Athletes Preparation based on a Complex Assessment of Functional State

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Abstract: Modern training of middle distance runners is characterized by significant increase in loading intensity owing to strengthening of the sports competition. Absence of the athletes' functional state complex diagnostics complicates the process of training and competitive loadings planning which can lead to failure in adaptation. Middle distance runners functional state assessment is considered in the article. Methods of functional diagnostics: polymyography, HR variability with active orthostatic test, research of physical working capacity (PWC170 test), the express -diagnostics of a functional state by Dushanin's method and the "Reaction to Moving Object" (RMO test). Research material. Physical working capacity is estimated by means of the PWC170 test, a psychofunctional state by the "RMO" test, an assessment of neuromuscular system by "Rehabilitation and diagnostic RDK-2 complex", an assessment of HR variability was done with active orthostatic test. Results. Complex diagnostics of the runners' functional state and its further complex assessment by means of the received indices were carried out. The runners' functional state improvement in the experimental group from the 1st to the 3rd investigation phase is observed. The correlation and factorial analysis of the indices is carried out, the model scale of a functional state assessment is developed.

1 INTRODUCTION

Training is recognized as a process which prepares an athlete for the highest possible level of performance. Training of elite athletes is a versatile and multi-factorial process of effective use of the whole combination of factors, including selection of means, methods and conditions, innovation technologies, ensuring proper adaptation effect on an athlete and the appropriative means for control of the level of their readiness for sport activity.

As the sport training attempts to lead the athletes to their genetics upper limits it must provide an appropriate stimulus for adaptation. The analysis of scientific-methodological and specialized literature revealed that middle-distance running is characterized by the significant growth of the volume and intensification of training loads. Their further increase can result in failure of adaptation, overtraining and pathological changes of the body functional systems (Konovalov, 1999; Wilmore, Costill, 2001; Makarova, 2002). The above-stated promotes the conclusion that management of athletes training lacks information on the integrated assessment of body's functional state.

In this regard, complex assessment problem of sportsmen functional state is very interesting. Control and assessment of functional readiness as a multifactor system has to be carried out in a complex of making main components (motor, the energy, the neural dynamic and mental).

Thus, we determined the purpose of our research – development and experimental justification of track and field runners method on middle distance on the basis of the functional state complex assessment.

Research Organization. The research was conducted on the basis of Povolzhskaya State Academy of Physical Culture, Sport and Tourism laboratory. Middle distance runners total of 30 people (15 athletes in the control group and 15 in the experimental group) took part in this research.

The research was conducted in 3 stages.

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2 METHODS

For definition the functional state of the athletes we used several methods and means (hardware and software systems (HSS)):

- for definition of physical working capacity we used the Test PWC170.The investigated exponents: absolute maximal oxygen consumption (VO2), relative maximal oxygen consumption (relative VO2), index PWC170, PWC170 relative (PWC170 rel.), assessment of the recovery period;
- for definition of psychofunctional state we used the test «Reaction to a moving object» (RMO) on device "Activatsiometr AC-9K", created by U.A. Tsagarelly (Russia). The parameters: accuracy of RMO, tendency of RMO to lag (ten. RMO to lag), tendency of RMO to advance (ten. of RMO to adv.), variation range;
- for definition of the heart rate variability (HRV) indicators with an active orthostatic test (AOT) we used electrocardiograph Poly-Spektrum-8/EX and software Poly-Spectrum-Rhythm. Determined: heart rate at rest (HR), indicators of spectral analysis(TP – total power, %VLF – very low frequency, %LF – low frequency, %HF – high frequency),stress index (SI), coefficient K30:15.
- the level of athletes functional state with the help of device «D&K-Test» by S.A. Dushanin's method. Indicators of: anaerobic metabolic capacity (ANMC), aerobic metabolic capacity (AMC), overall metabolic capacity (OMC), power of creatinephosphate source of energy supply, power of glycolytic source of energy supply (PGL), power of aerobic source of energy supply (PASES), HR on the threshold level of anaerobic metabolism (HR TLAM) were determined.
- for definition of the neuromuscular system (NMS) functional state we used HSS "Rehabilitation and diagnostic system RDK-2" and the method of polymyografiya, which was created by Y.V. Visochin (Russia). Indicators were defined: speed arbitrary intension of relative (SAIr), coefficient of maximum of relative arbitrary power (CMVPr), speed of arbitrary relaxation (SAR), integrated parameters: the functional state of the muscles (FSm), the functional state of the neuromuscular system (FSnms), the functional state of the central nervous system (FStcns).

