DIAGNOSTICS

Psychophysiological diagnostics of functional states in Sports Medicine

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Abstract

Objectives: **The methods of psychological diagnostics ignored the integral criteria of functional states which are used in athletes. That is the reason why the elaboration of psychophysiological diagnostics criteria for higher qualification athletes was performed.**
Background: **The diagnostics of psychophysiological functions obtains information on individual and typological characteristics of higher neural system, peculiarities of forming and improvement of special experience and indicators of fatigue and hypertension of athletes.**
Methods: **The 26 higher qualification athletes (men), members of National team (Judo) were examined. The psychophysiological and neurodynamic functions such as functional mobility of nervous processes, strength of nervous processes, time perception, attention volume, operational thinking coefficient and short-term memory volume were registered by a computer system. The differential scale of functional states of psychophysiological functions in athletes was elaborated.**
Results: **The results of the investigation showed that 10 subjects had high parameters of functional states of psychophysiological functions and 14 have the intermediate level. The functional states of psychophysiological functions in higher qualification athletes characterize the functional system responsible for the results of sport. The optimization of the perception and information processing using the short-term memory reflects the psychophysiological compensatory mechanisms of a decline of visual perception and information processing capability in athletes.**
Conclusions: **The psychophysiological states in higher qualification athletes are characterized by the functional system responsible for the result of sport *(Tab. 7, Ref. 13)*.**
Key words: psychophysiological functions, functional states, neurodynamic functions, higher qualification athletes.

The study on adaptation of functional systems in athletes in increasing physical and psycho-emotional performance is directed to modern stage of sports medicine. However, the problem of functional states diagnostics as a consequence of physical activity has arisen. The functional states of athletes reflect the integral complex of functional system elements which are responsible for the effectiveness of activity. The psychic reactions of athletes during physical activity cause psychophysiological changes (Filipovich et al, 2003). Due to this fact the psychophysiological diagnostics of athletes' functional states is one of the important ways of modern sports medicine. Many studies deal with the psycho-diagnostics (Lozhkin and Voronova, 2001), influence of physical performance on cognitive functions (Brisswalter et al, 2002), emotional states (Panksepp and Bernatzky, 2002), arousal (Shawn et al, 2003), anxiety (Graft et al, 2003) and emotions (Yeung, 1996) in athletes.

But the modern methods of psychological diagnostics are ignored in the integral criteria of functional states which are used for athletes.

The separate studies of human functional states in higher psycho-emotional tensions are in process. These studies have

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established that simple psychical functions and brain capability have phases changes in psychical stress (Guido and Kok, 2000). Such psychical functions as: attention, memory, and information processing speed stability are increased in higher psycho-emotional tension. During more intensive performance the effectiveness of informational processing decreases with reduction of attention perception and memory as well as the simple and complex reactions reduction (Makarenko, 1999).

The psychophysiological diagnostics heads towards additional information for functional states in athletes.

The first, psychophysiological functions are biological fundament of an individual and typological functions of higher neural system; and may be used in differentiate diagnostics of human functional states.

The second, psychophysiological functions are characterised by the processes of forming and improvement of special experience which integrates the state of functional system by technical performance of athletes.

The third, functional states of psychophysiological functions are a sensitivity indicator of fatigue and hypertension in athletes.

Thus, the psychological diagnostics has the possibility:

– to make a prognosis of an emotional tension level, anxiety, self-control ability of emotional states in different conditions of sports;

– to determine the peculiarities for emotional stability and instability, self-analysis, behaviour organisation, closing or opening, assurance or non-assurance in athletes;

– to make a prognosis of behaviour in different conditions of sports, cooperation with coach and member team;

– to study the psychological development of profile of the individual characteristics;

The aim of the study was to elaborate the psychophysiological diagnostic criteria of the functional states in higher qualification athletes.

Methods

26 higher qualification athletes (men), members of National team of Ukraine (Judo) were examined.

The psychophysiological functions: functional mobility of nervous processes, strength of nervous processes and neurodynamic functions were registered by a computer system (Makarenko, 1999).

The latent period of vision motor (simple and complex) reactions, functional strength of nervous processes and functional mobility of the nervous processes were examined.

The functional mobility of the nervous processes was the value of the minimum exposure of visual signals using which the number of erroneous reactions did not exceed 5 % in a series of some sensor motor choice reactions.

The states of psychical functions, perception and information processing were studied by a special computer test using two algorithm changes (Korobeynikov, 2002).

First algorithm

Four digits (from 0 to 9) are presented on the computer's monitor randomly. The subjects were requested to perform a combination digit test, the task was to calculate (in mind) the number of digits transposed on the display. The aim of each presented digits road was to transpose in the increasing order.

For example:

5 2 3 4 – initial order

2 5 3 4 – first transposition

2 3 5 4 – second transposition

2 3 4 5 – final transposition, the result.

Thus, the result of this task consists of "3" transpositions which need four digits on the display in the increasing order. To answer, a person must press the computer's key "3".

