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Original Article

Modern and methodic approaches to express-assessment of functional preparation of highly qualified athletes

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Abstract
The purpose of the study was to experimentally verify the informativity and objectivity of the innovative method for assessing the fitness of athletes to improve the effectiveness of the medical and biological control and training process. *The object of the study* is a system of medical and biological monitoring of the functional fitness of athletes. *The subject of the study* is the degree of coherence of the indicators of functional preparedness, determined by direct (laboratory) and indirect (innovative) research methods. *Participants.* To assess the validity and representativeness of the innovative method for determining the level of functional preparedness and its individual indicators, 15 athletes aged 19-20 years old attended the British Student Sports Clubs. *Results*. The analysis of the data allowed to establish the high informative and objective nature of the developed innovative method for assessing the current level of functional preparedness, which was reflected in the high degree of coherence between the parameters of functional preparedness of the surveyed athletes determined by two different methods. It was shown that the mean values of absolute and relative values of all studied indices were not significantly different ($p < 0.05$); for all indicators there was a strong correlation dependence; the magnitudes of the general error in the method of Blend-Altman did not exceed the marginal 10%; the value of the absolute difference between the values of all indicators of functional readiness was in the allowable range from 1.96 to+1.96 dB, and the coefficients of the linear regression equations did not exceed the limit values. In addition, the assessment of the reliability of the proposed method showed its undeniable representativeness. This was confirmed by the absence of significant differences between the results of the first and second consecutive tests, high correlation coefficients, minor variations in the coefficient of variation, and the general error of the Blend-Altman.
Key words: functional preparedness, innovative method, laboratory method, degree of coherence, representativeness, athletes 19-20 years.

Introduction

Functional readiness level control is carried out during diagnostic examination of an athlete to define the formation of pre-nosological diagnosis, which is intended to distinguish the occurring process due to the transition from normal to abnormal premorbid state [Achkasov et al., 2011]. Therefore, the problem of quality and operational assessment in the level of functional preparedness of different gender's athletes and specialization is one of the most urgent in the area of high performance in sport [Chorba et al., 2010; Karaulova et al., 2018; Romanenko et al., 2018]. It is due to the necessity to improve the system of medical and biological monitoring of the athletes' general state in different periods of the annual macro-cycle. In addition to improve the efficiency of the training process, and to achieve high outcomes in competitions of domestic and world levels. [Halson, 2014; Saw et al., 2016].

The diagnosis of the functional state of the organism (FSO) has played a leading role in the fitness assessment. The coach as well as an athlete feel an urgent demand for an objective diagnosis of the FSO during the annual training cycle-competitive, as well as directly prior the competition. Medical sports personnel would

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use this technology to improve the FSO, and in the early detection, help to notice overtraining and medicamental correction of undesired deviations critical functional performance [Antonov, 2017]. Functional parameters' changes reflect the level of the overall adaptation of athlete's body to a physical exercise loads as well as functional preparation to exercises in certain sports. Unfortunately, sports medicine has an insufficient set of FSO diagnostic technologies. This assessment of laboratory parameters, ECG analysis, heart rate and respiration parameters is under the influence of substantial (often the maximum) physical activity. FSO technology for medical diagnostics of children and adolescents does not exist at all [Raichlen et al., 2016]. It creates certain difficulties to conduct the selection of promising athletes in sports groups on the level of initial preparation. The load diagnostic of FSO for high level athletes, in Ukraine, is carried out only twice a year as part of a full medical examination. In studies, various methodological approaches were offered by experts to the definition of functional training of athletes specializing in different sports, and the list of indicators, sufficiently reflecting the current state [Valeria & Olexander, 2015; Tyshchenko, Hnatchuk et al, 2018]. The analysis of these studies revealed that main disadvantages of the studies are the lack of a clear list of parameters that objectively reflect the current level of functional preparation, the ability to operate in the process of testing based on traditional indicators (such as absolute and relative values of power and aerobic capacity) and considerable, based on power, load testing which is nothing to do with the training and competitive directivity [Vanyushin, & Khayrullin, 2015; Tishchenko, 2016]. Maintaining a high level of vegetative homeostasis indicates the certain fitness level of athletes, sufficiently maintain the high potential of sympathetic-adrenal system and to overcome hyperkinetic syndrome [Yuriy et al, 2016; Valeria et al, 2017].

