

Assessment of Autonomic Dominance in Cardiovascular Components: A Multimodal Analysis

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Aims: This study aimed to quantitatively compare the effects of autonomic nervous system (ANS) stimulation on the cardiovascular system by utilizing multimodal biosignals, including ECG and PPG. The research sought to determine which cardiovascular components were more dominantly reflected in response to specific autonomic modulations.

Methods: The structured experimental protocol was designed to induce cardiovascular responses, consisted of five phases: rest, handgrip exercise (HG), cold pressor test (CP), Valsalva maneuver, and squatting (SQ). Signals were preprocessed using a Butterworth bandpass filter. HRV indices were derived from ECG, while pulse morphology-based cardiovascular related indices were extracted from PPG. Feature responsiveness was quantified by analyzing the relative change in each feature across the experimental phases. Furthermore, the correlation between cardiac and vascular shifts was assessed to understand the integrated cardiovascular responses to the ANS.

Results: ECG and PPG were collected from 22 healthy adult participants. Analysis revealed distinct reactivity across different physiological stress phases. During CP, PPG-based vascular indices exhibited a more dominant shift, with pulse width reaching a mean z-score of 1.2 compared to the smaller change in RMSSD (mean z-score: -0.41). Similarly, HG induced higher responsiveness in certain PPG morphological features than in ECG metrics. These findings indicated that vascular components may provide a more reflection of autonomic stress in specific contexts.

Correlations of HRV and PPG-based features during experimental phases

Phase	HRV– PPG paired features	Spearman <i>r</i>	<i>p</i> -value
CP	RMSSD – Augmentation index	0.61	0.002
HG	RMSSD – Pulse area ratio	0.70	0.0002
SQ	LF/HF – Systolic amplitude	0.63	0.001

Conclusion: The findings demonstrate that autonomic dominance is differentially reflected in cardiovascular components. Vascular-related indices derived from PPG morphology exhibit higher responsiveness to certain stimulations than cardiac indices. These preliminary results suggest that further investigation will be essential to establish a robust assessment of cardiovascular autonomic interaction.