Second algorithm

Four digits (from 0 to 9) are presented on the computer's monitor randomly. The subjects were requested to perform a combination digit test, the task was to calculate (in mind) the number of digits transposed on the display. The aim of each presented digits road was to transpose in the decreasing order.

For example:

0 4 7 8 – initial order

0 4 8 7 – first transposition

0 8 4 7 – second transposition

8 0 4 7 – third transposition

8 0 7 4 – fourth transposition

8 7 0 4 – fifth transposition

8 7 4 0 – final transposition, the result.

Thus, the result of this task consists of "6" transpositions which need four digits on the display in order to calculate (in mind) the number of digits transposed on the display in the decreasing order. To answer, a person must press the computer's key "6".

The time and the accuracy of performing each assignment were registered in each subject. The duration of a whole informational process was 4 minutes (2 minutes for each test). The used model of visual perception and informational processing was submitted as part of the computer's system of psychophysiological capacity diagnosis (Korobeynikov G.V., 2002).

Based on the testing results, the following psychophysiological parameters were determined: attention volume (AV) and operational thinking coefficient (OT):

$$AV = (Nr / N)* 100\ \% \quad (1)$$

where

Nr – the number of tasks performed successfully, N – the number of all tasks performed.

$$OT = (Nr / T)* 100 \quad (2)$$

where

T – average time of solving a test problem (msec), 100 – coefficient.

Tab. 1. Differential scale of psychophysiological states in athletes.

Factors	Scale of the estimation of the condition psychological function				
	high	above average	average	below average	low
Latent period of simple sensor-motor reactions (ms)	≤189	190–236	237–268	269–315	≥316
Latent period of complex sensor-motor reactions (ms)	≤344	345–427	428–482	483–565	≥566
Functional motilities of the nervous processes (%)	≥120	110–100	90–80	70–60	≤50
Strenght of the nervous processes (%)	≤3.0	3.1–4.5	4.6–5.5	5.6–7.0	≥7.1
Time perception error (c)	<2	3–5	6–7	8–9	>10
Attention volume (%)	>92	91–88	87–67	79–67	<66
Short-term memory volume (%)	>94	93–65	64–49	48–21	<20
Operational thinking coefficient (secret unit)	>4.3	4.2–2.9	3.0–2.0	2.1–0.9	<0.8

Tab. 2. Categorization of psychophysiological condition index.

Level of psychophysiological conditions	Psychophysiological conditions index
High	≥30
Average	9–29
Low	≤10

Tab. 3. Parameters of psychophysiological conditions index in higher qualification athletes.

Psychophysiological conditions index	Level pf psychophysiological conditons	
	high n=10	average n=14
	33.11±1.14	24.66±0.97*

* p<0.05 compared to the higher group

Tab. 4. Parameters of neurodynamics functions in higher qualification athletes with different psychophysiological conditions.

Parameters	Psychophysiological conditions index	
	high n=10	average n=14
Latent period of simple sensor-motor reactions (ms)	229.54±29.57	235.25±6.37
Latent period of complex sensor-motor reactions (ms)	457.61±19.42	451.72±7.36
Functional motilities of the nervous processes (%)	83.33±10.80	80.11±11.21
Strenght of the nervous processes (%)	5.21±0.47	8.79±0.40*

* p<0.05 compared to the higher group

For the evaluation of a time perception, we used a modified „individual minute“ test proposed by Halberg F (1978) (time perception error).

The memory function was determined by using a method for measuring short-term memory volume (MV), which consists in estimating the correctly memorised digits among twelve two-digit figures presented for a subject on a display within 30 s.

Results

Using the results of our previous study, the differential scales of psychophysiological states (as a functional states of psychophysiological functions) were elaborated (Tab. 1).

As seen on Table 1, the high level of psychophysiological states has 5 points, the low has 1 points. Table 2 characterise the classification of psychophysiological conditions index (PCI) as a sum of psychophysiological factors (which include the functional states of psychophysiological functions in athletes).

The results of the investigation have shown that 10 subjects had a high level of psychophysiological functional state and 14 were at the intermediate level. The results of psychophysiological conditions index (PCI) among higher qualification athletes are described in Table 3. These data show a higher meaning of PCI in athletes with increasing level of psychophysiological conditions.

The data of neurodynamics functions in higher qualification athletes with different levels of psychophysiological conditions are shown in Table 4. Statistically significant differences among sportsmen are showed for the strength of the nervous processes parameters.

Tab. 5. Parameters of psychical functions in higher qualification athletes with different psychophysiological conditions.

