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STUDY OF THE INFLUENCE OF WRIST TAPPING ON ALPHA-RHYTHM SYNCHRONIZATION IN ADULTS

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ABSTRACT — Objective: To study the effect of hand tapping on the synchronization of the alpha rhythm in healthy adults. Materials and Methods: The study included 51 clinically healthy volunteers of working age. Results: We have shown that under the influence of wrist tapping in a state of sensory deprivation in healthy adults there is a statistically significant change in the peak frequency ($p = 0.0006$) and peak power of the alpha rhythm ($p = 0.0003$), but the width of the peak plateau remains unchanged ($p = 0.2$). This effect of wrist tapping indicates the potential for clinical use in JME, since it was previously shown that if the selected external frequencies enter into resonance with the neurons of the antiepileptic system, then an antiepileptic effect can be obtained.

KEYWORDS — electroencephalography, resonance, tapping, alpha rhythm.

INTRODUCTION

Epileptogenesis and plasticity of neural networks are two interrelated phenomena, since some epileptogenic ones demonstrate a clear reorganization of neuronal connections and the growth of neuronal elements. [1]. Lüders H.O. et al. (2000) showed that the *epileptogenic focus* includes several functional zones: epileptogenic substrate, zones of irritation and onset of an attack, symptomatic, epileptogenic zone, and also a zone of functional deficit. The zone of functional deficiency is an area of the cortex, functional changes in neurons cause the appearance of neurological and neuropsychological disorders. *Breakthrough* of epileptic activity from the focus with the onset of clinical manifestations of the disease, evidence of insufficiency of antiepileptic activation mechanisms and formers of the epileptic system [2]. The mechanism of epileptogenesis is based on the function of neurons, leading to an epileptic type of information transcoding [3] and the involvement of the brain in hypersynchronous activity, as a result of which it increases its readiness to be included in auto-rhythmic activity, which is associated with the excitatory factors of neurons under the trigger.

The most important property of an epileptic focus is its determinant nature, expressed in the ability to impose its mode of operation on other parts of the brain [4]. This leads, on the one hand, to the formation of secondary and tertiary epileptic foci, on the other, to a change in the information function of neurons in the entire brain. The set of mechanisms that prevent the spread and generalization of epileptic activity is called the antiepileptic system, which is represented primarily by the structures of the brain stem, mainly its caudal part [5], as well as the hypothalamus, caudate nucleus, cerebellum, which have an inhibitory function. The activation of these structures occurs under the influence of corticofugal impulses, and they exert an inhibitory effect on epileptic activity through inhibitory collateral influences that cause hyperpolarization of cortical neurons [6]. It is also known that each epileptic seizure increases the likelihood of the next one — the pathogenesis of this phenomenon can be based precisely on the kindling effect. Understanding this mechanism directly changes the approach to antiepileptic therapy: priority must be given to starting treatment as early as possible and preventing each subsequent epileptic seizure. This phenomenon was described by A. D. Speransky [7] as *the second blow phenomenon*. On the other hand, the theory of rekindling as a defense mechanism from the standpoint of biophysical processes is consistent with the theory of resonance. Resonance (fr. Resonance, from Lat. Resono *I answer*) is a frequency-selective response of an oscillatory system to a periodic external influence, manifested in a sharp increase in the amplitude of stationary oscillations when the frequency of the external influence coincides with certain values specific to this system. With the help of resonance, even very weak periodic oscillations can be distinguished and / or amplified. Resonant phenomena can lead to both destruction and an increase in the stability of mechanical systems and, consequently, epileptic systems. Exposure to external stimuli can provoke epileptic seizures and, conversely, if the selected frequencies come into

resonance with the neurons of the antiepileptic system, an antiepileptic effect can be obtained. The theory of resonance, nowadays, is increasingly used in neurorehabilitation, when the impact of external stimuli with a certain frequency, which is in resonance with the neuronal activity of protective systems, can have a clinically significant therapeutic effect [8, 9]. Thus, using the theory of resonance and hypersynchronization, we can, by external influence at certain frequencies, desynchronize neurons (neural network) in the focus of epileptic activity, achieve the phenomenon of resonance with neurons of the antiepileptic system and reduce the risk of developing generalized and secondary generalized seizures.

In recent years, not only drug-based, but also non-drug methods of epilepsy therapy have been actively studied [10], among which the method of hand tapping is of great interest [11], which leads to a decrease in the severity of anxiety in both healthy volunteers and patients with epilepsy [12] However, we have not found any works that study the effect of wrist tapping on the severity of alpha rhythm synchronization, both in healthy people and in patients with epilepsy, which is of undoubted scientific and clinical interest.

