Heart rate variability and heart rate asymmetry analysis: does the inspiration/expiration ratio matter?

László Hejjel
Heart Institute, University of Pécs, Pécs, Hungary

TO THE EDITOR: In the Journal of Applied Physiology, Wang et al. (2) published their studies on the effects of paced breathing at different inspiration/expiration (I/E) ratios on spontaneous baroreflex sensitivity (BRS), heart rate variability (HRV), and heart rate asymmetry (HRA). The authors concluded that the I/E ratio need not to be set in BRS or spectral HRV analysis.

In our recent work (1), an increase in HRA parameters but no significant change in time and frequency domain HRV parameters was demonstrated by the I/E ratios of 1:1 and 2:1 versus the physiological 1:2 in healthy volunteers.

Why is it not necessary to consider I/E ratio during spectral HRV analysis as empirically proven by above papers?

According to the Fourier theorem, every periodic signal can be synthesized from an infinite number of sinus waves of integer multiples of the fundamental frequency. The multiples are the second, third, fourth, etc. harmonics. The respiration and respiratory sinus arrhythmia (RSA) are not symmetrical (2). It is well known in DSP and also from electric power systems that any distortion in the sine wave produces harmonics.

We can clearly recognize the higher harmonics in Fig. 1. in Wang’s paper (2) in both the respiratory signal and RR intervals at 0.1 Hz breathing at uncontrolled, 1:2, and 1:3 but not at 1:1 ratio. In addition to the 0.1-Hz peak, the second and third harmonics are present. It may cause some inaccuracy in spectral HRV analysis despite the negative outcomes of the low-volume studies (1, 2). The second and higher harmonics at 0.25-Hz breathing are above the range of analysis, so these are ignored; however, this also may cause inaccuracies explained below.

As a consequence of the sampling theorem, at a heart rate of 60 beats/min, 0.5-Hz maximal frequency of RSA can be encoded in the tachogram. The aliasing phenomenon occurs if the sampling theorem is violated, namely, spectral components higher than the half of the sampling frequency are present. These higher frequency components appear erroneously as lower frequency components in the sampled signal (tachogram). The inappropriate contribution of this aliasing to the spectral integrals is most likely negligible or not present, because the mentioned two studies (1,2) did not find significant differences in spectral HRV parameters between asymmetrical (resulting in higher harmonics) and symmetrical (preventing higher harmonics) breathing patterns.

As a conclusion, standardization of the I/E ratio seems to be unnecessary in HRV but not in HRA analysis; however, breathing frequency above 0.2Hz is suggested to prevent harmonics formation in the high-frequency spectral band until its significance will be elucidated. The possibility of metronome-controlled symmetrical breathing in HRV analysis needs further examination.

DISCLOSURES
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