

FUNCTIONAL TESTING IN SPORTS PHYSIOLOGY: CARDIOVASCULAR, RESPIRATORY, AND AUTONOMIC SYSTEMS UNDER PHYSICAL LOAD**Sodikov Sardorbek Azamjonovich**Assistant of the Department of Rehabilitology, Sports Medicine
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Abstract. This article explores the role of functional tests in sports physiology, focusing on the cardiovascular, respiratory, and autonomic nervous systems. It examines the physiological changes that occur in the athlete's body under the influence of physical loads and highlights the diagnostic and preventive value of functional tests conducted under medical supervision. The paper emphasizes that functional testing is not only a tool for assessing current health and performance but also a means of predicting adaptation, preventing overtraining, and guiding individualized training programs. Drawing upon sports medicine, physiology, and international research, the article provides a comprehensive overview of classical and modern functional tests, their methodology, and their application in clinical and sports practice.

Keywords: sports physiology, functional tests, cardiovascular system, respiratory system, autonomic nervous system, physical load, athlete adaptation.

Introduction

Sports physiology studies the mechanisms of adaptation of the human body to physical activity and the changes that occur in functional systems under the influence of training and competition. Athletes are exposed to high-intensity loads that require coordinated responses from the cardiovascular, respiratory, and autonomic nervous systems [1]. Monitoring these systems is essential for ensuring safe participation in sport, optimizing performance, and preventing pathological conditions.

Functional tests are widely used in sports medicine as practical tools for assessing the state of vital systems. They provide objective data on the body's ability to adapt to stress, recover after exertion, and maintain homeostasis [2]. Unlike routine examinations, functional tests are performed under controlled physical load, which allows physicians to evaluate not only resting parameters but also the dynamic responses of the organism.

The aim of this article is to analyze the main functional tests used to assess the cardiovascular, respiratory, and autonomic nervous systems, to describe physiological changes in athletes under physical load, and to highlight the importance of medical supervision in their application.

Physiological changes in athletes under physical load

Physical training induces a wide range of adaptive changes in the human body. The cardiovascular system develops the so-called "athlete's heart," characterized by moderate myocardial hypertrophy, increased stroke volume, and bradycardia at rest [3]. These changes are physiological and reflect improved efficiency of cardiac function.

The respiratory system adapts through increased lung capacity, improved oxygen diffusion, and more efficient ventilation-perfusion ratios. Athletes demonstrate higher maximal oxygen uptake (VO_2 max), which is a key determinant of endurance performance [4].

The autonomic nervous system undergoes a shift toward parasympathetic dominance at rest, reflected in lower resting heart rate and improved heart rate variability. During exercise,

sympathetic activation ensures adequate cardiovascular and respiratory responses, while rapid parasympathetic reactivation after exercise is a marker of good fitness and recovery [5].

Functional tests of the cardiovascular system

Functional tests of the cardiovascular system are designed to evaluate the heart's response to physical load and recovery. Commonly used tests include:

- **Ruffier Test** – measures heart rate at rest, immediately after 30 squats, and after one minute of recovery. Provides an index of cardiovascular efficiency [6].
- **Harvard Step Test** – evaluates endurance by measuring heart rate recovery after stepping on and off a bench for a fixed period. Widely used for assessing physical working capacity [7].
- **Martinet-Kushelevsky Test** – involves squats with simultaneous ECG recording to detect hidden cardiac abnormalities.
- **Exercise ECG (treadmill or cycle ergometer test)** – provides detailed information on cardiac rhythm, conduction, and ischemic changes under load [8].

These tests allow physicians to distinguish between physiological adaptations and pathological responses, ensuring safe participation in sport.

Functional tests of the respiratory system

Respiratory function is assessed through tests that measure lung capacity, ventilation, and gas exchange.

- **Spirometry** – evaluates vital capacity, forced expiratory volume, and peak expiratory flow.
- **Stange and Genchi Breath-Holding Tests** – measure the duration of voluntary apnea after inhalation or exhalation, reflecting the body's tolerance to hypoxia and hypercapnia [9].
- **Maximum Voluntary Ventilation Test** – assesses the maximal ventilatory capacity of the lungs.
- **VO₂ max Testing** – performed with gas analysis during graded exercise, considered the gold standard for assessing aerobic capacity [10].

Functional tests of the autonomic nervous system

The autonomic nervous system regulates cardiovascular and respiratory responses to exercise. Its functional state can be assessed through:

- **Orthostatic Test** – evaluates heart rate and blood pressure changes when moving from lying to standing position, reflecting autonomic reactivity.
- **Valsalva Maneuver** – involves forced exhalation against a closed airway, used to assess autonomic control of heart rate and blood pressure [11].
- **Heart Rate Variability (HRV) Analysis** – provides information on the balance between sympathetic and parasympathetic activity.
- **Cold Pressor Test** – immersing the hand in cold water to evaluate sympathetic reactivity.

These tests are particularly important for detecting autonomic imbalances that may predispose athletes to arrhythmias, overtraining, or maladaptation.

Expanded discussion

The integration of functional tests into sports medicine practice provides a holistic view of athlete health. While routine examinations reveal baseline health status, functional tests uncover hidden abnormalities and provide insights into the body's adaptive capacity. They are indispensable for monitoring training effects, guiding load adjustments, and preventing overtraining [12].

Recent advances include the use of wearable technologies for continuous monitoring of heart rate, oxygen saturation, and respiratory rate during training. These tools complement classical functional tests and provide real-time data for coaches and physicians [13].

Moreover, functional testing is increasingly applied in youth sports to monitor growth and development, in rehabilitation programs for injured athletes, and in preventive medicine for the general population. The combination of traditional and modern approaches ensures both safety and performance optimization.

Conclusion

Functional tests are a cornerstone of sports physiology and medical supervision. They provide objective data on the cardiovascular, respiratory, and autonomic nervous systems, revealing both physiological adaptations and potential risks. Under medical supervision, these tests ensure that athletes train and compete safely, adapt effectively to physical loads, and avoid overtraining or injury [1], [2].

The physiological changes induced by training—such as the development of the athlete's heart, improved lung function, and enhanced autonomic regulation—are beneficial adaptations that increase performance potential. However, only systematic monitoring through functional tests can distinguish between healthy adaptation and pathological responses.

Thus, functional testing represents not only a diagnostic tool but also a preventive and educational instrument in sports medicine. Its integration into training and medical practice contributes to the preservation of health, the optimization of performance, and the sustainable development of sport.

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