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The Effect of Music and Aromatherapy on the Electrical Activity of Athlete's Brain

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Abstract: A research involving 8 middle distance men runners was conducted to study the impact of essential oils and music pieces of relaxation and activating nature, as well as their various combinations on electroencephalogram (EEG) parameters. The odorant stimuli were presented blindly with the random alteration of audio and odorant effects. We showed the character of their impact on the basic EEG frequency bands, identified the particular changes of the hemispheric asymmetry of EEG amplitude indices, defined the nature of their correlation relationships. Statistically significant differences were established for the hemispheric asymmetry of the θ-activity of the parietal region and α-activity in all EEG leads. It was found that the olfactory and musical influence of different modalities have unidirectional effect on the bioelectric activity indices. This EEG response is most likely associated with a common mechanism for implementing the effects of audio and odorant stimulants. It was found that the response to the combinations of sensory effects has different intensity. These data permit the sensory effects to be ranked in terms of their activation level, which makes it possible to purposefully influence the psycho-emotional states. Our findings are the basis for developing the methods and programs of modifying the athletes' functional states.

Keywords: EEG, Sensory Effects, Essential Oils, Functional Music, Athletes

1. Introduction

We must know the physiological mechanisms of regulation of athlete's mental and emotional status to develop optimal strategies for the safe modification of athletes' functional states, which is associated with constant tightening of anti-doping rules in sports. The means of body state control include functional music (FM) [1, 2] and essential oil (EO) combinations [3, 4]. There is evidence of the central mechanisms of music [5, 6] and EO [7, 8] effects, there are also some studies on the possibility of their joint use [9, 10].

It is known that an exposure to FM can lead to the decrease in anxiety and emotional stress [1, 2]. Listening to the musical fragments influences the autonomous nervous system state and functioning of cardiovascular and respiratory systems [1]. The responses to pleasant and unpleasant music correlate with the activity and blood supply of the limbic system [6]. In this regard, FM is increasingly used for the treatment of various disorders in the field of music therapy [1, 2].

Concerning the consequence of EO application, their pronounced ability to modify emotional states is well known [4]. There is also a close relationship between the smells of EO and the state of the autonomous nervous systems [4, 7].

The information available relates to particular effects, for example, the inhalation of a separate EO or the sound of FM [10]. Evidence for combined use is reduced to

establishing the positive results of EM and FM application [9]. The overwhelming majority of studies have focused on the use of FM and EM during various emotional disorders [1], while no studies of neurophysiological mechanisms of complex sound and odorant effects in athletes exposed to such stimulants have been found in the available literature. It is also unclear what will happen with bioelectrical activity in different parts of the brain as a result of its exposure to EO and FM blends.

This situation complicates the practical use of complex audio-odorant effects for purposes of non-drug therapy, rehabilitation and sports medicine. It is suggested that the efficiency of modification of various systems under complex impacts increases in comparison with the effect of FM or EO. Therefore our research purpose was to study the effect of FM and EO blends of different nature on the bioelectrical brain activity.

2. Methods

The study involved 8 randomly selected middle distance runners (male right-handers, aged 19 to 22 years) who had no complaints about their health. The subjects volunteered to participate in the study, they were aware of possible risks and discomfort, the informed consent to participate in the research was obtained from them. The small sampling size was due to the specified research conditions – participants' sports qualifications, mandatory regular training and participation in competitions, the lack of allergic reactions to essential oils used.

The subjects were exposed to some pieces of functional music (FM) of energizing (rock music) or relaxing (classical) music followed by the olfactory impacts with specially designed energizing and relaxing essential oil blends (EOB) through cold inhalation [3]. Specific blends were selected on the basis of some publications [3, 6, 7] and coded by a leading researcher for the blind study.

For objectification we used the same duration impacts – five-minute exposure, three-minute rest periods between stimuli, random alternation of audio and odorant impacts, blind method of stimuli presentation and result processing.

