Neuroendocrinology Letters No.6 December Vol.26, 2005

Assessment of the influence of exercise on heart rate variability in anxiety patients

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Submitted: October 19, 2005 *Accepted: October 30, 2005*

Key words: **heart rate variability; anxiety; exercise**

Neuroendocrinol Lett 2005; **26**(6):713–718 **PMID:** 16380702 NEL260605A10 ©Neuroendocrinology Letters **www.nel.edu**

Abstract

OBJECTIVES: The aim of the study was to determine the status of the autonomic nervous system (ANS) in anxiety disorder patients and to evaluate possible exercise intervention in order to improve the ANS and overall psychiatric status of patients.
PATIENTS AND METHODS: The ANS function was monitored via means of heart rate variability (HRV) changes during a 6-week hospitalization at the Psychiatric Clinic of University Hospital in Olomouc. The status of ANS was monitored by the new evaluation method of spectral analysis (SA) of HRV. The research involved 43 anxiety patients (29 women and 14 men) who underwent six weeks of intensive psychotherapy; part of the test group also participated in regular aerobic exercise.
RESULTS: In the sense of autonomic dysfunction we can not give clear-cut answers to the question whether the autonomic dysfunction could be one of the predictors of anxiety disorder, although our results suggest lower vagal representation in the spectra. Unlike in the healthy population the exercise had a positive impact only on a limited number of patients.
Regular endurance exercise on a stationary bicycle had a positive impact on the ANS efficiency only in patients with primary ANS activity reduction. In patients with normal ANS efficiency the exercise intervention had no effect; in some cases we even found activity reduction during the hospitalization period. However, the exercise had a positive effect on the course and outcome of the applied therapy in all patients.
CONCLUSIONS: ANS disturbances have not been exhibited in some patients suffering from anxiety disorder. Due to the positive impact of regular physical activity on cardiovascular, metabolic, neural, and psychological changes in organism, monitored exercise should be implemented into therapeutic programs for patients with anxiety disorders.

O R I G I N A L A R T I C L E

Abbreviations:

ANS	– autonomous nervous system
CGI	– Clinical Global Impression
CHR	– clamped heart rate test
HAMA	– Hamilton Scale of Anxiety
HRV	– heart rate variability
ICD-10	– International Classification of Diseases – 10th review
SA	– spectral analysis
SCL 90	– Self-Report Symptom Inventory
SVB	– sympatho-vagal balance – complex index of SA HRV
TP	– total power of SA HRV
TS	– total score – complex index of SA HRV
VA	– complex index of vagal activity

Introduction

Anxiety disorders belong to already common diagnosis. A wide range of somatic symptoms (e.g. higher muscle tone, perspiration, hyperventilation, palpitations, pain or pressure in the chest, tinnitus, dizziness, nauzea, genital-urinal complications, headaches, muscular pain and fatigue, trembling) are reflecting their clinical symptomatology [11].

These symptoms altogether indicate autonomous nervous system (ANS) dysfunction, and decrease in adaptation capacity of biological, affective and behavioral processes [11]. The ANS also has an influence on heart rate (HR) control, which continuously fluctuates. This **heart rate variability** (HRV) might be expressed as R-R interval variability. Spectral analysis of HRV is a non-invasive method that enables the identification of the heart rate rhythm, and thus the quantification of ANS activity. The HRV spectra is divided into three major frequency components – HF (high frequency – oscillations between 0.15 and 0.40 and up to 0.50 Hz), that is mediated by cardiac parasympathetic activity; LF (low frequency oscillations between 0.05 and 0.15 Hz) is mediated by both cardiac sympathetic and parasympathetic systems; VLF component (very low frequency – oscillations between 0.02 and 0.05 Hz) has been speculated to reflect the influence of the circulating catecholamines, thermoregulatory activity of veins, and oscillations in the rennin-angiotensin system [19].

Most of the authors are convinced of decreased **HRV in anxiety patients**, reduced vagal activity, and elevated sympathetic activity in anxiety (specifically in panic disorder) [2, 6, 22]. On the contrary, others point at normal to elevated HRV with higher values in both HF and LF powers [9], or unchanged vagal activity and a decrease in the sympathetic activity [11]. The discrepancies in the results of the above-mentioned studies indicate that sympathetic predominance and/or parasympathetic decrease do not always accompany anxiety disorders.

Most of the authors dealing with **exercise and anxiety disorders** agree on a very low exercise load tolerance in these patients [13, 14]. In spite of highly different experimental designs the influence of exercise on anxiety was highly positive. The more structured the exercise program the better the results (evaluated by the psychological questionnaires).

