Input-output Frequency Coupling and Sensitivity Spectral Measures of the Respiratory Sinus Arrhythmia System in Response to Increasing Respiratory Frequency

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To characterize the respiratory sinus arrhythmia mechanism (RSA) as a system, in 19 healthy subjects we assessed the effects of continuous and linearly increasing respiratory frequency (RF) from 0.05 to 0.8 Hz at constant tidal volume, in sitting (SIC) and standing (STC) conditions, on: the 90-s time-courses of the central frequency and power of the high-frequency components of RR (\(\text{CFHF}_{\text{FF}}\), \(\text{PHF}_{\text{FF}}\)) and respiration (\(\text{CFHF}_{\text{RES}}\), \(\text{PHF}_{\text{RES}}\)), estimated by a time-frequency distribution; the \(\text{CFHF}_{\text{RES}}\)\(\text{CFHF}_{\text{FF}}\) relation, the time-courses of the difference between \(\text{CFHF}_{\text{RES}}\) and \(\text{CFHF}_{\text{FF}}\) (\(\Delta_{\text{CFHF}}\)) and \(\text{PHF}_{\text{RES}}\)\(\text{PHF}_{\text{FF}}\) coherence (RSA\text{CO}) as indexes of RSA input-output coupling (RSA\text{IOC}), and alpha index (square root of \(\text{PHF}_{\text{FF}}/\text{PHF}_{\text{RES}}\)) as RSA sensitivity (RSA\text{S}) measure.

The responses of RSA measures to chirped RF in SIC, presented three stages with distinctive effects and RF ranges: between 0.09-0.18 Hz, \(\text{CFHF}_{\text{FF}}\) was unchanged, \(\Delta_{\text{CFHF}}=0.10\pm0.03\) Hz, RSA\text{CO} of 0.77\pm0.06 and abruptly rising RSA\text{S}; between 0.18-0.51 Hz, \(\text{CFHF}_{\text{FF}}\), \(\Delta_{\text{CFHF}}\) (0.02\pm0.04 Hz) and RSA\text{S} changed proportionally to RF, with correlations of 0.97\pm0.03, 0.86\pm0.10 and -0.81\pm0.12, regression intercepts of 49\pm47 Hz, -0.87\pm0.33 Hz, 245\pm115 ms/l respectively, and RSA\text{CO} of 0.92\pm0.03; between 0.51-0.82 Hz, correlations of \(\text{CFHF}_{\text{FF}}\), \(\Delta_{\text{CFHF}}\) (0.32\pm0.06 Hz) and RSAS with RF were -0.24\pm0.64, 0.79\pm0.08 and -0.36\pm0.67 respectively, with RSA\text{CO}=0.78\pm0.08. STC decreased RSA\text{CO} (p<0.02), correlations (p<0.01) and intercepts (p<0.03) of \(\text{CFHF}_{\text{RES}}\)\(\text{CFHF}_{\text{FF}}\), RF-\(\Delta_{\text{CFHF}}\) and RF-RSAS relations in the 0.18-0.51 Hz range.

In SIC and STC, RSA\text{IOC} and RSA\text{S} measures vary as a function of RF, showing three consecutive stages of some change, proportional change and no change, in distinctive RF ranges, specifically: in the low RF range, reduced RSA\text{IOC} and RSA\text{S} overshoot; in the medium one, strong correlations of RF with all RSA measures and high RSA\text{CO}, although \(\text{CFHF}_{\text{FF}}\) is smaller than RF; and in the high RF range, decreased RSA\text{IOC} and RSA\text{S}. Baroreflex activation significantly depresses RSA\text{IOC} and RSA\text{S} measures in the three stages.