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Unsupervised ECG Clustering Reveals Distinct Associations with Cardiac Magnetic Resonance Features

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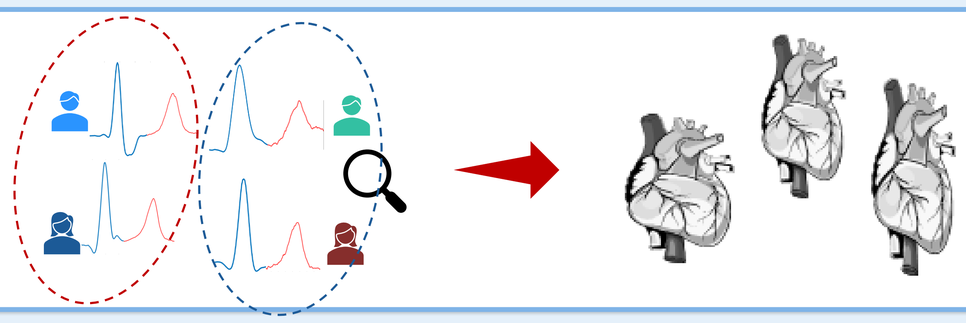
Background

- Exploring the association between the electrocardiogram (ECG) and cardiac magnetic resonance (CMR)-derived features may enhance our understanding of cardiovascular physiology and enable more detailed evaluation of the heart's structural characteristics.

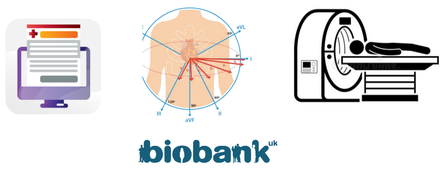


Objective

- We aimed to identify clusters of individuals without diagnosed cardiovascular disease (CVD) based on their ECG phenotypes in an unsupervised manner and evaluate their cardiac anatomical differences through CMR.

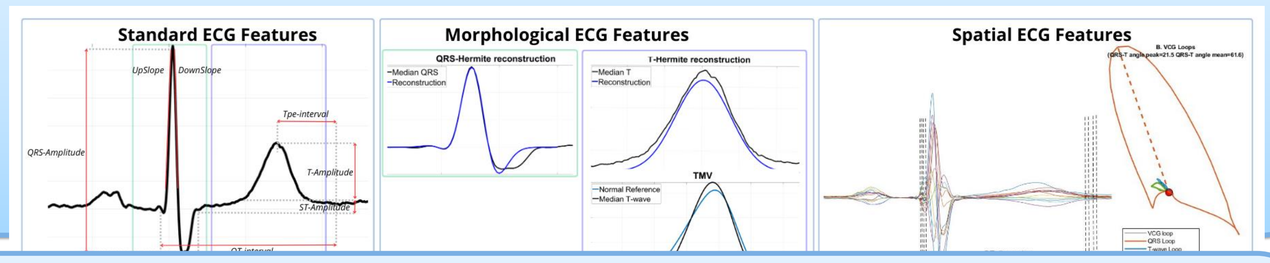
UK Biobank

- The study population consisted of 54,257 individuals without diagnosed cardiovascular diseases in the UK Biobank study. (Application number: 2964)



Methods

1. Calculate median heartbeats and extract ECG features



2. Unsupervised Identification of Clusters

Feature selection: 277 uncorrelated ECG features from 12 leads

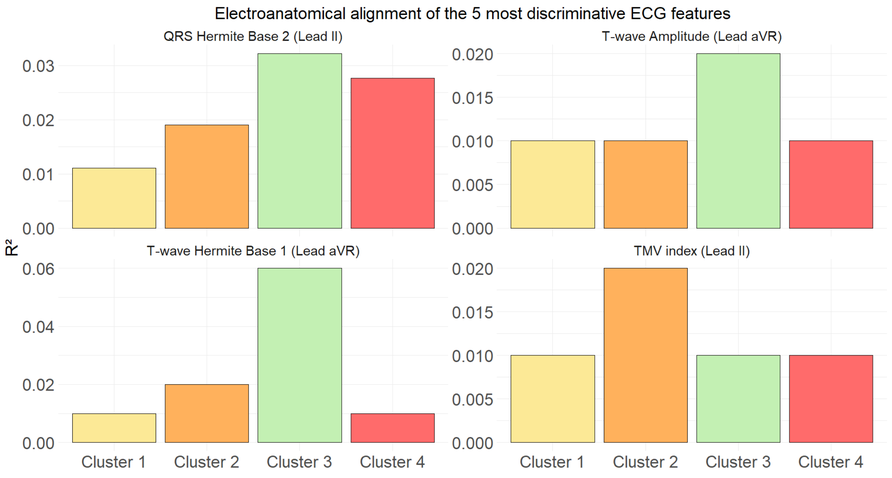
Remove confounding factors: Adjustment of ECG features by Age, Sex and BMI

