Dynamic Heart Rate Variability During Exercise in Athletes and Non-Athletes

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Aims: This study investigates dynamic heart rate variability (HRV) responses during exercise and recovery in athletes and non-athletes. The aim is to determine whether time-resolved and correlation-based HRV metrics, particularly dynamical detrended fluctuation analysis (DDFA), can better characterize differences in autonomic regulation and physiological adaptability between trained and untrained individuals.

Methods: ECG data from 12 participants (6 athletes, 6 non-athletes; age 17–33 years) were analyzed from the iAMwell dataset. Subjects completed a standardized treadmill protocol including rest, acceleration, steady running (85% HRmax), deceleration, and recovery phases. HRV metrics were computed using moving windows and included time-domain measures (SDRR, RMSSD), non-linear indices (SD1/SD2), and correlation-based measures (DFA α_1 and DDFA $\tilde{\alpha}(t)$). Temporal normalization of the different phases enabled group-level comparisons across exercise.

Results: During exercise, SDRR and RMSSD decreased markedly and similarly in both groups from rest, showing limited ability to distinguish training status under load. In contrast, athletes showed lower DFA α_1 and DDFA $\tilde{\alpha}(t)$ during acceleration and steady phases, suggesting more adaptable and less correlated cardiac dynamics. Non-athletes maintained higher scaling exponent values, reflecting more rigid autonomic control. During recovery, all HRV measures increased, with DFA α_1 and DDFA exceeding baseline values in both groups, indicating autonomic rebound. Athletes demonstrated a slightly stronger recovery response.

Conclusions: While conventional HRV measures show similar exercise responses in athletes and non-athletes, correlation-based metrics provide enhanced sensitivity to training-related differences in autonomic regulation. DDFA, in particular, captures dynamic changes in beat-to-beat correlation structure and may serve as a valuable tool for assessing physiological adaptability, training status, and recovery dynamics.