Original Contribution

METHODOLOGY FOR EVALUATION AND ANALYSIS OF THE FUNCTIONAL STATE OF ATHLETES

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ABSTRACT

During the training of athletes for different sports, distinct workloads are planned, corresponding to the training and the goals set by the coach and his team for achieving high sports results. The overall preparation of the athletes requires the use of different methods for the evaluation and analysis of the functional state of the main systems of their bodies. An important factor for ensuring the effectiveness in the management of the training process is the objective, complete and timely information that can be obtained using a package of established standardized indicators procured according to specific methodology with strict order and sequence. The examined methodology aims to present the necessary tools and techniques for conducting a functional analysis of the state of athletes. The stages, activities, and methods for performing the analysis are described in detail. Several pilot functional analyses are presented, through which the methodology and its application were tested.

Key words: volleyball, physical condition, sport testing.

BASIC STAGES OF FUNCTIONAL ANALYSIS

When conducting the analysis, four main stages should be followed with a set of sequential steps to achieve the expected results:

Stage 1. Preparation:
– provision of the necessary equipment and conditions for the efficient conduct of the analysis;
– informing athletes about the purposes of the analysis;
– acquainting the athletes with instructions for performing the tasks assigned to them;

Stage 2. Conduct of the functional analysis:
– maintaining a neutral attitude towards athletes, avoiding prompts and assistance;

Stage 3. Discussion of the results of the analysis and preparation of an action plan:
– compliance with the methodological instructions while processing the obtained results and correct interpretation of the results of the tests and individual tasks;

Stage 4. Monitoring and evaluation of performance:
– familiarization of the tested athletes with the obtained results and evaluation of their performance;
– creation of a database of the obtained results and comparison with data obtained by other methods and methodologies;
– summary of the experience with the testing methodology.

Before performing the functional analysis, each coach must determine the scope of activities that must be performed to achieve the goals of the analysis. Depending on the activities, the methods by which the analysis will be carried out, and the package of control exercises and tasks for general evaluation, special physical or technical-tactical preparation are determined.

The assessment of physical fitness is a sum of individual assessments of the level of basic physical qualities: speed, strength, endurance, flexibility, and agility. The main focus is on the qualities needed for a certain type of sport.
The assessment of technical readiness is the quantitative and qualitative assessment of the performance of the tasks set during the testing stages.

As a rule, through the phased complex examination four types of sports training can be examined: functional, psychophysiological, mental, and morphological status. The subject of our research will be the functional readiness (functional state) of athletes (1).

- Functional readiness. To determine it, tests are used to assess the level of functioning of individual systems of the human body. At rest (cardiovascular system and respiratory system) under specific loads - determination of the level of the specific working capacity of the body. For this purpose, laboratory tests (using an ergometer, treadmill, etc.) and field tests can be used.

In these tests, indicators are determined, such as: level of work ability, time of work, the level of increase in aerobic and anaerobic thresholds. Thus, the levels of development of the aerobic capabilities of the sports organism are determined. The level of the athletes' playing qualities, such as speed and speed-power endurance, is also established, as well as indicators such as: explosive power, average power, fatigue index, absolute peak and minimum power and reactive power index.

Tests for the study of endurance and aerobic capacity in athletes

The test for determination of aerobic power is based on the definition of criteria for the body's performance in athletes or direct measurement of aerobic power. One good method of measuring aerobic power is to calculate the maximum oxygen consumption during an incremental exercise test. To determine the aerobic capacity, aerobic thresholds are used, characterized by a total volume of work performed at an intensity reaching maximum fatigue (maximum aerobic capacity) (2).

An example of the level of aerobic power in volleyball players is given in Table 1.

✔ Ergospirometry - this is a method of functional diagnostics in which the analysis of breathing gases is performed during inhalation (inspiratory) and exhalation (respiratory), which allows drawing conclusions about the interaction of systems, such as blood circulation, cardiac, respiratory, and exchange of substances. This method is applicable in sports medicine, cardiology and pulmonology. On the basis of ergospirometry, accurate information can be obtained about the work of the body during the
During the test itself, the volleyball players move along the treadmill with a smooth and constant change in speed (Figure 1). During the first six minutes, the treadmill is at an angle of 0° or 0% at which the speed is 4 km/h. From the sixth minute onwards, the angle of the treadmill changes, the speed increases in accordance with the chosen protocol until the moment of termination of the test (3).

As a result of this test, data can be obtained about:
- The consumption of oxygen and the release of CO2 during the individual phases of the test;
- The minute volume of breathing;
- Maximum oxygen consumption;
- Respiratory coefficient;
- Aerobic/Anaerobic coefficient;
- Respiratory reserve.

