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Neurofeedback Successfulness and Electroencephalogram Changes in Sportsmen of Different Qualification

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Introduction

At present neurofeedback is used in training process of sportsmen more frequent. In addition to that many researches showed that not all sportsmen could master a skill of deliberate alpha-rhythm regulation [1-7]. According to V. Tristan's opinion [8] this effect requires more precise of neurophysiological mechanism of neurofeedback and it dependence on different factors.

Considering that sportsmen capacity to training and consequently the capacity to high sport mastery achievement as well as neurofeedback successfulness depend on plasticity of nervous system it is logical to surmise that highly qualified sportsmen more successful master a skill of deliberate regulation of cerebrum bioelectrical activity in alpha-band, because they have more plastic neurodynamic processes. But similar data are absent in literary sources. The changes of "background" EEG and neurofeedback course successfulness in different qualified sportsmen were analyzed for this question studying.

Material and Methods

216 sportswomen participated in the research. All participants were divided into 3 groups dependently on qualification. The first group (n=69) consisted of lowly qualified sportsmen having I and II grade. Candidates to master of sport formed the second group (n=77). The third group (n=70) was formed by Masters of sport and Masters of sport of international class. Average age of participants was 19 ± 0.1 years. The sportsmen were suggested to undergo 15-days neurofeedback course intended for cerebrum alpha-rhythm power increasing by O.V. Pogadaeva's methodology [4]. All sportswomen gave written contest for participation in the research. Neurofeedback sessions were carried out once per day in convenient time before training with help of software-hardware complex "Boslab-alpha" which was created in SRIMBB SB RAMS. Bipolar disposal was used for cerebrum biopotential recording. Electroencephalographic electrodes were located according international system "10-20" (F1, P3), two myographic electrodes were located on forehead (venter frontalis), thermoelectrode was fastened on middle finger of right hand. Neurofeedback successfulness was assessed by I.A. Svyatogor's et al. classification [6]. Electroencephalographic monitoring with opened and closed eyes was held before and after neurofeedback. The sportsmen did not have the task for alpha-rhythm power increasing during this monitoring. Time of each recording was 5 minutes.

Statistical analysis of received data was realized with help of software SPSS 13.0. Parametric and nonparametric methods of statistics for dependent and independent samples were used for data description. Normalcy of distribution was determined by Kolmogorov-Smirnov's criterion.

Results

Analysis of received data showed that post training changes of "background" cerebrum bioelectrical activity were observed in highly qualified sportsmen only and became apparent in increasing of power in alpha-band of left hemisphere. At the same time the increasing of absolute spectral power in this frequency band took place when eyes were closed in masters of sport and masters of sport of international class (Figure 1), but relative power increased both when eyes were closed and when they were opened. In addition to that only relative contribution of waves in alpha-band increased in condition with closed eyes in candidates to master of sport. The changes of sportsmen "background" EEG were not revealed any more.

The study of average course parameters of cerebrum bioelectrical activity of different qualified sportsmen (Table 1) showed that sportsmen of highest qualification were characterized by less absolute and relative value of spectral power in theta-band and by more value of age index in comparison with lowly qualified sportsmen. In addition the sportsmen of highest qualification had more significant relative contribution of alpha-band waves in spectral power of EEG in

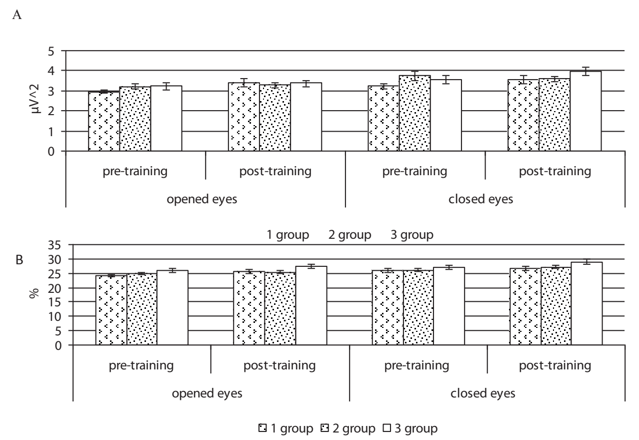

Figure 1: Changes in alpha-band of left hemisphere ("background" EEG): A) absolute spectral power; B) relative spectral power.

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Average course parameters	Lowly qualified sportsmen (n=69)	Candidates to master of sport (n=77)	Masters of sport, masters of sport of international class (n=70)
power in theta-band (μV²)	6.045 ± 0.130	5.898 ± 0.111	5.667 ± 0.110^
power in alpha-band (μV²)	3.499 ± 0.119	3.303 (2.915; 3.944)	3.324 (3.009; 4.218)
power in beta-band (μV²)	3.644 ± 0.086	3.758 ± 0.102	3.757 ± 0.098
relative power in theta-band (%)	45.480 ± 0.534	44.417 ± 0.580	42.736 ± 0.670^
relative power in alpha-band (%)	26.600 ± 0.404	26.001 (24.620; 29.009)	27.636 (25.541; 30.143)^*
relative power in beta-band (%)	27.921 ± 0.341	28.071 ± 0.317	28.946 ± 0.465
age index (con. unit)	0.585 ± 0.018	0.557 (0.486; 0.708)	0.587 (0.529; 0.740)^

*Annotation: ^-differences in comparison with the first group when P<0.05; *-differences in comparison with the second group when P<0.05*

Table 1: Average course parameters in sportsmen of different qualification completed training (Me (Q1-Q3); M ± m).

