Impact Factor:					
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	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
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	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science
p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)
Year: 2022 **Issue:** 02 **Volume:** 106
Published: 22.02.2022 **http://T-Science.org**

QR – Issue QR – Article

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DYNAMICS OF THE PSYCHOFUNCTIONAL STATE OF FOOTBALL PLAYERS AFTER THE COURSE OF NEUROBIOFEEDING

Abstract: *Quickly and late effects of training are observed dependently on sportsmen's initial cerebrum alpha-rhythm power and on neurofeedback holding successfulness. The reduction of achieved training effects is gradually and heterochronic.*

Key words: *phychophysiological state, brain rhythms, neurofeedback.*
Language: *English*
Citation: Ruzmetov, R. T. (2022). Dynamics of the psychofunctional state of football players after the course of neurobiofeeding. *ISJ Theoretical & Applied Science, 02 (106),* 531-535.
Soi: http://s-o-i.org/1.1/TAS-02-106-51 ***Doi***: https://dx.doi.org/10.15863/TAS.2022.02.106.51
Scopus ASCC: *3300.*

Introduction

The leading place in sports practice among methods based on biofeedback has been taken by neurofeedback. A significant number of works have been devoted to the study of the possibility of using neurofeedback in the training of athletes [1-8]. However, the aftereffect of the course of neurofeedback has not been sufficiently studied at present, which causes some coaches to doubt its safety and effectiveness and leads to the limited use of this technology in sports. In this regard, the aim of the work was to study the dynamics of the psychophysiological state of athletes aged 18-23 years who underwent a course of neurofeedback aimed at increasing the power of the brain alpha rhythm during the year. The study involved 57 athletes. Athletes had the following qualifications: one master of sports of international class, eighteen masters of sports, sixteen candidates for master of sports, fifteen athletes who had the first adult category and seven - the second adult category.

The average age of the examined persons was 20 ± 0.1 years. Neurofeedback was carried out using the software and hardware complex "Boslab-alpha", created at the Institute of Biomedical and Biological Biological Sciences of the Siberian Branch of the Russian Academy of Medical Sciences, according to the methodology developed by O.V. Pogadaeva [9]. To record the brain biopotentials, a bipolar lead was used, the electrodes were applied according to the international "10-20" scheme in F1 and P3 leads. The work evaluated changes in EEG power in the frequency ranges corresponding to theta- (4.0-7.9 Hz), alpha- (8.0-13.0 Hz), beta1- (14.0-19.9 Hz) rhythms . The criterion for the success of the training was an increase in the average power of the alpha rhythm per session, not less than 15% compared to the average power recorded during the first session [10].The assessment of the psychophysiological state of athletes was carried out using tests: the color test of M. Luscher [11], Spielberger-Khanin [12], E.P. Torrens [13], G.Yu. Eysenck [14], questionnaires "Self-assessment of the functional state" [1]. Psychophysiological testing of the examined persons was carried out five times. The first time - before the start of the neurofeedback course, the second time - after the end of the neurofeedback course, the third time - three months after the training, the fourth time - six months after the training, and the fifth time - twelve months after the neurofeedback course. To assess the changes in the studied indicators, parametric and non-parametric methods of statistical analysis were used for independent and dependent samples. The work was carried out using the statistical package SPSS 13.0 [15]. All athletes, depending on the registered power of the brain alpha rhythm at the

first neurofeedback session, were divided into 3 groups.

The first group included athletes (n-14) whose alpha rhythm power value corresponded to the lower quartile (up to 3.0 μV2/Hz). The second group consisted of athletes (n-29), whose alpha-rhythm power was in the middle of the distribution and corresponded to the second quartile (from 3.0 to 4.0 μV2/Hz). The third group included athletes (n-14), whose alpha-rhythm power value corresponded to the upper quartile (above 4.0 μV2/Hz). At the first training session, the groups differed statistically significantly from each other not only in the power of the alpha rhythm, but also in the power of the beta rhythm. The average values of the powers of alpha and beta rhythms in the first and second groups were less than in the third group (Table 1). During intragroup comparisons of the average values of the first session with the average course values, it was revealed that under the influence of the course of neurofeedback in the first and second groups, the power of alpha and beta rhythms increased, and in the third group, the power of the studied brain rhythms remained practically unchanged (Table 1).

