Supplementary Materials

Supplementary Methods S1: Statistical Rationale for Developmental Normalization

Why polynomial regression? We assume that, within the healthy pediatric population, each ECG feature varies smoothly with age and heart rate, with possible sex-related shifts. Polynomial regression provides a simple, stable approximation to these smooth developmental trajectories while preserving interpretability.

Model specification. For each feature f_k, we fit a linear model in polynomial basis:

$$f_k = \beta_0 + \beta_1 \text{Age} + \beta_2 \text{HR} + \beta_3 \text{Sex} + \beta_4 \text{Age}^2 + \beta_5 \text{HR}^2 + \beta_6 (\text{Age} \cdot \text{HR}) + \epsilon, \tag{1}$$

optionally extended to degree 3 with $(\text{Age}^3, \text{HR}^3, \text{Age}^2\text{HR}, \text{AgeHR}^2)$ terms. The fitted expectation $\hat{\mu}_k$ defines the developmental norm; the residual standard deviation (estimated in controls) defines scaling.

Interpretation as covariate adjustment. The z-score is a standardized residual after projecting out age/HR/sex effects, so downstream analyses emphasize deviations not explained by maturation or physiologic rate differences.

Validation via correlation collapse. We quantify removal of developmental trends by comparing Spearman correlations between each feature and age before vs after normalization (Supplementary Table 1).

Supplementary Figures

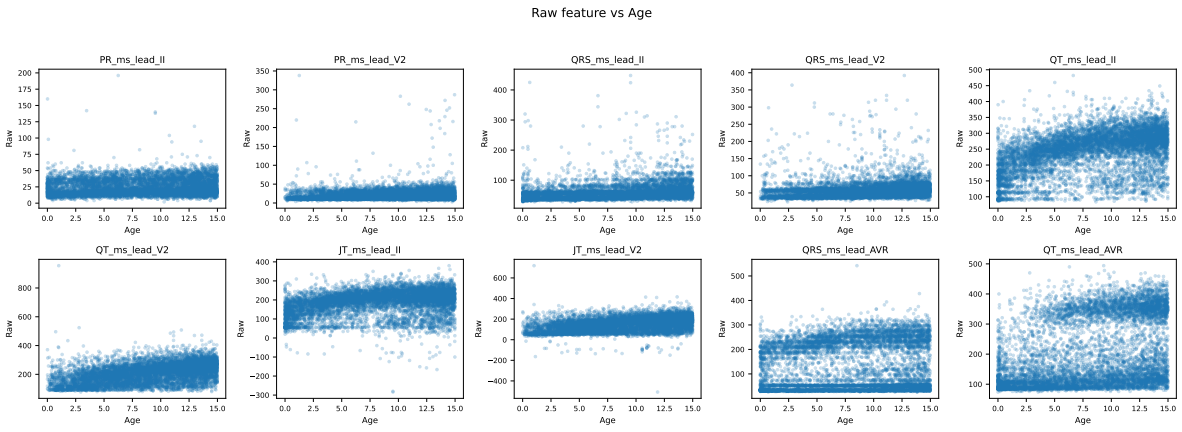

Figure 1: Supplementary Fig. S2 (page 1). Developmental curves and z-score plots (raw vs normalized) for interval features.

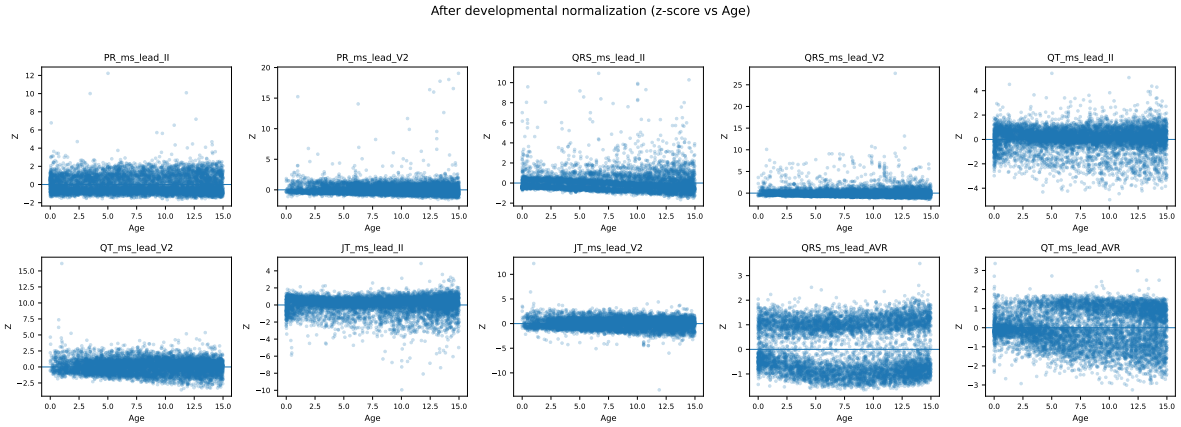

Figure 2: Supplementary Fig. S2 (page 2). Continuation of interval feature developmental curves and z-score plots.

Including full multi-page PDFs (recommended)

Supplementary Tables

Table 1: Supplementary Table S1. Reduction of age-dependence after developmental normalization (example top-10).

Feature	n_{raw}	$\rho_{\text{age,raw}}$	p_{raw}	n_z	$\rho_{\text{age},z}$	p_z
QT_ms_lead_V2	12097	0.475	$< 10^{-6}$	8655	0.0067	0.53
QT_ms_lead_II	13971	0.447	$< 10^{-6}$	10102	-0.0336	7.2e-4
JT_ms_lead_V2	12097	0.429	$< 10^{-6}$	8655	0.0181	0.093
QT_ms_lead_AVR	12452	0.416	$< 10^{-6}$	8958	0.0351	9.0e-4
JT_ms_lead_II	13971	0.345	$< 10^{-6}$	10102	-0.0040	0.687

A large drop in $|\rho_{\text{age}}|$ from raw to z indicates that the normalization successfully removed age-related developmental trends in the feature. Large p_z values are expected when ρ_z is near zero; this indicates absence of residual age dependence after adjustment.