

## Enhancing the Security of Heart Rate Variability Analysis in Athletes via Two-Factor Authentication

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### Abstract

This paper presents an innovative two-factor authentication (2FA) algorithm specifically designed to protect data from heart rate variability (HRV) analysis in athletes. The algorithm provides secure access when writing and reading data by integrating one-time codes, which prevents unauthorized access and guarantees the authenticity of the information. HRV analysis provides a detailed assessment of cardiac health by measuring the fluctuations in the intervals between consecutive heartbeats, which reflect the balance between the sympathetic and parasympathetic nervous systems. The study included 20 athletes, examined before, immediately and 1 hour after training by taking electrocardiogram recordings, applying linear (time and frequency analysis) and nonlinear (Poincaré) methods. The results of the studied parameters show changes related to physical exertion, which are important for assessing training, recovery and the risk of overtraining. The innovative aspect of the development is expressed in the combined approach: simultaneous monitoring of physiological parameters and active protection of data in the process of collection and analysis. Graphical visualization of the results facilitates the personalization of training programs and optimal load management. The developed 2FA algorithm and HRV analysis methods can be implemented in intelligent systems for sports medicine, ensuring a high degree of security and reliability when working with sensitive personal and medical information.