A comparative analysis of the obtained data showed that most of the athletes of the first group, who have low alpha-rhythm values (up to 3.0 μV2 / Hz), complete the course of neurofeedback more successfully than athletes in other groups ($\chi 2 = 5.4$; P = 0, 02).

Table 1. Power indicators of the studied electroencephalogram rhythms, μV2/Hz, M±m

№	Group / Rhythm of the brain	First group	Second group	Third group	Difference among groups (P<0,05)
1	The power of the alpha rhythm of the first session	2.48±0.01*	3.02±0.05*	4.37±0.29 1	1-2; 1-3; 2-3
2	The power of the alpha rhythm ofthe last session	3.09±0.18**	3.80±0.48	4.54±0.54	2-3
3	Average power of the whole course	3.28±0.17	3.50±0.14	4.11±0.39	2-3
4	The power of the beta rythym of the first session	2.97±0.06*	3.61±0.23	4.49±0.32	1-3; 2-3
5	The power of the beta rythym of the last session	3.44±0.29	4.10±0.45**	4.68±0.51	
6	Average power of the whole course	3.42±0.17	3.57±0.14	4.25±0.37	2-3
7	The power of the theta rythym of the first session	5.75±0.25	6.11±0.38	5.19±0.35	
8	The power of the theta rythym of the last session	4.61±0.70	6.39±0.74	5.5±0.70	
9	Average power of the whole course	5.91±0.17	5.99±0.19	5.35±0.25	

*Note: * - intragroup difference between the power of the brain rhythm compared with the average power for the entire course (P<0.05).*

Immediately after the end of the neurofeedback course, the following changes in the psychophysiological state (term effects) were revealed in athletes. In all groups, the level of mental tension decreased, the indicators of the index of originality of non-verbal creativity and the speed of information processing (intelligence quotient) increased. It should be noted that the level of mental tension throughout the study was higher in the third group. In the first group, after neurofeedback, the index of originality of verbal creativity increased and the coefficient of vegetative balance decreased. In the third group, athletes assessed their functional state better than before the training. Other indicators of the psychophysiological state did not have statistically significant differences (Table 2). According to V.V.

Matveeva [16], the results achieved with the help of biofeedback expand the behavioral repertoire of the individual, stabilize the mechanisms of attention, improve memory, restore disturbed psychophysiological stability, which in the future can help to cope with stressful influences using the most energy-saving strategies that exclude destructive behavior.

Longitudinal observations of athletes who have completed a course of neurofeedback have shown that the effects of training gradually and heterochronously fade away over the course of a year without the development of negative consequences. In the first

and second groups, athletes have an originality index of verbal creativity for up to three months. The achieved level of the IQ and the index of originality of non-verbal creativity decrease gradually during the year after the end of the training, but not lower than the initial level. In athletes of the second group, a reduced level of mental tension persists for up to three months, and the level of vegetative balance persists for up to six months. Interestingly, in the third group, the level of mental tension continued to decrease within six months after the end of the training, and the increased speed of information processing persisted throughout the year. The improvement in the functional state of athletes after the training lasted up to three months (Table 2).

In the first group of athletes, delayed training effects were identified, possibly associated with the successful completion of the course of neurofeedback in comparison with other groups. Within three months after completing the neurofeedback course, their self-assessment of the functional state increased, with its gradual decrease by twelve months. The level of mental tension and personal anxiety also changed in waves. The post-training decline persisted for six months followed by an increase by twelve months. The level of vegetative balance during the year increased gradually. The level of situational anxiety slightly decreased immediately after the training, increased after twelve months (Table 2).