We conducted mathematical and statistical analysis of the data.

3 RESULTS

The complex diagnostics functional state of the middle and long distance runners has been conducted in the first stage of our research. At the first stage of the study PWC170 tests with physical load were fulfilled in order to determine the level of physical working capacity. There were no significant differences in physical working capacity between two groups. In the control group (CG) PWC170 equaled 1397,6±30,27 kgm/min, and relative PWC170 was 20,25±0.29 kgm/min/kg; in the experimental group (EG) they equalled 1376±30,27 kgm/min and 20,32±0.42 kgm/min/kg respectively (the differences were insignificant: p=0,658, p=0,889). VO2 max values in both of the groups were similar. In the CG VO2 max and relative VO2 max were 3,67±0,07 l/min and 53,85±0,43 ml/ (kg*min), in the EG – 3,59±0,07 l/min and 53,63±0,68 ml/ (kg*min), respectively (p=0,429; p=0,786).

The rate of recovery is a principal and almost absolute index to estimate adaptation to load and fitness level. The recovery dynamics during a 5 minute period was determined. In both of the groups recovery processes were similar, and difference was insignificant (p>0,05). The heart rate (HR) in the CG recovered as follows: 1st minute – 118,27±1,42 bpm; 2nd min – 101,07±1,58 bpm; 3rd min – 92,93±0,83 bpm; 4th min – 92,80±0,73 bpm; 5th min – 88,27±0,44 bpm. In the EG HR changed as: 1st min – 117,93±1,49 bpm; 2nd min – 100,53±1,35 bpm; 3rd min – 94,93±1,0 bpm; 4th min – 91,60±0,92 bpm; 5th min – 88,00±0,98 bpm.

The athletes' psychofunctional state was determined by the RMO test (Table 1). In the CG the accuracy of RMO amounted to 18,95±0,87 ms; the tendency of RMO to lag – 22,11±0,80 ms; the tendency of RMO to advance – 19,24±1,1 ms; the variation range – 68,67±3,22 ms. In the EG these RMO values were 17,03±0,86 ms; 22,89±0,97 ms; 21,06±0,83 ms; 69,33±3,16 ms, respectively (the differences were insignificant, p>0,05).

The heart rate variability (HRV) technique is applied to estimate regulation of physiologic functions, of general activity of the regulation mechanisms, of heart neurohumoral regulation, and of the relation between sympathetic and parasympathetic systems of involuntary nervous system. In our study a modification of this technique with active orthostatic test (AOT) was applied. In the CG the HR value in rest equaled 62,13±2,10 bpm; the results of HRV spectral analysis were the

Table 1: The test «Reaction to a moving object» indicators.

Indicator	$\overline{X}\pm\sigma$	
	CG	EG
Accuracy of RMO, ms	18,95±0,87	17,03±0,86
The tendency of RMO to lag, ms	22,11±0,80	22,89±0,97
The tendency of RMO to advance, ms	19,24±1,1	21,06±0,83
The variation range, ms	68,67±3,22	69,33±3,16

following (Table 2): total spectral power (TP, ms^2) – 3144,07±138,36 ms^2, percentage of variations in very low frequency in the total power (%VLF) – 33,86±1,54%, percentage of variations in low frequency in the total power (%LF) – 26,18±1,02, percentage of variations in high frequency in the total power (%HF) – 36,83±1,42, stress index (SI) – 83,86±3,80 c.u., current FS – 10,47±0,47 points. In the EG these values equaled 61,47±1.81, 3286,73±167,27 ms2, 35.82±0.98%, 28,13±1,42%, 37,47±1,19%, 84,24±2,87 c.u., 10,07±0,41 points, respectively. The differences in all these values between two groups were insignificant (p>0,05).

At the first stage of HRV with AOS all values were uniform (p> 0,05): HR was 81,20±1,98 bpm; the results of HRV spectral analysis: TP – 3107,33±111,90 ms2, %VLF – 43,26±1,53%, %LF – 38,03±1,63, %HF – 19,66±0,91; K30:15 – 1,14±0,03 c.u.. In the EG these values were: 78,87±2,49; 3100,80±131,33 ms2, 42,73±1,50%, 37,33±1,91%, 18,02±0,59%.