The electroencephalographic (EEG) recordings were performed at baseline, during each sensory impact and after its completion at 8 standard bipolar leads according to the 10-20 international scheme with a Neuron-Spectrum electroencephalograph (LLC Neurosoft, Ivanovo). After removing the artifacts the individual 4 sec EEG segments were processed using the spectral analysis method (fast Fourier transform algorithm, implemented in the software supplied with the electroencephalograph). Averaging the six measurement data on amplitude and spectral power reduced the influence of artifacts and individual variability. The average amplitude value was calculated in standard delta (Δ), theta (θ), alpha (α) and beta (β) bands. To evaluate the EEG lateralization the hemispheric asymmetry coefficient (HAc) was calculated using a formula (1):

$$HAc=\frac{(Rl\ SP+Ll\ SP)}{(Rl\ SP+Ll\ SP)}\times 100 \qquad (1)$$

where

R1 SP - right lead spectral power in the investigated frequency band,

L1 SP - left lead spectral power in the investigated frequency band.

Statistical processing (pairwise nonparametric analysis, multivariate analysis of variance) was performed in Statistica 6.0 software.

3. Results

The most pronounced changes in average amplitude of the bioelectric activity occurred in the temporal leads: when exposed to an energizing EOB 19±11 μV to 24.7±8.8 μV for delta (Δ) rhythm and 12.2±4 to 14.3±5.3 μV for alpha (α) rhythm (hereinafter, values are given in M±σ format). It was found that with the combination of energizing EO and FM, the effect does not differ from the use of one factor. Thus, an increase in amplitude of alpha activity was noted with a energizing FM, with the effect of energizing EO and with combination of the same EO and FM influences.

However, these effects, as well as the less pronounced average data dynamics for other impact types were not statistically significant (p=0,33). Therefore, the hemispheric asymmetry of the rhythms amplitude was compared at the next stage. It was found that the theta (θ) activity amplitude in the right temporal region and the α-activity in all leads used (Fp2, T4, C4, O2), had a statistically significant (P<0,05) exceedance over the values obtained from symmetrical points of the left hemisphere when exposed to energizing EO (Figure 1). Along with this, there was an increase in Δ- amplitude and θ-activity on the left in the central leads when exposed to relaxing FM (P<0,05). For other impacts the hemispheric response asymmetries were not significant.

This fact confirms the view that the olfactory perception is associated with changes in hemispheric asymmetry of the brain bioelectrical activity in alpha and theta bands [8]. It should also be emphasized in connection with the special role of functional brain asymmetry in organization and execution of complex motor activities [11].

In combinations, it is most interesting the hemispheric amplitude asymmetry reducing under the blends with the same effects and insignificant increase from opposite effects.

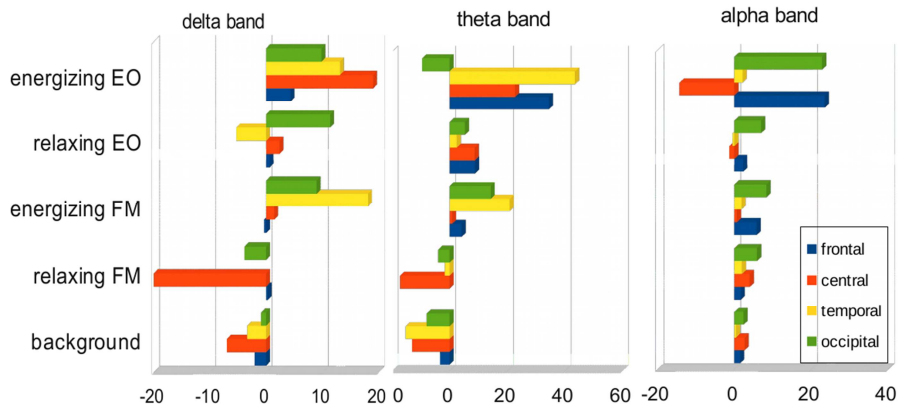

Figure 1. *Hemispheric amplitude asymmetries of Δ, θ and α-activity after isolated audio- and odorant influences.*

For example, in the case of relaxing EO and energizing FM the response pattern was approaching the characteristic only for relaxing EO (Figure 2).

There is a tendency of decrease in cross-correlation from exposure to activating effects (from 0.65 to 0.47), and its increase on exposure to the relaxing effects of (0.55 to 0.7). The cross-correlation changes reflect the development of generalized responses (desynchronization on exposure to decreased or synchronization on exposure to increased non-specific reticulothalamic and reticulocortical influences). This confirms the nonspecific nature of the effect and can testify to the similarity of impact mechanisms of the EO and FM activating effects.

