Automated Detection of Premature Atrial Contractions in Noisy Exercise Electrocardiograms

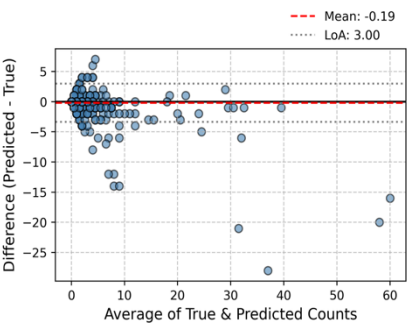
Anna M. Bator, Stefan van Duijvenboden, Rohan Sajeev Wijesurendra, Aiden Doherty

University of Oxford
Oxford, United Kingdom

Introduction: Automated analysis of exercise electrocardiograms (ECGs) offers significant clinical value but is challenged by motion artefacts, muscle noise, and baseline drift. Premature atrial contractions (PACs) are of particular interest during exercise, where physiological stress may unmask arrhythmic burden, but remain difficult to distinguish from normal beats, especially in single-lead recordings. To date, no validated method exists for automated PAC detection in exercise ECGs.

Methods: We developed a deep learning–based approach for PAC detection from single-lead exercise ECG signals using a CNN–BiLSTM U-Net with self-attention. The dataset was derived from the UK Biobank exercise cohort and divided into a training set (n = 695) enriched for ectopic activity and a held-out test set (n = 1410) of participants without cardiovascular disease, reflecting a real-world distribution with low PAC burden. Model performance was evaluated using beat-level classification metrics and agreement in PAC counts per participant, with inter-participant 5-fold cross-validation and independent testing on the held-out cohort.

Results: On the held-out test set, the model achieved a beat-level PAC F1 score of 0.74, with precision of 0.82 and recall of 0.68 within a multi-class classification framework. Bland–Altman analysis demonstrated good agreement between predicted and ground truth PAC counts per participant, with a mean bias of −0.19 and limits of agreement ±3.00 beats.



Bland–Altman agreement for PAC counts per participant.

Conclusion: This study demonstrates the feasibility of high-precision PAC detection in noisy, single-lead exercise ECGs. The proposed approach enables scalable and reliable estimation of PAC burden, supporting its use for population-level phenotyping.