Knowledge of the functional state of athletes in their preparation for the season as well as during the season has important meaning for the rational construction of the training process and the possibility of adjustment to achieve optimal results. In connection with the above, the main topic of research may be considered as promising, associated with the search for the most informative and uncomplicated to use practical methods for an operative assessment of male athletes' level of functional readiness, and female athletes of different qualification and expertise, especially with modern advances IP-technologies. Unfortunately, the analysis of the published literature allowed to state the limitations of the experimental work on the issue that determines the relevance and practical significance of the study.

Materials and Methods

Participants

The study, which was conducted at the Department of Sports in the functional diagnostics laboratory of the University of Greenwich (UK), selected 15 athletes between the ages of 19-20 years old of student sports clubs in the United Kingdom. The studies were conducted in accordance with the ethical standards of the Declaration of Helsinki and was approved by the Ethical Committee of the University of Greenwich research (UREC). Prior of presenting a written informed consent to participate in the study, the participants were fully informed of the nature and risks of the research. Participants were required to refrain from heavy exercises for 24 hours before each test, and as well as having a meal 3 hours before tests.

Goals, methods and procedures

The aim of the study – to experimentally verify the information content and the objectivity of the innovative method of the functional readiness's assess of athletes to improve the efficient system of medical and biological controls and training process.

The object of the study – the degree of indicators' harmonization of functional preparation defined by a direct (laboratory) and indirect (innovative) research methods.

Certain goals of the research, prior to the assignment, were created and had tasks to be followed:

1. To analyze the scientific-methodical literature on the research problem.
2. To define main indicators of athlete' functional readiness aged 19-20 years old with a direct (laboratory) and indirect (innovative) research methods.
3. To assess the degree of the parameters' consistency of the athletes' functional readiness, aged 19-20 years old who are determined by two different methods of the study based on the results of correlation analysis and Bland-Altman's mathematical analysis.
4. To assess the degree of margin of the proposed innovative method for determining the functional readiness based on a comparative analysis of the results of two successive surveys of the present method.

The tasks were solved on the basis of scientific and methodical literature analysis, generalization of primary practical experience with the use of the following methods in the study:

1. Analysis and generalization of scientific and methodical literature in the study.
2. Natural experiment.
3. Sub-maximum test PWC_{170}.
4. The computer program of express assessment of functional readiness of the body, "Sport-Express" [Malikov et al, 2014].
5. Methods of Mathematical Statistics.

We have developed an innovative method for express assessment of the functional preparation level, and its components that involve the simultaneous use of traditional submaximal test PWC_{170} in conjunction with the developed "Sport-Express" computer program. The basis of this program is known theoretical representation regarding the nature of changes in the functional state of the athlete's body wuile he is performing physical activities of various capacities. Its peculiarity carries the fact that only on the basis of the specified 10-min submaximal test, PWC_{170}, calculates almost all the parameters of functional readiness of the athlete's body (fig. 1).

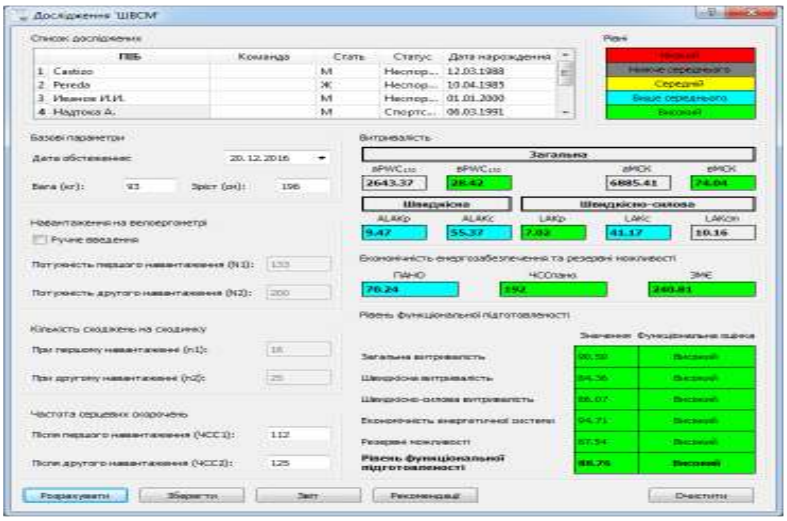

Fig. 1 **Active screen of computer program for express-assessment of functional preparation, "Sport-Express"**

The results are automatically recorded in the survey, and compared with the norm and the previous data of the athlete. This allows the sports doctor to easily determine which parameters have changed or gone beyond the limit of normal in one direction or another. The monitoring is based on the analysis of the physiological changes in the body, typical for sports activities, while non-invasive measurement of various physiological parameters of central and peripheral hemodynamics, transport and oxygen consumption and respiratory function.