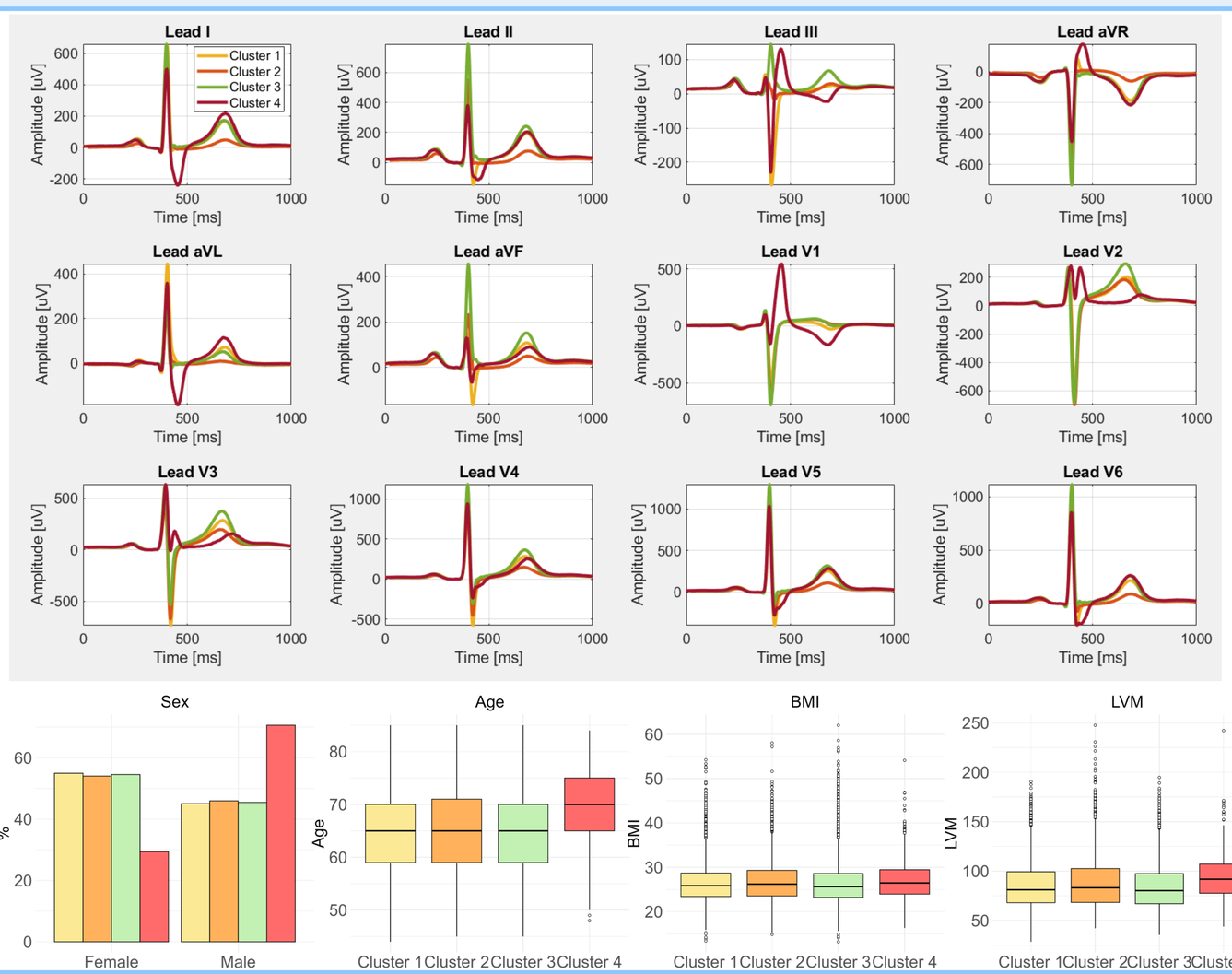
Clustering algorithm: K-means

3. Statistical analyses were conducted to assess ECG, demographical and CMR differences across clusters, and multivariable linear regressions evaluated the electro-anatomical alignment within each cluster.

Results

- Four distinct ECG-based clusters were identified (N1=19,470, N2=22,256, N3=8,997 & N4=1,302), with significant differences in ECG morphology and CMR-derived anatomical features.
- The most discriminative ECG features involved ventricular repolarization in precordial leads.
- Cluster 3 showed the strongest electro-anatomical alignment, with right ventricular end systolic and end-diastolic volumes contributing importantly to the ECG variation across clusters.
- Cluster 4 showed high variability and ECG morphological abnormalities.





Conclusions

- Our findings show that ECG phenotyping through unsupervised clustering can reveal anatomical cardiac differences, offering new perspectives on early cardiovascular variation in the general population. Future research should assess the longitudinal and prognostic implications of these phenotypic clusters.

References: MARTÍNEZ, J.P. et al. A Wavelet-Based ECG Delineator Evaluation on Standard Databases. In IEEE Transactions on Biomedical Engineering. 2004. Vol. 51, no. 4, s. 570–581.

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