Thus, at the first stage of the study differences between the CG and the EG were statistically insignificant, and both groups were uniform.

Table 2: Heart rate variability at rest.

Indicator	$\overline{X}\pm\sigma$	
	CG	EG
HR, bpm	62,13±2,10	61,47±1.81
TP, ms^2	3144,07±138,36	3286,73±167,27
VLF,%	33,86±1,54	35.82±0.98
LF, %	26,18±1,02	28,13±1,42
HF, %	36,83±1,42	37,47±1,19
SI, c.u	83,86±3,80	84,24±2,87

The FS level and athlete's body reserve (Table 3) were determined by S.A. Dushanin's technique which enables to estimate the FS without invasive methods, and to get an approximate representation of the main parameters of aerobic and energetic metabolism.

The results at the first stage were uniform for both groups (p>0,05). In the CG we obtained: anaerobic metabolic capacity (ANAMC) – 85,22±4,53%, aerobic metabolic capacity (AMC) – 241,17±6,93%, overall metabolic capacity (OMC) – 322,45±8,99%, power of creatinephosphate source of energy supply (PCSES) – 31,99±0,97%, power of glycolytic source of energy supply (PGSES) – 30,73±0,64%, power of aerobic source of energy supply (PASES) – 68,96±1,23%, HR on the threshold level of anaerobic metabolism (HR TLAM), that characterizes the energy supply of muscles by ATP aerobic synthesis, – 168,98±1,65 bpm; FS parameters: integral – 29±0,67 points, current – 28,29±0,73 points, operational – 19,87±0,34 points. In the EG the results were as follows: ANAMC – 85,59±4,35%, AMC – 240,84±6,09%, OMC – 323,77±6,63%, PCSES – 32,03±1,55%, PGSES – 30,53±0,84%, PASES – 69,40±1,38%, HR TLAM – 169,31±1,65 bpm, FS parameters: integral – 29,13±0,32 points, current – 28,93±0,40 points, operational – 20,07±1,03 points.

Table 3: Functional state level and athlete's body reserve (S.A. Dushanin's technique).

Indicator	$\overline{X}\pm\sigma$	
	CG	EG
ANAMC, %	85,22±4,53	85,59±4,35
AMC, %	241,17±6,93	240,84±6,09
OMC, %	322,45±8,99	323,77±6,63
PCSES, %	31,99±0,97	32,03±1,55
PGSES, %	30,73±0,64	30,53±0,84
PASES, %	68,96±1,23	69,40±1,38
HR TLAM, bpm	168,98±1,65	169,31±1,65

The FS of neuromuscular apparatus were determined by the polymyography. At the first stage of study both of the groups showed similar results (p>0,05). In the CG the rate of relative arbitrary tension (RATr) was 6,31±0,30 kgf/kg×s, the coefficient of relative maximal arbitrary force (CMAFr) – 6,95±0,37 kgf/kg, the rate of arbitrary relaxation (RAR) – 4,42±0,27 1/s, the FS of muscles (FSm) – 10,05±0,28 c.u., the FS of neuromuscular system (FSnms) – 8.56±0,43 c.u., the FS of central nervous system (FScns) – 4,90±0,27 c.u.. In the EG these parameters equalled 6,58±0,25 kgf/kg×s, 7±0,54 kgf/kg, 4,3±0,22 1/s, 10±0,92 c.u., 8,51±0,75 c.u., 4,94±0,29 c.u., respectively.

The special training level was estimated by means of 800m and 1500m runs, ten jumps, 60m run, standing long jump. At the first stage of the study both of the groups showed similar results (p>0,05). In the CG the following results were recorded: 800m run – 2,07,5±0,01 min, 1500m run – 4,11,3±0,03 min, ten jumps – 22,26±0,86 m, 60m run – 7,92±0,16 s, standing long jump – 246,53±5,68 m. In the EG the results were as follows: 800m run – 2,06,8±0,02 min, 1500m run – 4,12,1±0,03 min, ten jumps – 22,28±0,69 m, 60m run – 7,90±0,18 s, standing long jump – 247,87±6,27 m.