It should be emphasized that the calculation of the quantities $aPWC_{170}$, $rPWC_{170}$, aMOC and rMOC conducted by generally known formulas, while the definition alactic values, lactate anaerobic power (ALANp and LANp) and capacity (ALANc and LANc) threshold anaerobic exchange (TAE), heart rate at the level TAE (HR_{TAE}) and the integral index (level of functional readiness, LFR) is carried out in accordance with the formulas which were developed by our team. According to the algorithm of the program value, all indicators are ranked functional classes 'low", "lower middle", "mean", "above average" or "high" with the help of specially developed scales of the assessment.

Statistical analysis. The mathematical calculation of the results of the study carried out via statistical software package "Statistika 7.0" and EXELL counting traditional indicators: the arithmetic mean (M), an error arithmetic mean (S), t – t-reliability criterion for equal samples and the correlation coefficient is Pearson (R).

Absolute values (Δabs) and relative (Δrel,%) of the difference between the values of the indicators that were identified direct (invasive) and indirect (non-invasive) methods, their distribution in the range of up to – 1,96SD + 1,96SD, nature of the mathematical function as a linear regression equation, magnitude of the total error (E,%) were calculated using a Bland-Altman technique.

The value of the absolute differences calculated by the following formula:

$$\Delta abs = Xcriterial - Xpractical,$$

where in Xcriterial – index value, which is defined by an indirect method; Xpractical – value of the index, which is determined by the direct method.

The value of relative differences was calculated by the following formula:

$$\Delta rel = 100 \times (Xcriterial - Xpractical / Xcriterial).$$

Reliability or representative test re-testing, the proposed non-invasive method was confirmed using ANOVA analysis of variance for repeated measures where the coefficient of variation (CV,%) was calculated.

The level of significance was taken as $p<0,05$ both in direct and in indirect tests. Outcomes are presented as mean ± standard deviation, or as a mean value ± error of the arithmetic mean. The test report required to conduct two direct and two indirect (by means of a computer program, "Sport-Express") tests.

The level of functional readiness and its individual components were determined by the indirect method (using submaximal test PWC_{170} and computer program, "Sport-Express) and direct (laboratory) research method (using submaximal and maximal tests on a bicycle ergometer "Lode Corival" (Groningen, Netherlands), Biochemistry analyzer of blood samples "Analox P-LM5" (Analox; London, UK) and a gas analyzer "Metalyzer 3B" (Biophysik; Leipzig, Germany).

Results of the research

With a view to experimental verification of the information content, our proposed method was used to study the coherence of indicators of functional readiness, which were determined by the direct (laboratory) and indirect methods of the research.

The obtained outcomes on this point indicated no significant differences in the average values of all the functional readiness indicators that have been determined by various methods (Table 1).

Table 1 Indicators of functional readiness of sportsmen of 19-20 years, as determined by direct (DM) and indirect (IDM) methods, $\bar{x} \pm S$

Indicators	DM	IDM	Δabs	Δrel	R	E
$aPWC_{170}$, kgm/min	1150,9±78,99	1159,2±69,57	86,7±12,57	7,42±1,03	0,95	6,2
$rPWC_{170}$, kgm/min/kg	15,31±0,92	15,40±0,76	1,14±0,16	7,37±1,00	0,94	6,3
aMOC, l/min	3,21±0,14	3,26±0,12	0,19±0,02	5,93±0,70	0,93	6,5
rMOC, ml/min/kg	43,25±1,77	43,80±1,39	2,20±0,30	5,20±0,77	0,95	5,9
LANp, W	111,23±5,26	114,60±5,23	5,83±1,76	5,52±1,65	0,91	7,6
LANc, mmol/l	6,03±0,29	5,83±0,26	0,37±0,06	6,35±1,01	0,93	7,6
TAE, % from MOC	44,39±1,53	43,20±1,34	2,60±0,57	5,79±1,19	0,84	7,7
HR_{TAE}, h/min	114,07±3,38	113,93±3,32	7,60±1,54	6,67±1,41	0,71	7,6
rMOClt, ml/min/kg	19,56±1,19	19,09±1,09	1,26±0,27	6,32±1,13	0,94	7,9
Lactate Threshold, mmol/l	2,12±0,15	2,15±0,15	0,13±0,02	6,43±0,99	0,96	7,6