Due to the fact that regular exercise of adequate intensity has a positive impact on the HRV in healthy people, and to the fact that exercise decreases the overall anxiety we assessed the impact of exercise via means of SA HRV and psychopathology scales SCL-90 [4], HAMA [8] in anxiety patients.

Patients and methods

The study involved 43 anxiety patients (29 women and 14 men) hospitalized for 6 weeks of intensive psychotherapy treatment. The experimental group consisted of 27 patients (5 men, and 22 women) aged 33.50 ± 9.59 years old. The control group consisted of 16 non-exercising patients (7 women, and 9 men), mean age 32.76 ± 9.71 years old. All patients signed informed consent; and the research was authorized by the ethical committee of the Medical School of Palacky University, Olomouc.

We measured SA HRV via means of the original hardware and software VarCor TF4 [15]. The SA HRV was performed in alternating orthostatic stimulation of sympathicus and clinostatic stimulation of vagus (supine-standing-supine) to identify not only the ANS activity, but also to quantify the possible level of its dysfunction. Breathing frequency was not controlled in our study. After the SA HRV entry examination, patients of the experimental group took an exercise test with constant heart rate – CHR-test (Clamped Heart Rate Test) [20] in the exercise laboratory. Based on the results of CHR-test, an individual optimum exercise load for the stationary bicycle was prescribed. Afterwards the patients exercised 3 times a week for 30 minutes on a stationary bicycle after initial stretching. The exercise load was monitored by a heart rate monitor – SportTester by Polar.

The controls underwent an identical 6-week Integrative Therapeutic Program [10], omitting the exercise and exercise testing.

HRV was monitored again after three weeks and at the end of hospitalization (after six weeks) in all patients (a total of 3 measurements in each patient).

For evaluation of SA HRV we used complex indexes, which combine all age dependent partial parameters into age standardized indexes (parameters) of vagal activity (VA) and sympatho-vagal balance (SVB) [21]. The values of VA decrease with age as well as with work load. The values of SVB increase with age and with work load. By combining these two complex indexes we obtain a total score (TS) of SA HRV. TS enables the quantification of overall ANS efficiency [21]. All complex parameters are age standardized on a 10 point scale; positive values indicate increased vagal activity and a shift of sympato-vagal balance towards vagus. Negative values indicate the opposite. Normal values are in individual parameters within –2.5 to +2.5 points, in complex parameters is normal range evidently narrower (–1,5 to +1,5 points). Due to the combining of individual parameters of SA HRV the sensitivity of the method significantly increases, and enables unambiguous identification of less vivid changes of the power spectrum, which may not be pronounced while using the standard procedures.

Table I: Initial values of complex indexes in individual diagnosis

Diagnosis Index		F40.0 n=4	F40.1 n=4	F41.0 n=10	F41.1 n=6	F41.2 n=19
TS	M	0.04	0.11	-1.51	-0.67	-1.57
[points]	SD	1.72	2.59	2.51	2.34	2.21
VA	M	-0.38	-0.13	-1.26	-0.19	-1.50
[points]	SD	2.32	2.37	2.33	1.78	1.95
SVB	M	0.83	0.56	-1.15	0.36	-0.47
[points]	SD	0.82	3.04	2.01	1.29	1.93
TP	M	-0.20	0.68	-1.61	-1.97	-2.31
[points]	SD	2.50	3.98	2.03	3.11	2.61

Table II: Differences in complex indexes between initial and final assessment during 6 weeks hospitalization

Index	a n=27			b n=16			ac n=18			ad n=9			bc n=8			bd n=8		
	M SD	p	direction	M SD	p	direction	M SD	p	direction	M SD	p	direction	M SD	p	direction	M SD	p	direction
TS points	0.782 2.287	ns	↓	0.412 2.161	ns	↓	0.031 2.322	ns	↓	1.189 2.223	ns	↓	0.990 2.545	ns	↓	0.166 1.664	ns	↑
VA points	0.420 2.063	ns	↓	0.056 1.674	ns	↑	0.205 2.026	ns		0.732 2.066	ns	↓	0.110 1.606	ns	↓	0.222 1.835	ns	↑
SVB points	0.874 2.431	ns	↓	0.138 1.944	ns	↓	0.224 2.971	ns	↓	1.199 2.134	ns	↓	0.128 1.795	ns	↓	0.148 2.208	ns	↓
TP points	0.653 2.969	ns	↓	0.002 1.862	ns	↓	0.420 2.669	ns	↓	0.769 3.176	ns	↓	0.235 2.535	ns	↓	0.230 0.936	ns	↑