Spectral power	Frequency band		
	theta	alpha	beta
Lowly qualified sportsmen			
average mean of the first session	6.044 ± 0.171	3.010 (2.690; 3.779)	3.596 ± 0.118
average mean of 2-15th sessions	6.045 ± 0.121	P<0.02 3.251 (2.925; 4.060)	3.691 ± 0.074
Candidates to master of sport			
average mean of the first session	5.890 ± 0.167	3.226 (2.677; 3.852)	3.317 (2.896; 4.185)
average mean of 2-15th sessions	5.907 ± 0.091	P<0.001 3.448 (2.975; 3.950)	3.772 ± 0.066
Masters of sport. masters of sport of international class			
average mean of the first session	5.695 ± 0.162	3.232 (2.683; 3.840)	3.299 (2.956; 4.030)
average mean of 2-15th sessions	5.639 ± 0.113	P<0.01 3.541 (3.139; 4.103)	P<0.01 3.843 ± 0.085

Table 2: Changes of cerebrum bioelectrical activity power in different qualified sportsmen during neurofeedback course (Me (Q1-Q3); M ± m). μV²

Group	Training successfulness (%)	Amount of sportsmen undergone the training		P
		successfully	unsuccessfully	
lowly qualified sportsmen	40 ± 3.5	41	28	>0.05
candidates to master of sport	42 ± 3.4	43	34	>0.05
masters of sport. masters of sport of international class	45 ± 3.6	48	22	<0.03

Table 3: Parameters of training successfulness in different qualified sportsmen.

Model	Non-standardize coefficients		Standardize coefficients	t	P
	B	St. error Beta	Beta		
Lowly qualified sportsmen					
(Constanta) Spectral power in theta-band LH. CE	-18.615 1.261	20.376 0.431	0.337	-0.914 2.926	0.364 0.005
Candidates to master of sport					
(Constanta) Spectral power in theta-band RH. OE	124.964 -1.795	19.587 0.422	-0.443	6.380 -4.253	0.000 0.000
Masters of sport. masters of sport of international class					
(Constanta) Spectral power in beta-band LH. OE	74.933 -8.388	13.202 3.531	-0.287	5.676 -2.376	0.000 0.021

Table 4: Neurophysiological predictors of training successfulness in different qualified sportsmen.

comparison with sportsmen of other groups. It is interesting during EEG parameters studying the significant differences between the groups were not revealed during first session of the training (Table 2). During neurofeedback course all groups of sportsmen had increasing of spectral power in alpha-band, but it was accompanied by significant growth of power in beta-band in sportsmen of highest qualification only. According E.N. Levin's et al. data [3] the changes in beta-1 activity specific are related with inhibition of movement reactions, but beta-2 and beta-3 accompanied startup and inhibition of movements.

Neurofeedback successfulness was approximately equal in all groups of sportsmen (Table 3), but persons' amount undergone training successfully was significantly more than amount of undergone training unsuccessfully one at a group of highest qualification sportsmen.

With help of multiple regression analysis it was identified that from parameters of cerebrum "background" bioelectrical activity a spectral power of left hemisphere in theta-band in a state of closed eyes was a predictor of neurofeedback successfulness at a group of lowly qualified sportsmen. At the same time spectral power of right hemisphere in theta-band in a state of opened eyes was a predictor of training successfulness at a group of candidates to master of sport

(Table 4). In addition direct relation was at the first group, but inverse relation was at the second group.

Training successfulness was related inversely with spectral power of left hemisphere in beta-band in a state of opened eyes at a group of masters of sport and masters of sport of international class.

Conclusion

Thereby the quantitative value of neurofeedback course successfulness did not depend on sport qualification. But the most part of highest qualification sportsmen successfully mastered a skill of deliberate regulation of bioelectrical activity in alpha-band. At the same time the sportsmen could reproduce achieved functional condition in a state of quiet wakefulness without additional refreshment. The increasing of power in alpha-band was observed in all sportsmen during neurofeedback course, but it was accompanied by rise of power in beta-band in sportsmen of highest qualification. In whole course average cerebrum bioelectrical activity parameters indicated a higher value of relative power in alpha-band in sportsmen of highest qualification in comparison with less qualified sportsmen. Sportsmen of low qualification had higher value of absolute and relative power in theta-band and less value of age index in comparison with sportsmen of highest qualification.

The spectral power in theta-band of left hemisphere when eyes were closed was predictor of training successfulness in sportsmen of low qualification, spectral power in theta-band of right hemisphere with opened eyes-in candidates to master of sport, spectral power in beta-band of left hemisphere with opened eyes-in sportsmen of highest qualification.

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