Values of the absolute and the relative differences between them were minor. Moreover, the value of the total error of the method hood-Altman (E) does not exceed the limit value 10% and ranged from 5.9% for the rMOC values of up to 7.9% for aMOC values at TAE level. A significant proof of the high degree of consistency between the different methods of evaluation were also functional readiness of correlation analysis, the evidence of a strong correlation between measures, certain direct and indirect methods (correlation coefficients were recorded in the range from 0.71 to heart rate values at TAE to 0.95 $aPWC_{170}$ for absolute values. In addition, the graphical analysis of the method Blenda-Almtman showed that the absolute value of the difference between the values of all parameters of functional readiness, certain direct and indirect methods were in an acceptable range from 1.96 δ to -1.96 δ, and the values of the coefficients straight inclination in the linear regression equations do not exceed allowable values (Fig. 2).

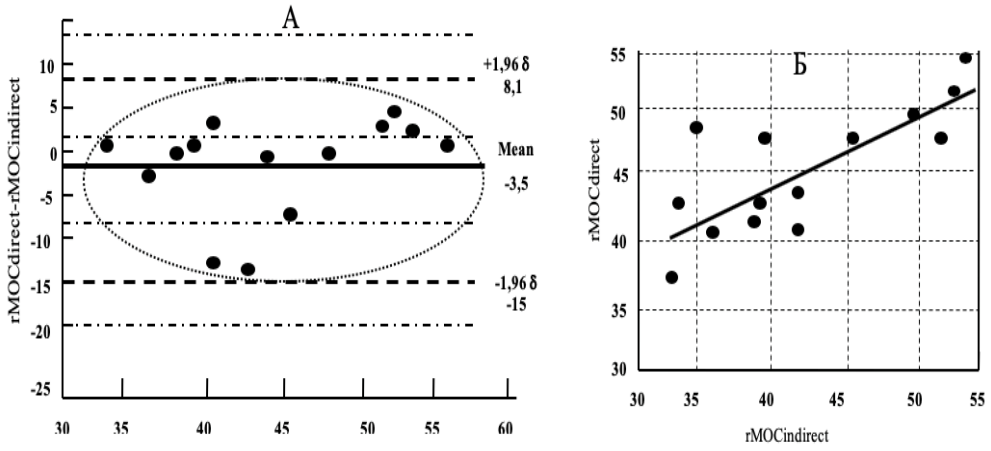

Fig. 2 Distribution of the absolute difference values (A) and the mathematical relationship (B) by Bland-Altman between the values of parameters of functional readiness, certain direct and indirect methods (for example quantities rMOC)

It has been well known that one of the most important characteristics of the validity of methodical approach is its representation. Therefore, we additionally conducted a comparative analysis of functional preparation that was obtained by the developed indirect method. The method was based on two consecutive surveys of athletes who participated in the experiment. The time interval between surveys was 72 hours. The results of the research allowed to state the following (Table 2).

Table 2 Outcomes of comparative analysis of functional readiness values of 19-20 years old athletes defined in

two successive surveys by indirect method, $\bar{x} \pm S$

Показники	Δабс.	Δвідн., %	T	R	CV, %	E, %
$aPWC_{170}$, kgm/min	28,18±5,29	2,51±0,45	0,11	0,97	2,01	3,6
$rPWC_{170}$, kgm/min/kg	0,41±0,07	2,67±0,44	0,15	0,98	2,13	3,7
aMOC, l/min	0,05±0,01	1,51±0,27	0,12	0,97	1,23	2,2
rMOC, ml/min/kg	0,72±0,12	1,66±0,27	0,12	0,97	1,34	2,3
ALANp, W	0,15±0,02	3,01±0,45	0,34	0,98	2,40	4,0
ALANc, mmol/kg	0,83±0,13	2,86±0,43	0,15	0,98	2,29	3,9
LANp, W	0,11±0,02	2,77±0,54	0,15	0,93	2,15	3,9
LANc, mmol/l	0,14±0,03	2,60±0,51	0,14	0,98	2,03	3,6
TAE, % from MOC	0,41±0,07	1,00±0,20	0,93	0,89	1,70	5,8
HR_{TAE}, h/min	0,87±0,24	0,77±0,21	0,50	0,97	1,02	3,0
rMOClt, ml/min/kg	0,23±0,04	1,26±0,21	0,61	0,95	2,06	7,1
Lactate Threshold, mmol/l	0,05±0,01	2,42±0,45	0,62	0,96	2,93	8,0
LFP, points	1,56±0,26	3,44±0,55	0,29	0,96	3,10	6,0