✓ Bicycle ergonomics test to determine the athlete's aerobic capabilities - at maximum load without using gas analysis, the maximum oxygen consumption is calculated according to formulas that take into account the power consumed at maximum load. During the execution of the tests, a number of physiological parameters are registered, such as the frequency of heart activity and the change in arterial pressure at each stage of the test and during its recovery period. The obtained indicators can be compared with the level of the aerobic threshold and the power of physical exertion and used to control the training process when fatigue occurs (4).

✓ Cooper's test (Cooper-test) - proposed by the American Dr. K. the Cooper test aims to determine the maximum distance the athlete can reach in 12 minutes. This test can be performed at any place with a flat surface with the possibility of covering a distance of 400m through 100m (5,6). At the start of the test, each athlete takes his place and on command starts, striving to maintain maximum
running speed. In case of fatigue, athletes are allowed to walk (normal walking). After 12 min. the test is terminated and the distance traveled by the athlete is determined with the accuracy to 100m. The test results are classified according to the following indicators: for men under 39 up to 1.5 km. - very bad; 1.6 km. up to 1.9 km. – bad; 2 km. up to 2.4 km. - satisfactory; 2.5 km. up to 2.7 km. – good; 2.8 km. and more - excellent. Table 2 presents Cooper's test norms for different ages (7).

**Table 2. Cooper's test norms for different ages**

<table>
<thead>
<tr>
<th>Gender and age (in years)</th>
<th>Excellent</th>
<th>Average</th>
<th>Low</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juniors 13-14</td>
<td>&gt;2700km</td>
<td>2400-2700km</td>
<td>2100-2199km</td>
<td>&lt;2100km</td>
</tr>
<tr>
<td>Girls 13-14</td>
<td>&gt;2000km</td>
<td>1900-2000km</td>
<td>1500-1599km</td>
<td>&lt;1500km</td>
</tr>
<tr>
<td>Juniors 15-16</td>
<td>&gt;2800km</td>
<td>2500-2800km</td>
<td>2200-2299km</td>
<td>&lt;2200km</td>
</tr>
<tr>
<td>Girls 15-16</td>
<td>&gt;2100km</td>
<td>2000-2100km</td>
<td>1600-1699km</td>
<td>&lt;1600km</td>
</tr>
<tr>
<td>Juniors 17-19</td>
<td>&gt;3000km</td>
<td>2700-3000km</td>
<td>2300-2499km</td>
<td>&lt;2300km</td>
</tr>
<tr>
<td>Girls 17-20</td>
<td>&gt;2300km</td>
<td>2100-2300km</td>
<td>1700-1799km</td>
<td>&lt;1700km</td>
</tr>
<tr>
<td>Men 20-29</td>
<td>&gt;2800km</td>
<td>2400-2800km</td>
<td>1600-2199km</td>
<td>&lt;1600km</td>
</tr>
<tr>
<td>Women 20-29</td>
<td>&gt;2700km</td>
<td>2200-2700km</td>
<td>1500-1799km</td>
<td>&lt;1500km</td>
</tr>
</tbody>
</table>

✓ **Hoff-Helgerud test** - represents a specific timed passage through a dribbling track specifically constructed by Norwegian scientists. This test assesses aerobic capacity using a ball. By means of a repeatable circular advance past cones and obstacles, the athlete overcomes a distance equal to 300 m by kicking a ball (Figure 2). The duration of the test is 8 min. The test allows for a correlation between the distance covered and the maximum oxygen consumption at a sprint distance (r = 0.70) (8).

![Figure 2. Hoff-Helgerud test](image)

This test, according to its authors, can be used both for testing athletes and for aerobic endurance training. The run between controls A and B is done in reverse. The height of the obstacles is standard 20cm and for one complete cycle the athlete covers a distance of 300m by kicking a ball in front of him. When performing the test, additional physiological parameters such as heart rate and lactacidemic responses (carbohydrate metabolism) can be registered.

✓ **YO-YO test** for determining the aerobic capabilities of the athletes' body in field conditions - Nowadays, this test is one of the most commonly used, with the help of which the aerobic capacity is established in situational sports. It includes a distance between marks - markers located 20 m from each other, a sound signal is given, and the time between sound signals is shortened every minute (Figure 3). There are many versions of this test, but the most used one has a starting speed of 8.5 km/h between the marks, increasing by 0.5
km/h, every minute when the signal is given. Athletes’ level of fitness is assessed by how much distance they run between markers at a pre-selected set of cues.

The athlete’s score is the total distance they have run up to the point where they fail to reach signal pace. The YO-YO endurance test usually lasts between 6 to 20 minutes for the first level and between 2 to 10 minutes for the second. In addition to the total distance covered, the test may sometimes indicate the number of shuttles taken or the level reached.

Figure 3. Placement of the markers (cones) in the YO-YO test

One of the great advantages of this test is that it can be used to test large groups of competitors with minimal expenditure of time and materials. As a disadvantage, the experience and current mood of the tested athlete can be noted which can significantly affect the results. The test is usually conducted outdoors and environmental factors can have a significant impact (9).

