores before treatment were 25 ± 2.45 (confirming moderate depression) and were reduced to 14± 1.33 (mild depression) after the treatment. Obtained statistical significance is on the level $p < 0.05$.

Numerical changes in pulse and arterial tension are presented on Table 1.

Table 1 Student t- test for changes of arterial tension and pulse

TA before	TA after	t- value	p value
126.3333 ± 13.18	113.0952 ± 6.46	4.3	0.000047*
Pulse before	Pulse after	t- value	p value
69.16± 8.4	63.85± 8.8	8.2	0.0011*

The qEEG recording was made before and after 10 sessions of cranial electrotherapy in two conditions: eyes open and eyes closed.

Fig. 1 shows brain spectra for adolescent patient with anxiety in eyes closed condition. As can be seen beta frequency is dominant confirming the high anxiety which is reduced after electro stimulation (Fig 2).

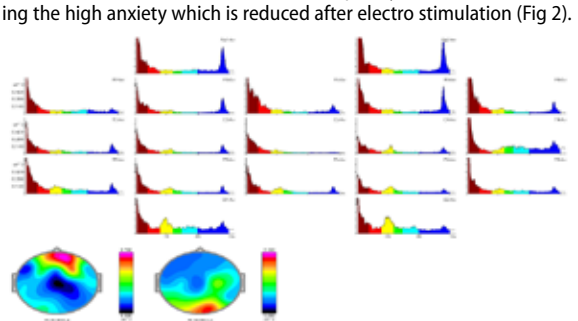

Fig. 1 Brain map in adolescent with high anxiety in EC condition

(Vertical axis shows % of relative power in μV2, horizontal axis presents frequencies in Hz, colors are related to power as shown on legends near the brain map; red signify maximal intensity of frequency band; High beta in frontal region is related to anxiety)

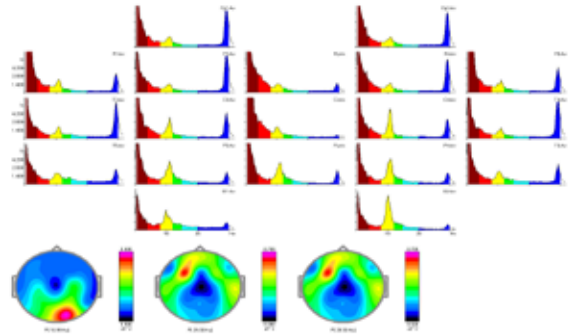

Fig. 2 Spectra of the same patient after CES treatment (there is decrease of beta in frontal region)

Alpha waves calculated separately in different scalp points before and after CES treatment are presented on Fig. 3. It is obvious that alpha brain waves are higher after cranial electro stimulation. Theta frequencies are alsochangedafter stimulation therapy (Fig.4).

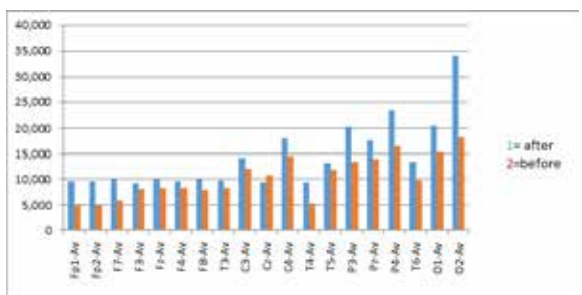

Fig. 3Changes of alpha brain waves

Fig. 4 Changes of theta brain waves

Calculated brain-rate parameter in CZ shows small shifting trough under arousal (Table 2). Using neurofeedback in ADHD children we obtained changes in EEG spectra and brain-rate parameter as well. Figure5shows our own obtained results concerning neurofeedback treatment in ADHD children.It is well presented that neurofeedback treatment changes the power of theta, beta brain waves, the ratio theta/beta, as well as the brain rate.

Table 2: Brain rate parameter (before and after CES)

Before training		After training		
Disorder	EC	EO	EC	EO
Anxiety-adults	10.54	8.56	9.45	7.26
Anxiety-children	8.19	7.57	7.23	6.45

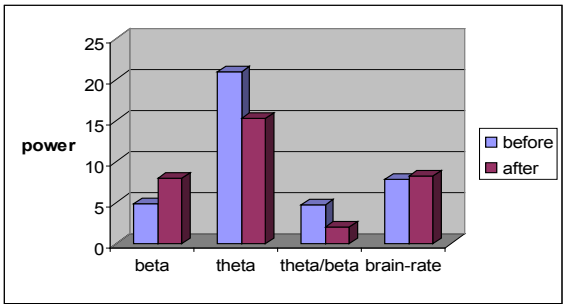

Figure 5. Changes of biofeedback parameters (before and after NF training)

Discussion

A bibliography cited by Kirsch, listed 126 scientific studies of CES involving human subjects and 29 animal studies. Generally, indications for CES in these studies were depression, general anxiety and sleep problems and the author confirms the very good obtained results.

In 2006, Ray B. Smith published one of several meta-analyses on the body of research performed with CES devices. The result of the analysis showed that the overall effectiveness of CES was improvementin 67%for sleep problems and in 47% for depression.

The exact mechanism of action of CES remains unclear but it is supposed that it reduces the stress that underpins many emotional disorders. In addition, CES may stimulate regions that regulate pain messages, neurotransmitter function, and hormone production via the hypothalamic-pituitary axis (Feusner, 2012; Nitsche, 2011; O'Connell, 2010).

It can be disputable if this modality influence directly on the brain or it is indirectly, through vagal stimulation. Because the vagus nerve is associated with many different functions and brain regions, research is being done to determine its usefulness in treating illnesses such as anxiety disorders, Alzheimer's disease, migraines, fibromyalgia, obesity, and tinnitus, conditions very similar to these treated with CES.

It is proved that CES treatments induce significant changes in the electroencephalogram, increasing alpha (8–12 Hz) relative power and decreasing relative power in the delta (0–3.5 Hz) and beta (12.5–30 Hz) frequencies. Increased alpha correlates with improved relaxation and increased mental alertness or clarity. Decreased delta waves indicate a reduction in fatigue. Beta-wave reductions between 20 and 30 Hz correlate with decreases in anxiety, ruminative thoughts, and obsessive/compulsive-like behaviors (Kennerly, 2004).

Different protocols used with neurofeedback therapy can induce changes in the electroencephalogram, as well. Our experience in this field is very positive, especially in the treatment of stress-related disorders, but also in high functioning autism (Pop-Jordanova 2009, 2010). In addition, calculated brain-rate parameter was shown as a simple indicator of arousal level (Pop-Jordanova and Pop-Jordanov, 2004, 2005, 2010).

It was proved that CES treatments are cumulative; however, most patients show at least some improvementafter the first treatment.

CES is cost-effective compared with drugs and other devices used in psychiatry. It is easyto use in both clinical and home settings.However, in modern medicine biophysical tools are used frequently as a unique or additional therapies which highly diminish use of drugs.

Conclusion

Our results in this pilot study confirm efficacy of electro stimulation therapy in patients with moderate hypertension, anxiety and depression. We did not obtained significant improvement for symptomatology in ADHD children. This group of patients respond very well to neurofeedback therapy.

The effects of cranial electro stimulation therapy are nonlinear with the clinical symptoms as well as with the duration of the treatment.

Improved research designs, larger sample sizes, more integrity in data collection, and improved data analysis are needed in the future.

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