Identified indicators allowed to conduct a correlation analysis of the obtained data. Analysis helped us to establish significant correlation between the registered data in the research period. However, this action represents complexity for analyze large number of indicators. It is necessary to select the major components, which influence studied object, in this case, the functional state.

Multivariate statistical analysis methods (cluster, factor, component, pattern recognition and multidimensional scaling) allow classification of objects on a large set of attributes to study their structure. Methods of factor (component) analysis decide this problem.

On the basis of factor analysis, we presented the characteristic components. Factor analysis allowed to select five components, which characterize the structure of the athletes functional state. Amount of contributions in all components was 65,29%, the proportion of unaccounted factor was 34,71%.

The I structural component of the functional state was interpreted as by us "functional productivity". This component is the largest, its share in total dispersion accounted for 19.23%. It includes some indicators of physical working capacity (absolute and relative indicators of PWC170), MOC, parameter VLF and with a lower load factor accuracy of RMO, the functional state index of the neuromuscular system (correlation coefficient 0,52, 0,62, 0,60, respectively).

The share of the II structural component of the functional state was 13.5% of the total variance. The united indicators of resting heart rate (r = -0,70) and indicators of the test "Reaction to a moving object" - the tendency of the reaction to a moving object to lag and variation range (r = 0,72 and 0.77, respectively). With a smaller load factor in this group included the index of the autonomic nervous system parasympathetic division activity (% HF), stress index (r = 0,51 and 0.54, respectively) and a negative correlation - performance in run 1,500 m and 10 jumps (r = -0,54 and -0.52, respectively). This component can be interpreted as the "economization of recovery processes."

The III structural component of the functional state (weight factor 12,35%) – "the indicators of central regulation". It united indicators in running for 800 m (r=0,81), indicators TP (total spectral power) (r=0,69), with a negative correlation entered power energy supply glycolytic source (PGL), long jump from the space and index central nervous system functional state (r=-0,68; -0,59 и -0,52 respectively).

The IV structural component (11,14%) is "efficiency of metabolic processes" against weak loads factor loadings attract attention of overall metabolic capacity (r=0,82), aerobic metabolic capacity (r=0,61), power of creatine phosphate source of energy supply, power of aerobic source of energy supply (r=0,62; r=0,62 respectively), HR on the threshold level of anaerobic metabolism (r=0,62).

The V component of the structural functional state was interpreted by us as "the neuromuscular system functional state" has a share of total dispersion 9,07%. The largest factor loadings in the component entering indicators of speed arbitrary intension introduce in athletes weight and the functional state of the muscles (r=0,80; r=0,63 respectively).

Allocated components describe the significance of physiological systems and make the largest contribution to the change in the functional state. Conducted factor analysis allow to estimate the functional state in summary form, structural indicators which are average statistical. Owing to it, we have developed estimation scale for every indicator, which enters into the component analysis structure. For construction of a 10-point estimation scale, we used the scale intervals. Proceeding from this, it is possible to calculate the total score of indicators group and its arithmetic meaning value, which characterizes every component.

The model values of the group and the level of the components athletes functional state the factual values development in the structure are shown on the figure 1.

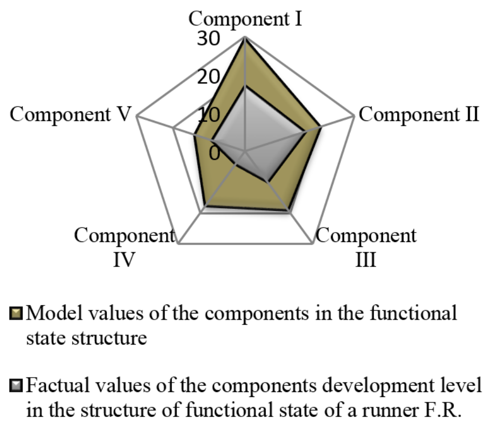

Figure 1: Average group models and factual values of the athlete functional state structure components development.

4 CONCLUSIONS

Technique of complex assessment includes a comprehensive diagnosis of an athlete of functional state, revealing its most significant components, also the estimation of every indicator functional state scale, which allows to value the structure of the factorial analysis. It is allowed to compare the main group model values and factual values of the runner's functional state structure development level.

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