The purpose of this study is to assess the effect of hand tapping according to the author's method on the synchronization of alpha activity in healthy adults.

MATERIALS AND METHODS

The frequency spectrum of the alpha rhythm was assessed using a computer encephalographic complex ("Neurocartograf", MBN, Moscow). The following parameters of the alpha rhythm in the occipital leads (O1, O2), the minimum frequency of the alpha rhythm (Hz), the maximum frequency of the alpha rhythm (Hz), the width of the peak (Hz), the type of the peak of the alpha rhythm (monopeak, bepeak, polypeak). In addition, the power of the alpha rhythm (Hz/MkV2) in the occipital leads was analyzed. The above characteristics of the alpha rhythm were analyzed and recorded by us before the hand tapping technique and during the first three minutes after its completion. EEG recording was carried out in a state of sensory (visual and sound) deprivation. The study of wrist tapping was carried out using a modified author's technique "A method of influencing the individual rhythm of a person by means of exogenous rhythmic stimulation" (RF patent No. 2606489 dated 01/10/2017). The modification of the method consisted in the fact that the study of the individual rhythm of the subjects was carried out without the use of exogenous rhythmic stimulation. The study was carried out in the morning in conditions of exclusion of external sensory stimuli (loud sound, bright light), the presence of other people (except for a doctor and a volunteer) during the tapping technique. The temperature regime of the environment was observed in the range of 22–25° C. Tapping was performed with the subject's eyes closed. The technique consisted of striking the hand with a finger on the surface of the device (a Xiaomi smartphone based on Android, the country of origin China), followed by registration of the time parameters of this process in the author's program based on the modified technique "Method of influencing the individual rhythm of a person through exogenous rhythmic stimulation" (RF patent No. 2606489 dated 10.01.2017). A mechanogram was reflected on the screen of the device, where vertical strokes indicated the moments of contact of the finger of the hand with the smartphone screen.

Inclusion criteria: healthy adults; signed voluntary informed consent; male and female; age period: adolescence (m 17–21 years old; f 16–20 years old); the first period of middle age (m 22–35 years old; f 21–35 years old); the second period of middle age (m 36–60 years; f 36–55 years); Russian speaking Europeans.

Exclusion criteria from the study: children and adolescents; refusal to participate in this study; participation in other studies; acute and chronic neurological, psychiatric and endocrinological diseases at the time of the study; alcohol intake (2 or more drinks within the last 2 weeks); use of narcotic drugs at the time of the study and in history.

The study included 51 clinical healthy volunteers of working age (median age — 39 [21; 56] years.

Volunteers received no remuneration for participating in this study. The researchers did not receive any remuneration for conducting this study.

Statistical processing was carried out using the Statistica software package (StatSoft, version 10, USA). All data distributions were evaluated using the Shapiro-Wilk test. As a result of the study, nonparametric variables were obtained. Statistical significance was determined using the nonparametric Wilcoxon test (differences between groups were considered statistically significant at $p < 0.05$).

RESULTS

Under the influence of wrist tapping in a state of sensory deprivation (Table 1), in healthy adults there is a statistically significant change in the peak frequency ($p < 0.001$) and peak power of the alpha rhythm ($p < 0.001$), but the width of the peak plateau remained unchanged ($p > 0, 05$). The majority of the subjects (71%) showed a change in the peak of the

alpha rhythm (Table 2), of which 43% showed its splitting and transformation into a polypeak, and 27% — a decrease in the number of peaks. Only in 29% of the surveyed the characteristics of the peak of the alpha rhythm did not change.