Table 2. Changes in the psychophysiological state of athletes during the year after the course of neurofeedback, M±m (arb. units)

Indicator	Group	Time intervals of testing				
		1	2	3	4	5
Originality and nonverbal creativity index	1	0,58±0,06 P1-2<0,05	0,74±0,04	0,73±0,03	0,61±0,07	0,79±0,07 P1-5<0,05
	2	0,55±0,04 P1-2<0,05	0,70±0,04	0,81±0,03 P1-3<0,05	0,66±0,06 P3-4<0,05	0,72±0,04 P1-5<0,05
	3	0,59±0,04 P1-2<0,05	0,80±0,05 P2-4<0,05	0,68±0,07	0,49±0,07	0,63±0,05 P2-5<0,05
Originality and verbal creativity index	1	0,48±0,04	0,56±0,04 P2-3<0,05	0,47±0,04	0,49±0,05* P4-5<0,05	0,36±0,04 P2-5<0,05
	2	0,55±0,03 P1-2<0,05	0,65±0,03 P2-3<0,05	0,53±0,05	0,53±0,04** P2-4<0,05	0,51±0,05 P2-5<0,05
	3	0,62±0,06	0,67±0,06 P2-3<0,05 P2-4<0,05	0,46±0,06 P1-3<0,05	0,29±0,06 P1-4<0,05 P3-4<0,05	0,52±0,06 P2-5<0,05 P4-5<0,05
level of situational anxiety	1	36±2,1	33±2,5 P2-5<0,05	36±2,5	35±2,9	41±2,9
	2	37±1,4	38±1,5	36±1,8	39±2,1	43±2,7
	3	38±1,4	38±2,0	42±3,3	41±3,0	36±2,3
level of personal anxiety	1	40±2,1 P1-4<0,05	39±2,2	39±2,8	37±2,7	41±3,2
	2	40±1,2	41±1,2	38±1,2	40±1,9	39±2,4
	3	39±1,7	41±2,1	42±2,3	45±2,1	40±2,4
mental tension	1	18,6±2,9* P1-2-0,05	14,5±2,3*	15,2±1,6 P3-4<0,05	11,1±2,4 P4-5<0,05	16,4±2,9
	2	15,5±1,5 P1-2<0,05	11,4±1,5 P2-3<0,05	15,7±2,1	14,3±2,3	16,4±3,0 P2-5<0,05
	3	24,1±3,3 P1-2<0,05	18,4±3,0 P2-4<0,05	22,3±2,9 P3-4<0,05 P1-3<0,05	14,6±3,2 P1-4<0,05	17,4±3,3
level of vegetative balance	1	1,8±0,2 P1-5<0,05	1,5±0,2	2,0±0,1* P3-5<0,05	2,4±0,5	2,3±0,3
	2	2,3±0,6 P1-2<0,05	1,7±0,3 P2-5<0,05	1,5±0,1	2,5±0,7 P1-4<0,05	4,2±2,3
	3	2,4±0,8	2,2±0,7	2,1±0,2 P3-5<0,05	1,9±0,3	1,8±0,2

intelligence coefficient	1	108±7,4 P1-2<0,05	125±10,1 P2-5<0,05	124±11,3	121±12,4	120±12,2 P1-5<0,05
	2	104±6,0 P1-2<0,05	121±6,0	125±12,7 P3-4<0,05	123±9,6	118±5,8 P1-5<0,05
	3	85±6,7 P1-2<0,05	111±7,7	113±12,2	118±8,4 P1-4<0,05	103±9,0 P1-5<0,05
score on the survey "self assessmentof functional condition"	1	50±1,4 P1-5<0,05	53±2,4	54±2,8 P3-4<0,05	50±2,3	48±3,3 P3-5<0,05
	2	50±1,0	51±1,2	52±1,7	50±1,3	45±3,9
	3	49±0,7 P1-2<0,05	52±1,3 P2-5<0,05	48±1,4	49±2,3 P1-4<0,05	49±1,5 P4-5<0,05

*Note: testing time: 1 - before the training, 2 - after the end of the training, 3 - three months after the training, 4 - six months after the training, 5 - twelve months after the training. * — statistically significant differences with the third group, ** — statistically significant differences with the first group*

The study made it possible to draw the following conclusions: dynamic rearrangements of the bioelectrical activity of the brain in athletes who have completed a course of neurofeedback depend on the initial power of the alpha rhythm of the brain. Alpha-stimulating training has a positive effect on the psycho-functional state of athletes. Depending on the initial power of the alpha-rhythm of the brain and the success of the neurofeedback course, athletes experience immediate and delayed training effects. The fading of the achieved effects of training occurs gradually and heterochronously. There were no negative effects of the course of neurofeedback.

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