Parameters	Psychophysiological conditions index	
	high n=10	average n=14
Time perception error (s)	0.56±0.07	6.29±0.08*
Attention volume (%)	71.21±10.55	76.16±4.61
Short-term memory volume (%)	73.31±4.92	45.82±3.34*
Operational thinking coefficient (secret unit)	2.61±0.83	1.17±0.20*
First algorithm		
Average time of test performed (ms)	759.28±86.79	1090.89±101.56*
Coefficient of variation of the average time of test performed (%)	64.40±5.08	44.95±5.67*
Number of errors	4.66±1.84	3.16±0.74
Productively (number of positive tests performed)	20.22±2.18	14.58±1.17*
Second algorithm		
Average time of test performed (ms)	665.03±91.03	1002.77±107.82*
Coefficient of variation of the average time of test performed (%)	54.87±6.65	54.40±4.89
Number of errors	1.33±0.55	2.75±0.77
Productively (number of positive tests performed)	20.89±2.13	15.08±1.24*

* $p<0.05$ compared to the higher group

According to the analysis of psychical functions, the athletes with higher level of psychophysiological conditions have promotion of a short-term memory volume, operational thinking coefficient and productivity.

The reduction of time perception error reflects the positive correlation with increasing PCI.

The statistically significant reduction of average time of solving the test in first and second algorithm indicates the higher informational processing speed in athletes with increasing PCI (Tab. 5).

The reduction of tension level of psychophysiological regulation in athletes with increasing PCI testifies the higher meanings of variation coefficient of the average time of first algorithm performed (Tab. 5). The statistically significant variation coefficient of the average time of second algorithm, performed in athletes with different PCI, is absent (Tab. 5).

In the view of this fact, the adaptation to the performed activity in athletes with increasing PCI is characterised by reduction meanings of the variation coefficient of the average time of the performed test. Athletes with decreasing PCI are characterised by higher meanings of the variation coefficient of the average time of the performed test.

According to our previous studies, the variation of functional system parameters is not an artefact but a basic property of a search for adaptation to inner or outer conditions in organisms (Tkachuk and Korobeynikov, 2000). The increasing meanings of variation coefficient of the average time of the preformed test in athletes with higher levels of psychophysiological conditions index show a search for adaptation in organisms. As the results of this search, the corrections of functional system regulation in terms of rejection and reduction of elements of functional system are viewed.

As a consequence of a short-term memory used, the effectiveness process of perception and informational processing in athletes is increased. It shows the higher level of PCI in athletes and increasing productivity during performed test (Tab. 5).

The correlation analysis in the study of peculiarities of cooperation among functional system of informational processing elements was used.

The correlation coefficient in athletes of higher level of psychophysiological states is shown in Table 6.

The correlation coefficient of attention volume and number of errors with strength of the nervous processes has shown a significant link to neurodynamic and attention functions (Tab. 6).

Tab. 6. Data of correlation analysis between parameters of athletes with higher level of psychophysiological states.

Parameters	Latent period of simple sensor-motor reactions	Functional motilities of the nervous processes	Strength of the nervous processes
Time perception error	0.74	–	0.37
Attention volume	–	0.47	-0.70
Operational thinking coefficient	0.35	0.66	–
Average time of test performed	-0.55	-0.47	–
Coefficient of variation of the average time of test performed	–	-0.48	–
Number of errors	–	-0.39	0.78
Productively	0.49	0.59	–

Tab. 7. Data of correlation analysis between parameters of athletes with low level of psychophysiological states.

Parameters	Latent period of simple sensor-motor reactions	Functional motilities of the nervous processes	Strength of the nervous processes
Time perception error	-0.73	–	0.36
Attention volume	–	–	-0.39
Operational thinking coefficient	–	–	–
Average time of test performed	–	0.37	–
Coefficient of variation of the average time of test performed	0.50	–	–
Number of errors	–	–	–
Productively	–	–	–

This result is in accord with author's data on relation of individual-typological characteristics of nervous system and attention (Makarenko, 1999). The correlation between functional motilities of the nervous processes with parameters such as attention, operational thinking coefficient, average time of the performed test, number of errors and productivity confirms this fact (Tab. 6).

The negative correlation between functional motilities of the nervous processes and variation coefficient of the average time of the performed test testifies the difficult determination of organisation of informational processing system in athletes with higher PCI.

The correlation coefficient in athletes with low level of psychophysiological states is show in Table 7. The correlation between time perception error and latent period of simple sensor-motor reactions and strength of the nervous processes proves these data (Tab. 7).

Discussion

In our previous studies, the concept of psychophysiological organisation as forms of functional system (Anokhin, 1975) in human activity was substantiated (Korobeynikov, 2002). According to this concept, the psychophysiological organisation includes the adaptive-compensatory mechanisms of a decline of visual perception and information processing capability protection starts to activate. One of these mechanisms is linked with the optimalization of perception and information processing using the short-term memory. As the results, productivity and operational thinking in higher qualification athletes with higher level of psychophysiological condition are increased.

Conclusions

1) The elaboration method of psychophysiological diagnostics provides a possibility to control the functional states of higher qualification athletes with individual-typological peculiarities.

2) The psychophysiological states in higher qualification athletes are characterized by a functional system responsible for the result of sporting activity.

3) The optimization of the perception and information processing by a short-term memory reflects the psychophysiological compensatory mechanisms of a decline of visual perception and information processing capability in athletes.

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