Table III: Efficacy of treatment – comparison of entry and final psychiatric assessment test values

Test	a n=27		b n=16	
	M **SD**	**p**	**M** **SD**	**p**
HAMA	16 7.54	<0.0001	13.50 9.00	<0.001
SCL 90	13.33 6.74	<0.0001	8.94 9.23	0.002

From the psychothreapeutical point of view patients were evaluated by SCL-90, Hamilton Scale of Anxiety and Clinical Global Impression – CGI [7] at the beginning and at the end of the therapy.

Basic statistical characteristics (mean, and standard deviation) were used for interpretation of the results. The Wilcoxon test for two related samples was used for the comparison of individual SA HRV parameters. The psychotherapeutical data were statistically analyzed with the use of t-test. Measured data were statistically processed by Microsoft Excel and Statistica 5.0 programs.

Results

Table I depicts the representation of individual diagnosis within the anxiety disorders according to the ICD-10. Decreased ANS activity assessed by the TS values was found only in patients with panic disorder and mixed anxiety and depressive disorder patients.

There was no significant decrease in the initial values of TS, VA, SVB or TP in anxiety patients compared to the healthy population (Table II). Considering the discovered high variability in the initial values of TS, which is the complex index of ANS activity, we also divided the research participants based on these. The bottom limit for indication of normal ANS function was –1.5 points [18]. Although the level of statistical significance was not reached, there were tendencies of an increase in VA values in the exercising patients with initial normal ANS efficiency. Similar tendencies were observed in TS, VA, and TP (Figures 1–3) in the controls with initial decreased ANS efficiency. When assessing the ANS activity after the first three weeks of the psychotherapy and exercise program we observed increasing tendencies in all complex indexes and TP in all the patients with initial decrease ANS activity. In the groups of patients with initial normal ANS activity the tendencies were inverse.

Discussion

Based on our results we cannot unequivocally agree with reports of decreased HRV in anxiety. This is contrary to the findings by most of the authors dealing with HRV in anxiety disorders [2, 6, 22]. They agree on reduced HRV due to an increase in LF power, which is suggested to be an indicator of increased sympathetic

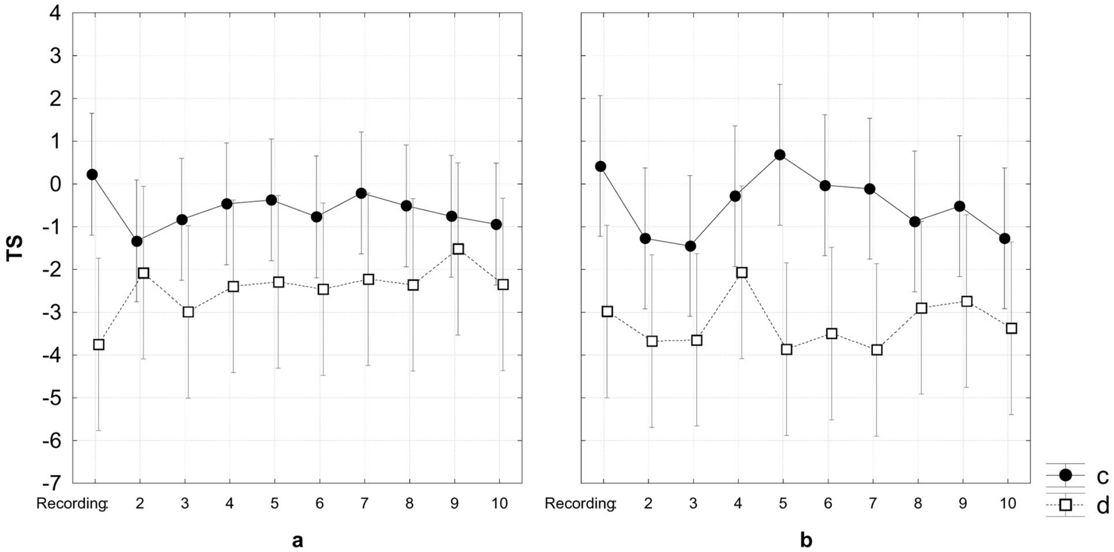

Figure 1: Dynamics of TS complex index during 6-week hospitalization (intensive monitoring of SA HRV, total of 10 assessments)