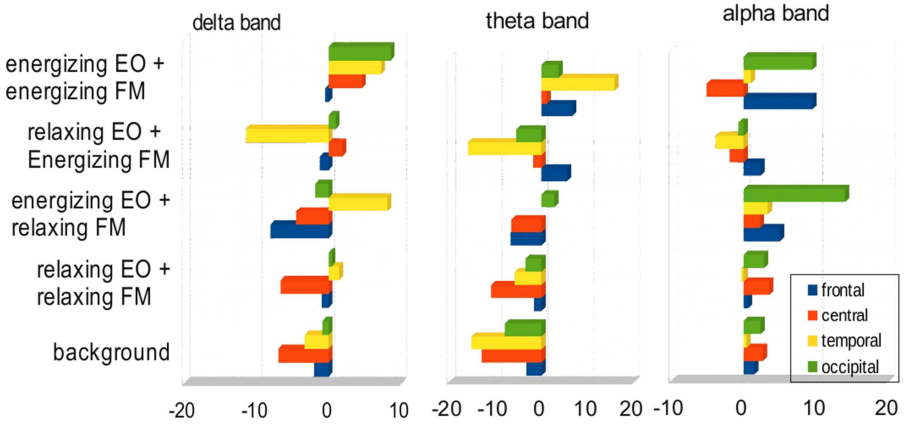

Figure 2. *Hemispheric amplitude asymmetries of Δ, θ and α-activity after audio-odorant blends influences.*

4. Discussion

Our results suggest both activating and inhibitory effect on various brain pacemaker structures, including the diencephalon nuclei, mediated by the impact of energizing and relaxing sensory stimuli [12, 14]. The most likely cause of the unidirectionality of the considered effects on EEG may be the common mechanisms of their implementation through the emotion-generating structures, including the activation of the limbic system and, in particular, the thalamus [12, 13], which is consistent with the exicting concepts [8, 12, 13]

It was found that, with the isolated action with the help of a relaxed EO and energizing FM, the EEG response pattern was approaching that which is characteristic for the relaxing EO only.

Additionally, there is a slight effect of the same impacts, which do not exceed the intensity of the change in interhemispheric asymmetry for individual factors. With the isolated action of the relaxing FM, a pronounced left-sided gradient of theta and delta activity in the central leads was observed. In the combinations of the effects of the relaxing FM and aroma compositions, the gradient did not exceed the values which are typical for background ones. With the isolated effect of the energizing EO, a pronounced right-sided gradient of slow rhythms in frontal, central and temporal brain areas was noted. In the combinations of the energizing EO and energizing FM, the gradient decreased.

The most significant result of the study is that the predominance of different effects of aroma compositions and functional music on the hemispheric asymmetry of EEG was shown.

Thus, the most pronounced changes in EEG parameters are explained by the relationship between olfaction and the limbic system [13, 14].

The low intensity of the energizing FM effects may be due to the fact that the laboratory conditions of the experiment (calm, silence, posture, etc.) typically lead to the state of

relaxation.

The results obtained suggest that exposure to isolated impacts can play a leading role in the modification of athletes' functional states. The techniques designed for athlete's psycho-emotional state control, body relaxation or activation, should include the use of essential oil blends of directed action [4].

The revealed dynamic changes in the functional asymmetry of the brain can affect sports performance due to the special role of functional asymmetry of the brain in the organization and execution of complex motor activities [11].

The established different intensity of responses to a combination of sensory effects is of particular importance in developing the impacts on the emotional state of athletes. On the basis of these facts, an objective assessment of the sensory impact on the activation level indicators and development of programs aimed at controlled correction of athletes' psychoemotional state is possible.

At the same time, the inclusion of unidirectional musical fragments in combined effect techniques will lead to a decrease in both the hemispheric asymmetry and the expected performance effects.

5. Conclusions

A significant similarity in the structure of changes in the EEG patterns was observed under the influence of music and aromatherapy.

Effects of the use of essential oils were slightly higher than those of music. One of the probable reasons is that the results of exposure to odors are less dependent on conscious perception than on music.

The results of the joint application of audio and olfactory influences according to EEG data did not differ in principle from the results of using only music or essential oil.

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