DISCUSSION

According to S.N. Aksenov (2004) [13], constant movement from one unstable state to another allows living organisms to adequately adapt to constantly changing external conditions. Thus, living organisms have their own biorhythms synchronized with the external rhythms of the environment [14]. The main regulator of biorhythms and the life processes caused by them is the brain [25], the biorhythm of which is associated with the individual characteristics of self-regulation mechanisms and the level of plasticity of neurodynamic processes [16]. Considerable attention is paid to the study of synchronization of various parts of the cerebral cortex, primarily in the range of alpha and beta rhythms, in the processes of regulation and changes in the functional state of the body [17, 18]. The concept of dynamic functional connectivity is an important aspect of resting brain functional activity that looks at variations in functional connectivity over a short period of time. Dynamic functional connections are currently being explored in a variety of contexts related to both behavior and neural activity, thus deepening our understanding of functional networks in the brain. Numerous studies have shown reproducible patterns of short-term neuronal activity that travel throughout the brain [19]. Analysis of dynamic functional connections showed that spontaneous transitions between networks of interacting brain regions are highly organized into a hierarchy of two types of meta states: one for higher-order cognitive systems, and the other for sensorimotor systems [20]. New evidence is also emerging indicating that dynamic functional relationships are influenced by a variety of factors, such as mental states [21], sleep [22], learning [23], and brain disease [24]. Several studies have shown hyperdynamic activity in some specific functional networks at rest in various subtypes of epilepsy [25]. Thus, the processes of synchronization of the bioelectric activity of the brain in various physiological and pathological states of the body in active wakefulness and relaxation, as well as in the presence of anxiety, have not been sufficiently studied. Comprehensive study of the processes of synchronization of brain biorhythms both at rest and with external (exogenous) stimuli contributes to the understanding of the processes of development of plasticity of nervous processes and the regulatory function of the brain.

Table 1. *Characteristics of the alpha rhythm before and after wrist tapping in healthy adults*

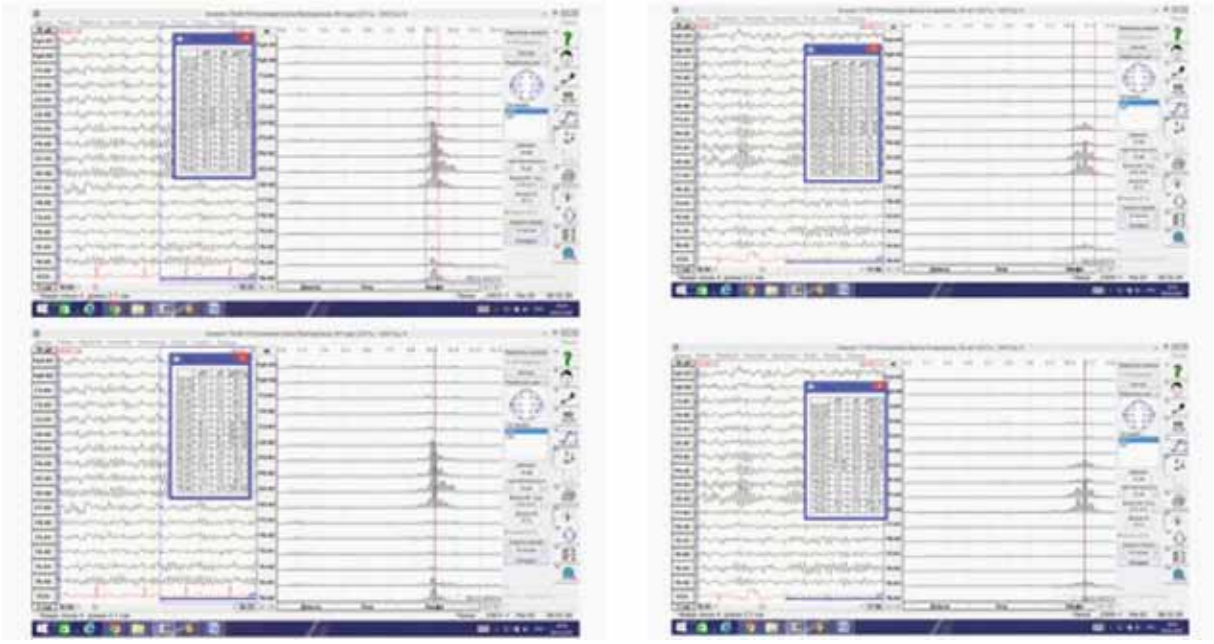
Before tapping Me [P25;P75]	After tapping Me [P25;P75]	*p*
Peak frequency (Hz)		
10,2 [9,6; 10,8]	10,6 [10; 11,1]	0,000613
Peak power (Mv / Hz)		
1357,4 [688; 2913]	1398,172 [501; 1472]	0,00036
Plateau width (Hz)		
1,2 [1; 1,5]	1,2 [0,7; 1,8]	0,2

Table 2. *Changes in the characteristics of the alpha-rhythm peak in the occipital leads before and after wrist tapping in healthy adults*

Peak characteristic		Amount (%)
Before tapping	After tapping	
Remained unchanged		15 (29%)
Monopeak	Monopeak	3 (5,8%)
Doublepeak	Doublepeak	5 (9,8%)
Polypeak	Polypeak	7 (13,7%)
Increasing the number of peaks		22 (43%)
Monopeak	Doublepeak	9 (17,6%)
Doublepeak	Polypeak	6 (11,7%)
Monopeak	Polypeak	7 (13,7%)
Reducing the number of peaks		14 (28%)
Polypeak	Monopeak	5 (9,8%)
Polypeak	Doublepeak	8 (15,6%)
Doublepeak	Monopeak	1 (1,9%)