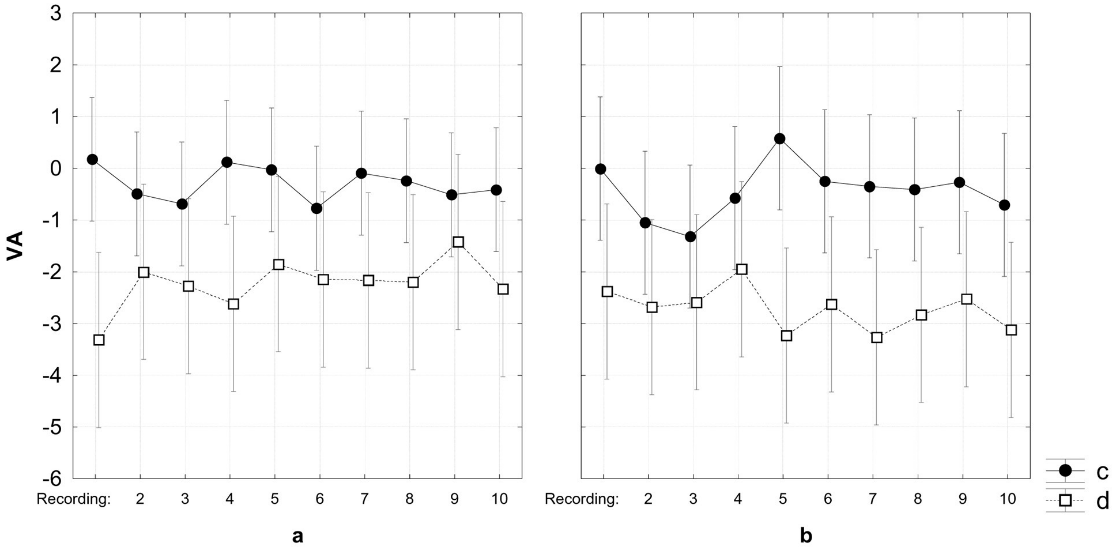

Figure 2: Dynamics of VA complex index during 6-week hospitalization (intensive monitoring of SA HRV, total of 10 assessments)

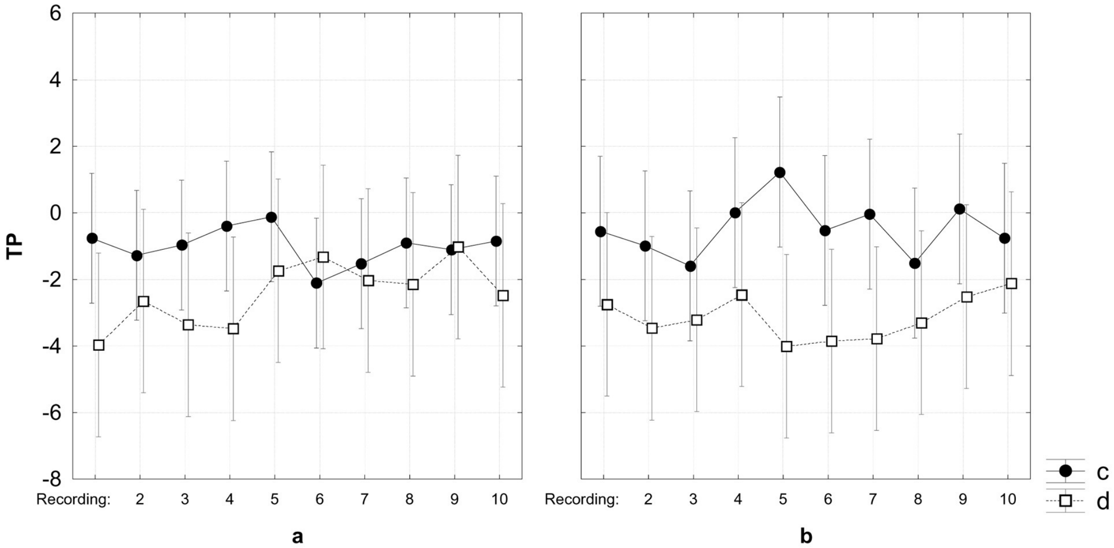

Figure 3: Dynamics of TP during 6-week hospitalization (intensive monitoring of SA HRV, total of 10 assessments)

