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Медико-биологическое функциональное тестирование спортсменов и управление тренировочным процессом

В статье приводится интерпретация и систематизация функциональных показателей организма спортсмена в нагрузочном тестировании с газоанализом. Приводятся решения функциональных проблем организма при неудовлетворительных результатах тестирования.

Medico-biological functional testing of athletes and control of the training process

Topicality

In the recent years, modern sport has undergone significant changes which have dramatically influenced the organization and content of athletes' training.

Increase in the number of competitions and high intensity of the sport combat significantly increased the requirements for the integrated preparedness and stability of the results of athletes in the conditions of frequent and critical starts. Most sports have taken an all-season character, which suggests a reduced duration of the preparatory period of basic training [1].

To optimize the physical preparation of athletes in the modern conditions, it is necessary to have an integrated, comprehensive and objective assessment of their physical state. The organization of the staged control of physical preparedness based on such assessments should include data reflecting various aspects of preparedness. One of such methods of functional control of athletes is the maximal load exercise testing with analysis of the inhaled and exhaled air. Achievements of the instrumentation for sports activities enable to diagnose the condition of many systems of the human body in the load exercise test involving gas analysis, the main challenge for the coach and athlete being the interpretation of numerous data obtained.

Problem: How to systematise the exercise training data with the gas analysis and correct the training process based on the test results?

Aim of the study: Interpretation of functional indices of the athlete in the load exercise testing for correction of the training process.

Methods and organization of the study

The study was conducted in the laboratory of "Recovery technology and selection in sport" of Ural Federal University. In the present study, to determine the functional state of the organism and its main systems providing physical performance, the maximal (pre-failure) test was used - pedalling on a Schiller bicycle ergometer (AG, Switzerland) with continuously rising exercise load (the RAMP protocol). The athlete started testing from zero power maintaining the frequency of 80 rpm. After a minute of unloaded pedalling, the pedalling power automatically increased smoothly and continuously by 0.75 watts per second until the athlete failed to maintain the desired pedalling rate of 80 rpm. During the entire testing procedure, the heart rate (HR) was automatically recorded by a Garmin wireless sensor of HR registration.

To analyse the composition of the exhaled and inhaled air, the metabolic gas analyser Fitmate PRO (Cosmed, *Italia) was used.*

During the test and the recovery period, the instruments automatically recorded the following parameters: load power, W; HR,

beats/min; the amount of inhaled air, l/min, and respiratory rate, inhalations/min; oxygen consumption level, ml/min/kg.

In the study, about three hundred athletes of different skills at the age of 8 to 58 years were tested. They represented such sports as football, ice hockey, Russian hockey, basketball, volleyball, cross country skiing, biathlon, swimming, triathlon, rowing, athletics and cycling.

Results of the study and discussion

We paid the main attention to the following indices:

- Maximal (limit) power, W – the power of failure to perform the physical work – an indicator of the power preparedness of the leg muscles. The test ended in two cases: the athlete could not maintain the desired frequency of 80 rpm, or the athlete refused to continue the workout;
- Heart rate at a load of 40 W, beats/min;
- Heart rate of the refusal of work, beats/min;
- Speed of the recovery of the heart rate (HR) after loading;
- Volume of air inhaled by the athlete, l/min, and respiratory rate;
- Maximal oxygen consumption (VO2max) ml/min/kg.

According to the results of testing the functional state of the athletes, we were able to determine the following deviations (see Table 1):

Table 1. Indices of the functional testing of the athletes by the gas analyser

Index	Adult sport norm	Non-satisfactory test results
Maximal power of failure, W	>350	Refuse to perform the test at low power
HR of the refuse to continue the test, beats/min	180-195	HR of the refuse of work much less than 180 beats/min
		HR of the refuse of work higher than 200 beats/min
HR at a load of low intensity	<100	High HR at aerobic load
Volume of air inhaled by the athlete per min of intensive work, l/min	120-180	Small volume of air
Speed of recovery of HR, 2 min after testing, beats/min	120 and less	After 3 min HR became less than 120 beats/min
Level of VO_{2max}, ml/min/kg	60-75 and higher	Low level of VO_{2max}

If after the testing the athlete has one of the problems listed in the table, we recommend the following corrections to be made in the training process.

1. Low maximal power of failure. The athlete stops working without revealing the abilities of power supply because of the mismatch of the suggested high load power to abilities of the locomotion system. Forced leg work should be included in the training process.

2. If the maximal HR of failure is less than 180 beats/min then the limiting factor of physical performance is the muscle system, the strength of muscles should be increased. A failure at HR in the range of 180 to 200 indicates a balanced development of the cardiovascular system and the muscles. If the refusal to work occurred on the pulse of more than 200, we can conclude that the heart is underdeveloped with respect to the level of muscle development. In the preparatory period one should focus on outdoor aerobic exercises, such as prolonged walking, jogging, skiing and swimming.

3. High HR during aerobic exercise. This suggests that the athlete has a small stroke volume of the heart. Work on slow muscle fibre hypertrophy should be included in the training process [3].

4. The amount of air inhaled by the athlete characterizes the throughput of the pulmonary system. The volume of one inhalation is a function of the work produced. In a state of rest, about 0.5 litres of air go into the lungs. For 12-year-old children footballers the volume of one breath-in is less than 1 litre, while that for adult rowers can reach up to 4 litres. The reduced amount of inhaled air is observed in processes associated with a decreased strength of respiratory muscles and respiratory rate. To increase the strength of respiratory muscles, resistant breathing should be used (exhale into water, inflating balloons), exercises with opening the chest to the beat of inhalation and its contraction to the beat of exhalation.

5. Low level of VO2max. VO2max is an integrated indicator of the athlete endurance. The reason for the low oxygen consumption is both an underdeveloped cardiovascular system and low power preparedness. Besides that, the respiratory system often limits the physical performance of the athlete. Therefore solution of the above problems, identified by the maximal exercise stress testing, will help improve the physical preparedness of the athlete [2].

We were able to analyse and systematize the results of testing the functional parameters of the athlete during load exercise testing. A

comprehensive assessment for optimization of the physical preparation of athletes was obtained. As a result of our research, we managed to establish a number of problems of the functional state of the athlete and make appropriate recommendations for changing the training process, depending on the indices of the functional testing the athlete.

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VI. Социальные проблемы современного общества

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Когнитивное улучшение: новый этический вызов

В статье представлен актуальный краткий обзор позиций ряда европейских исследователей, имеющих отношение к использованию современных нейротехнологий, способствующих улучшению когнитивных способностей человека. В частности, представлены