CONCLUSION

Our study shows that the use of manual tapping according to the author's technique allows reducing the severity of alpha rhythm synchronization and leads to a shift in the peak frequency of the alpha rhythm in the occipital leads towards the alpha2-subfrequency range and an increase in its maximum power in healthy volunteers. Taking into account the theory of hypersynchronization of cortical rhythmics (neural networks) and bioelectrical activity of the brain in general during the development of epileptiform activity on the EEG and epileptic seizures, in particular, the technique we have developed may be promising. as a method of non-drug therapy and (or) prevention of the development of generalized and secondary generalized epileptic seizures at the aura stage or simple focal epileptic seizures. In addition, this wrist-tapping effect indicates clinical use in JME, as it has previously been shown that if selected external frequencies resonate



a b

Fig. 1. *Changes in the characteristics of the alpha rhythm before (A) and after (B) carrying out carpal tapping in the healthy male A. (36 years old): the splitting of the peak of the alpha rhythm in the occipital leads and its transformation into a polypeak is shown*

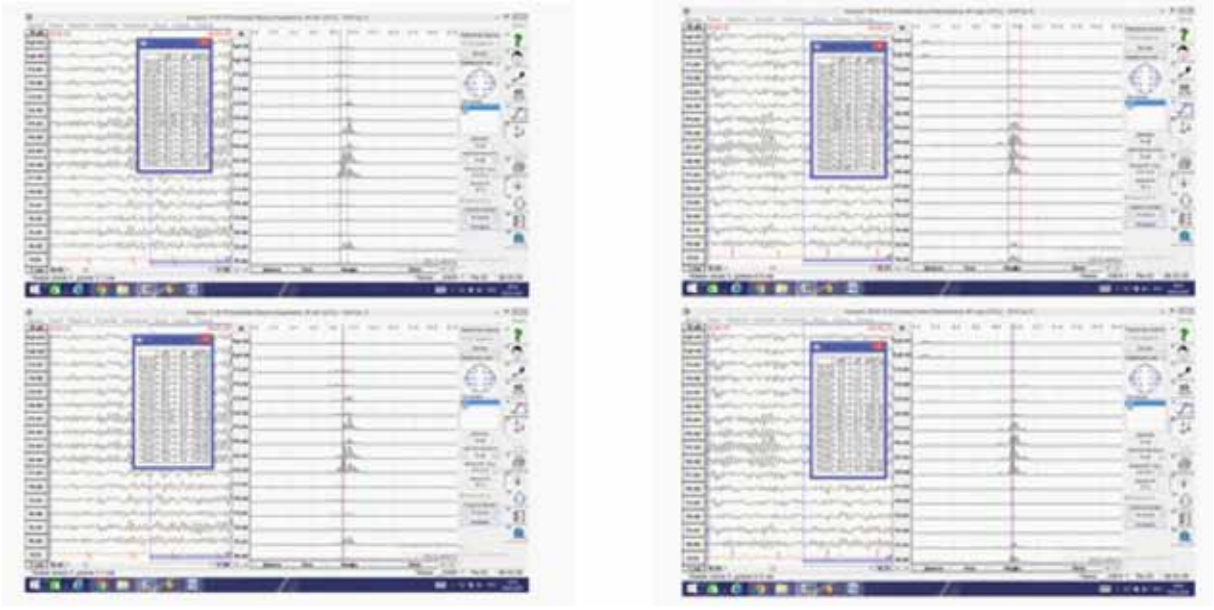


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Fig. 2. *Changes in the characteristics of the alpha rhythm before (A) and after (B) carrying out hand tapping in the a healthy male T. (39 years old): the shift of the peak of the alpha rhythm in the alpha2 subband and an increase in the number of peaks in the occipital leads is shown*

with antiepileptic neurons, an antiepileptic effect can be obtained. However, the confirmation of our hypothesis requires further study with the inclusion of a sample of patients suffering from focal and generalized forms of epilepsy.

Conflict of interest

The authors declare no obvious and potential conflicts of interest related to the publication of this article.

Contribution of authors

E.A. Narodova — review of publications on the topic of the article, writing the text of the manuscript, designing the article; Schnayder N.A. — concept development, selection of articles for analysis, writing and correction of the manuscript text; Narodova V.V — a review of publications on the topic of the article, the design of the article

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