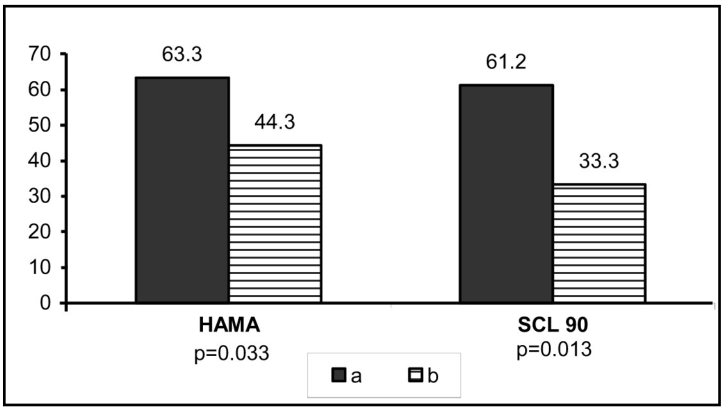

Figure 4: Psychiatric assessment – decrease in test values in %.

activity. On the contrary, the findings of Stein and Asmundsen [16], who studied the responsiveness of ANS to a wide range of autonomous function tests, prove that the ANS efficiency is not decreased in panic disorder. Normal responsiveness of ANS was recorded in patients during various tests with different levels of ANS load compared to the ANS reaction in controls. Our results were not distinctly in agreement with either conclusion. 60% of our research participants had normal, and in exceptional cases even above average ANS efficiency; decreased ANS efficiency was found only 40% of the participants.

Ito et al. [9] are careful with stating that there is only LF power increase in anxiety. In their study they monitored SA HRV in 8 early-stage panickers during resting and during a head-up tilt-test. They found not only increased activity in LF range, but HF power was also significantly higher in panic disorder patients. The LF/HF ratio was without pronounced changes between the groups. They explain this result discrepancy with the fact that most of the studies deal with later stages of panic disorder whereas their research was focused on very early stages of panic disorder. Different results of HF activity were found by Yeragani et al. [22]. In their study they monitored the 24-hour ECG in 29 panic disorder patients and 23 controls. The HF power did not differ significantly between the groups. McCraty et al. [11] came to the same conclusion of unaltered and even slightly higher HF power. Other authors [5, 6], while monitoring anxiety disorders (without closer specification), found significant decreases in the HF component in comparison to the healthy population. Further, McCraty et al. [11] not only recorded a decrease in HRV and unaltered HF, but also pointed at decreases in LF and VLF, and a decrease in the LF/HF ratio. In agreement with McCraty et al. [11] and Ito et al. [9] we found decreased activity in the LF power in the entire group of patients with panic disorder.

Regular exercise increases vagal activity; in the HRV spectra it is manifested by an increase of total power at rest, a shift of the spectra to faster fluctuations, and decrease in resting sympathetic activity [1, 3]. Our findings did not unequivocally prove this statement. In our research group we recorded an increase in TS and vagal activity only in the group of exercising patients with initial decrease ANS activity. In patients with initial normal ANS activity, as well as in non-exercising controls, there were no pronounced changes in the TS. These differences across the groups can be explained in several different ways. Melanson and Freedson [12] in their study hypothesized that in order to increase the spectral power in HF, the exercise intensity has to exceed 70% of maximum heart rate reserve, and the exercise has to be carried out for minimum of 12 weeks. Unfortunately, neither of these conditions was met in our study.

The results of exercise intervention studies can also be influenced by the level of initial values of the monitored parameters. It is generally accepted that people with high initial values demonstrate lower training differences than people whose initial values are lower. This phenomenon is called *the law of initial values* [17]. According to this the vagal activity decrease in patients with the highest initial vagal activity can be explained, as well as the increase in vagal activity in patients with under the average TS values. The changes of SA HRV presented in literature must not necessarily mean a dysfunction in one of the ANS branches. Complex indexes even show that the variability within one diagnosis is relatively high.

According to the psychiatry assessment results (Table III, Figure 4) there was a more significant decrease in anxiety values in the group of exercising patients compared to the non-exercising group. These findings are in agreement with the SA HRV assessment conclusions.

Conclusion

Based on the results of SA HRV we can say that in the wide spectrum of anxiety disorders there is not an unequivocal decrease in ANS activity. From the psychopathology exercise decreased anxiety on a larger scale than psychotherapy only. Due to the positive impact of regular physical activity on cardiovascular, metabolic, neural, and psychological changes in an organism, monitored exercise should be implemented into the therapeutic programs for patients with anxiety disorders.

Acknowledgments

This paper was partially supported by the grant IGA NF/7500-3 from the Czech Ministry of Health.

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