Despite these minor drawbacks, the test continues to develop progressively and nowadays three types of YO-YO tests are popular: 1st usual; 2nd periodic for endurance; 3rd for recovery.

- In a periodic YO-YO endurance test, athletes shuttle between markers with short recovery intervals. This test assesses the athlete's ability to endure sustained intermittent exercise at significant physical effort (rest time is 5 sec. between shuttle runs between markers).
- The YO-YO recovery test determines the athlete's ability to recover after intense physical exertion. With it, the speed of execution is greater and the rest series are from 10 sec (4).

When checking the results obtained from the YO-YO test, normative results given in tables 3 and 4 (men-women) according to data from the topendsports.com site can be used (10).

Table 3. Normative YO-YO test results for men

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Poor</th>
<th>Satisfactory</th>
<th>Normal</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-13</td>
<td>3/4-5/1</td>
<td>5/2-6/4</td>
<td>6/5-7/5</td>
<td>7/6-8/8</td>
<td>&gt; 10/9</td>
</tr>
<tr>
<td>14-15</td>
<td>4/7-6/1</td>
<td>6/2-7/4</td>
<td>7/5-8/9</td>
<td>8/10-9/8</td>
<td>&gt; 12/2</td>
</tr>
<tr>
<td>16-17</td>
<td>5/1-6/8</td>
<td>6/9-8/2</td>
<td>8/3-9/9</td>
<td>9/10-11/3</td>
<td>&gt; 13/7</td>
</tr>
<tr>
<td>18-25</td>
<td>5/2-7/1</td>
<td>7/2-8/5</td>
<td>8/6-10/1</td>
<td>10/2-11/5</td>
<td>&gt; 13/10</td>
</tr>
<tr>
<td>26-35</td>
<td>5/2-6/5</td>
<td>6/6-7/9</td>
<td>7/10-8/9</td>
<td>8/10-10/6</td>
<td>&gt; 12/9</td>
</tr>
<tr>
<td>36-45</td>
<td>3/8-5/3</td>
<td>5/4-6/4</td>
<td>6/5-7/7</td>
<td>7/8-8/9</td>
<td>&gt; 11/3</td>
</tr>
<tr>
<td>46-55</td>
<td>3/6-4/6</td>
<td>4/7-5/5</td>
<td>5/6-6/6</td>
<td>6/7-7/7</td>
<td>&gt; 9/5</td>
</tr>
<tr>
<td>56-65</td>
<td>2/7-3/6</td>
<td>3/7-4/8</td>
<td>4/9-5/6</td>
<td>5/7-6/8</td>
<td>&gt; 8/4</td>
</tr>
<tr>
<td>&gt;65</td>
<td>2/2-2/5</td>
<td>2/6-3/7</td>
<td>3/8-4/8</td>
<td>4/9-6/1</td>
<td>&gt; 7/2</td>
</tr>
</tbody>
</table>
Algorithm for conducting the YO-YO test:
1. The athlete who will be tested is equipped with a watch (HRM) for reading heart rate and runs a distance between two markers (cones) located 20 m apart from each other (Figure 4) when giving a sound signal. During the test, the time of the sound signals is shortened;
2. Upon receiving a new signal, the athlete must have reached the opposite cone and turned back, starting to run towards the starting line.
3. If the cone is not reached on time, the athlete must run to the cone and try to "catch up" within two more beeps.
4. The test is terminated if the athlete fails to catch up the pace at both ends of the lines of cones.

![Figure 4. Schematic for the execution of the YO-YO test](image)

Based on the results of the test indicators such as aerobic power, anaerobic threshold, heart rate, and maximum oxygen consumption are judged.

**CONCLUSIONS**

The studies conducted on the application of a methodology for assessing the functional state of athletes show that thanks to these variations of tests, coaches have a quick and adequate response and successfully reorganize the training-competitive process.

With such dynamically developing sports these days, a timely monitoring is of fundamental importance in the realization of high sports achievements and the construction of an Action Plan. Through the number of tests that are applied in the separate phases of the sports-preparatory work, another interesting factor is also distinguished - the mental one. During the testing, it is noticed in the contestants that when they manage to pass the test successfully, their self-esteem increases and they gain additional self-confidence in their abilities. In this way, at the moment of maximum load, the athlete is more cool-headed towards the performance of the task and is even able to exceed their capabilities.

This test methodology gives a result on both the physical and mental qualities of the competitor. In team sports, such as volleyball, a vital factor in achieving maximum physical capabilities and high sportsmanship is the mutual trust between coach and athlete.

That is why timely judgment and instant reaction are so important, firstly for the quick and adequate reaction in a moment of difficulty during a game, secondly for the interrelationship between coach and players.
REFERENCES


