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Multivariate Analysis of Heart Rate Variability as a Predictor of Cardiac Events

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Heart Rate Variability (HRV) has been widely studied as a non-invasive tool for assessing autonomic nervous system function and its relationship with cardiovascular diseases. Reduced HRV has been linked to increased risk of post-myocardial infarction mortality and sudden cardiac death [1]. This study aims to identify HRV parameters that can serve as predictors of cardiac events by differentiating between healthy individuals, patients with myocardial infarction, and individuals with ventricular tachycardia.

The research used electrocardiographic data from the Physionet database, analyzing 178 RR interval time series distributed among 75 healthy individuals, 74 myocardial infarction patients, and 29 individuals with ventricular tachycardia. Time-domain, frequency-domain, and non-linear methods were applied to extract HRV features, and statistical analyses were performed to determine significant differences among the groups. The prediction model is applied to perform predictive analysis using these variables and to characterize the studied groups by calculating the F1 score for each variable (or their combinations). In this study, a multimodal logistic regression approach was employed (suitable for more than two groups), enabling the assessment of each variable's influence on the outcome. In this context, evaluating the contribution of individual variables or their combinations across different methods represents a key contribution of this work, as it offers valuable insight into the predictive capabilities of HRV analysis methods in diagnostic applications.

The results revealed that the parameters of both linear (time and frequency domain) [3], [4] and nonlinear methods showed significant statistical differences between the groups [2]. The time domain and non-linear parameters distinguished healthy individuals from patients with myocardial infarction, as well as patients with myocardial infarction from those with ventricular tachycardia. However, the parameters in the frequency domain exhibited statistical differences between all groups, suggesting their potential for a broader classification of cardiac conditions.

To improve predictive precision, a logistic regression model was developed, considering individual HRV parameters and combinations of multiple variables. The best performing model, which

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combined four HRV parameters, achieved a mean F1 score of 78.4% to predict cardiac events. The study underscores the importance of integrating different HRV features into predictive models and highlights HRV as a valuable tool to assess cardiac risk.

These findings suggest that HRV analysis, when applied using a multivariate approach, could provide clinicians with a reliable method for the early identification of individuals at risk of severe cardiac events, potentially improving preventive and therapeutic strategies. Future research should explore the integration of HRV with machine learning techniques to refine predictive accuracy and clinical applicability.

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