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Heart rate variability, trait anxiety, and perceived stress among physically fit men and women

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Abstract

Background: It is unclear from prior reports whether the relationships between self-ratings of anxiety or emotional stress and parasympathetic nervous system components of heart rate variability are independent of personality and cardiorespiratory fitness. We examined those relationships in a clinical setting prior to a standardized exercise test. *Methods and results:* Heart rate variability (HRV) was measured during 5 min of supine rest among 92 healthy men ($N = 52$) and women ($N = 40$) who had above-average cardiorespiratory fitness as indicated by peak oxygen uptake measured during grade-incremented treadmill exercise. HRV datasets were decomposed into low-frequency (LF; 0.05–0.15 Hz) and high-frequency (HF; 0.15–0.5 Hz) components using spectral analysis. Self-ratings of trait anxiety and perceived emotional stress during the past week were also assessed. *Conclusions:* There was an inverse relationship between perceived emotional stress during the past week and the normalized HF component of HRV ($P = 0.038$). This indicates a lower cardiac vagal component of HRV among men and women who perceived more stress. That relationship was independent of age, gender, trait anxiety, and cardiorespiratory fitness. It was also independent of heart rate; mean arterial blood pressure; and respiration rate, factors which can influence HRV and might be elevated among people reporting anxiety and perceived stress. We conclude that vagal modulation of heart period appears to be sensitive to the recent experience of persistent emotional stress, regardless of a person's level of physical fitness and disposition toward experiencing anxiety.

Keywords: Nervous system; Autonomic; Heart rate; Cardiac-vagal

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1. Introduction

Heart rate variability (HRV) provides non-invasive, unobtrusive information about modulation of heart rate by the autonomic nervous system in a variety of dynamic circumstances (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996), including evoked emotions (McCraty et al., 1995) and exercise (Saito and Nakamura, 1995). Heart rate variability is commonly described by the standard deviation of intervals between successive R waves (SDRR) of the cardiac cycle. Short-term variation (e.g. measured during periods of several minutes) can be decomposed mathematically into spectral components which estimate autonomic modulation of heart rate. The high frequency (HF) spectrum (0.15–0.5 Hz) corresponds to vagally-mediated modulation of HVR associated with respiration (i.e. respiratory sinus arrthymia). The low frequency (LF) spectrum (0.05–0.15 Hz) corresponds to baroreflex control of heart rate and reflects mixed sympathetic and parasympathetic modulation of HRV, depending upon the circumstances of the assessment. When measured during slow, deep breathing or in the supine position (Pomeranz et al., 1985; Grasso et al., 1997), LF activity is believed to be vagally controlled. Activity in the very low frequency (VLF) spectrum (0.0033–0.05 Hz) can provide another index of sympathetic influence on heart rate during apnea (Shiomi et al., 1996). To estimate autonomic balance during short-term fluctuations in heart rate, the HF and LF spectra are commonly normalized to their total power (e.g. $[HF/(HF + LF) \times 100]$) in order to remove influences of VLF. Long-term (e.g. 24 h) monitoring of HRV permits assessment of the ultra low frequency (ULF) spectrum (< 0.0033 Hz) which is strongly correlated with the 24-h SDRR (i.e. total HRV).

Interest in the relationship between HRV and persistent emotional stress has increased after findings that perceived stress is predictive of transient myocardial ischemia (TMI) (Jiang et al., 1996; Gullette et al., 1997) and that HRV is associated with perceived stress (Sloan et al., 1994) and a reduced threshold for TMI (Goseki et al., 1994). Also, low HRV is associated with cardiac arrhythmia, cardiac mortality, and all cause mortality after myocardial infarction (Bigger et al., 1992; Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). Therefore, HRV may be a population risk factor for cardiac events (Tsuji et al., 1996).

Alterations in HRV have been reported in people with clinical anxiety disorders (Friedman and Thayer, 1998). In one report, patients with generalized anxiety disorder had a lower HF component of HRV during a resting baseline and during worry, consistent with reduced cardiac-vagal modulation, when compared with a non-anxious control group (Thayer et al., 1996). Yeragani et al. (1993) reported lower LF and ULF components among panic disorder patients compared with controls. In contrast, Rechlin et al. (1994) found a higher VLF component, consistent with elevated sympathetic modulation of HRV, in panic disorder patients compared with controls who were matched on age and gender. A study of patients with Posttraumatic Stress Disorder (PTSD) (Cohen et al., 1997) reported elevated power in normalized LF and HF components. However, PTSD patients had similar total HRV power, compared with case-controls matched on age, gender, and smoking habit.

Aside from studies of patients with clinical anxiety disorders, it is unclear whether HRV is altered among otherwise healthy people who have personality dispositions toward high anxiety or who experience persistent emotional stress. Fuller (1992) reported that HRV in the high frequency spectrum measured the day before a comprehensive examination was lower among female graduate students having high trait anxiety when compared with peers having low trait anxiety. Those findings are difficult to interpret, because the two groups did not differ on state anxiety the day of the exam. Because of this, it was not possible to conclude that the difference in the HF spectrum resulted from different emotional responses in anticipation of the examination or from other attributes associated with autonomic balance that could have affected HRV. Also, the high and low HRV spectra examined in that study were not