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Autonomic dysregulation in panic disorder and in post-traumatic stress disorder: application of power spectrum analysis of heart rate variability at rest and in response to recollection of trauma or panic attacks

Hagit Cohen[a,*], Jonathan Benjamin[a], Amir B. Geva[b], Mike A. Matar[a], Zeev Kaplan[a], Moshe Kotler[a]

[a] *Mental Health Center, Anxiety & Stress Research Unit, Faculty of Health Sciences, Ben Gurion University of the Negev, Beer-Sheva, Israel*

[b] *Department of Electrical and Computer Engineering, Ben Gurion University of the Negev, Beer-Sheva, Israel*

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Abstract

Power spectral analysis (PSA) of heart rate variability (HRV) offers reliable assessment of cardiovascular autonomic responses, providing a 'window' onto the interaction of peripheral sympathetic and parasympathetic tone. Alterations in HRV are associated with various physiological and pathophysiological processes, and may contribute to morbidity and mortality. Previous studies of posttraumatic stress disorder (PTSD) found lower resting HRV in patients compared to controls, suggesting increased sympathetic and decreased parasympathetic tone. This article describes the analysis of HRV at rest and after psychological stress in panic disorder (PD) patients, in an enlarged sample of PTSD patients, and in healthy control subjects. Standardized heart rate (HR) analysis was carried out in 14 PTSD patients, 11 PD patients and 25 matched controls. ECG recordings were made while subjects were resting ('rest 1'), while recalling the trauma implicated in PTSD, or the circumstances of a severe panic attack, as appropriate ('recall'), and again while resting ('rest 2'). Controls were asked to recall a stressful life event during recall. While both patient groups had elevated HR and low frequency (LF) components of HRV at baseline (suggesting increased sympathetic activity), PTSD patients, unlike PD patients and controls, failed to respond to the recall stress with increases in HR and LF. HRV analysis demonstrates significant differences in autonomic regulation of PTSD and PD patients compared to each other and to control subjects. HRV analysis may augment biochemical studies of peripheral measures in these disorders.

Keywords: Heart rate variability; Power spectrum analysis; Autonomic nervous system; Anxiety disorder; Panic disorder; Post-traumatic stress disorder

* Corresponding author. Tel.: +972-7-6401743; fax: +972-7-6401742.
E-mail address: hagitc@bgumail.bgu.ac.il (H. Cohen).

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'The loss of neuromodulation that is at the core of PTSD leads to loss of affect regulation' (Van der Kolk and Fisler, 1993).

1. Introduction

Heart rate (HR) is not constant, but oscillates around a mean value. These oscillations are due to modulations of autonomic nervous system (ANS) activity, which control heart rate through the sympathetic and parasympathetic systems. Cyclic changes in sinus rate over time are termed heart rate variability (HRV) (Akselrod et al., 1981; Malliani et al., 1990; Stein and Kleiger, 1999). Power spectrum analysis (PSA) of HRV assesses the quantitative contribution (or 'density') of high frequency (HF, 0.15–0.5 Hz), low frequency (LF, 0.04–0.15 Hz) and very low frequency (VLF, 0.01–0.04 Hz) components to the total variance ('power') of HR. Numerous experimental results have suggested that HF is a marker of vagal activity (Task Force, 1996; Stein and Kleiger, 1999). The LF power is proposed by some researchers (Ori et al., 1992; Amadi et al., 1995; Task Force, 1996; Winchell and Hoyt, 1996) to be a marker of both sympathetic and parasympathetic activity, and may be associated with baroreceptor activity. There is, however, no consensus on the association between LF and sympathetic nervous system activity. The Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996), Winchell and Hoyt (1996), Amadi et al. (1995) and others regard LF as reflecting sympathetic activity directly, although Sloan et al. (1994) and Skyschally et al. (1996) demonstrate no association between serum epinephrine levels and LF power. Factors known to enhance sympathetic activity increase the LF component, e.g. postural changes such as tilt test (Vybiral et al., 1989) and standing up (Pomeranz et al., 1985), mental/emotional (Hyndman and Gregory, 1975) and physical stress (Perini et al., 1990), sympathomimetic pharmacologic agents (Rimoldi et al., 1990), baroreceptor unloading by nitroglycerin infusion, and coronary occlusion (Malliani et al., 1991). Conversely, bilateral stellectomy (Rimoldi et al., 1990) and β-adrenergic blockade (Chess et al., 1975) are associated with a reduction in peak LF power. Because LF may also be influenced by parasympathetic activity, the LF/HF ratio provides a measure of the sympathovagal balance, where an increase in the LF/HF ratio reflects a predominance of sympathetic over parasympathetic activity, and may estimate sympathetic tone more accurately than LF alone.

The VLF component has not yet been given a precise physiological meaning and is subject to considerable debate, having been attributed variously to thermoregulatory processes, peripheral vasomotor activity, and the renin–angiotensin system.

Power analysis of HRV, which is reliable and noninvasive, can utilize the assessment of cardiovascular autonomic regulatory responses to provide a general indication of peripheral sympathetic and parasympathetic tone, and can thus be used to explore the nature of sympathetic–parasympathetic interactions. Recent work has suggested that HRV can be used to measure physiological changes in a number of psychiatric illnesses such as major depression (Rechlin, 1994a,b; Yeragani et al., 1991), generalized anxiety disorder (GAD) (Kawachi et al., 1995; Thayer et al., 1996), schizophrenia (Zahn and Pickar, 1993; Malaspina et al., 1997), panic disorder (PD) (Yeragani et al., 1992, 1993, 1995) and posttraumatic stress disorder (PTSD) (Cohen et al., 1997).

Exposure to extreme traumatic events may lead to a cluster of complex and persistent behavioral and physiological abnormalities, which are recognized as the clinical syndrome of Post-Traumatic Stress Disorder (PTSD). PTSD diagnostic criteria (DSM-IV) include chronic hyperarousal and anxiety, and two kinds of acute symptomatology: (1) vivid intrusive re-experiencing of the traumatic event ('flashbacks'); and (2) extreme anxiety and avoidance upon exposure to stimuli resembling the event. Alongside the chronic psychological hyperarousal that characterizes the syndrome of PTSD, physiological assessments in these patients demonstrate higher basal heart rate and blood pressure at rest than found in control subjects