Notes: Δabs – the absolute difference between the results of the first and second survey; Δrel, % – the relative difference between the results of the first is the second survey; t – criteria of Student; R – coefficient of correlation; CV – coefficient of variation; LFP – level of functional preparedness; E – the magnitude of the total error of the Bland-Altman

It is indicated that for all parameters used in the study were typical of minor magnitude relative and absolute differences which were respectively from 0.15±0.02 W for ALANp to 28.18±5.29 kgm/min for the quantities $aPWC_{170}$ and 0, 77±0,21% to HR_{TAE} to 4.99±0.76% for the quantities speed endurance.

It should be noted that the significant differences between the mean values of all parameters, registered in the first and second surveys have been recorded, in favor of which showed insignificant value t-test (from 0.11 to 0.93). A high degree of representatively of our proposed methodical approach also indicated high Pearson correlation coefficients (from 0.89 to 0.98) and minor variation coefficient values (from 1.02% to 3.10%) and common errors of Bland-Altman (from 2.2% to 8%).

Discussion

The outcomes of the experiment indicated the necessity to improve the system of medical and biological control of the overall level of preparedness of athletes in preparation for the competitive season. First of all, it concerns the development and introduction to the process of innovative methods for the rapid assessment of a specified integral indicator that have a high degree of agreement with the generally accepted methods of its direct (laboratory) definition. The introduction of minimum invasive methods of functional state's study of the body, which in the current operational inspections and provided the opportunity to get maximum information regarding the condition of the body, ensuring adaptation to physical activity and indicate the level of fitness [Evhen & Valeria, 2017]. For example, there is a variation pulsometry method for the current functional training control and automated method of impedance rheography used for control of the functional state of the circulatory system; computer software "SHVSM" for functional level of preparedness has been used for sportsmen and innovation computer program to assess psychomotor, sensory-perceptual functions in sport games [Malikov et al, 2012; Lisenchuk et al, 2019]; multifunctional hardware-software system with no load assessment of functional condition of the athletes "Simon 111" – fitness and readiness for its current manifestation [Antonov, 2017]. The above study indicates that the application of the system of medical and biological monitoring of the athletes condition, we proposed an innovative method of rapid assessment of functional training that would conduct: ranking of athletes during training camps and prior of the competition; selection of the players for the national team; assessment of fitness level before signing the contract; rapid diagnosis of overtraining; assessment of training load (enough redundancy); optimization of individual workouts and competitions; selective correction of disturbed physiological functions and evaluate the effectiveness of the selected remediation.

This provides the core of the grounds to recommend the method to develop the practical use in the medical and biological monitoring of the general health condition of highly qualified athletes.

Obviously, the implementation in medical and biological monitoring of athletes general health condition, and rapid assessment of functional readiness methods as a base component for the development of other types of completeness (general and special physical, technical, tactical) contribute to the possible operational correction program training sessions within individual micro and meso-cycles, and thus, they significantly improve the efficiency of the training process and the achievement of high outcomes.

Conclusions

During the process of the study, it was experimentally proved highly informative, objectivity, speed and convenience offered an innovative non-invasive method of the athletes. It was proven an undoubted prospect of its use in the system of medical and biological monitoring of the general health condition of the athletes of

various sports. The computer program allows you to evaluate the functional response of cardiopulmonary system as a response to the previous specific chosen sport training and competition loads, as well as rehabilitation measures. It has reliable verification and known to a wide circle of specialists for each of the applicable methodic. Having generalized complete (integrated) assessment of functional readiness level is understandable and useful for successful work and outcomes of sports doctor, trainer and athlete in the future.

Conflicts of interest − The authors declared no potential conflicts of interest with respect to the research, authorship and publication of this article.

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