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HRV biofeedback training in allergic patients and anxious individuals: A pilot study

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Abstract

OBJECTIVES: Heart rate variability (HRV) is currently considered to be a relevant indicator of the autonomic nervous system's activity.

METHODS: In the presented pilot study we observe the effect of the HRV biofeedback training using emWave device on the parameters of HRV in highly anxious and allergic subjects. We are following the existing research findings, which documented the presence of the dysfunction of the autonomic nervous system in both allergy and anxiety. On the sample of 20 subjects we analyze time-domain, frequency-domain and also nonlinear parameters of HRV, using ECG measurements obtained before, during and after HRV biofeedback training, which consisted of eighteen 20-minute exercises. In addition, we also focused on the effect of HRV biofeedback training on variables such as: subjectively perceived distress, heart rate, development of the achieved coherence during training and comparison of total score achieved during training between particular groups.

RESULTS AND CONCLUSION: Data analysis did not show a significant effect of HRV biofeedback training on HRV parameters or above-mentioned variables and no significant differences were found between groups except different total average score between the group with a low challenge level and a group with a medium challenge level of training.

INTRODUCTION

Currently one of the most widely used methods of assessing autonomic nervous system activity is heart rate variability (HRV). Its analysis provides fairly detailed and time-available information about the function of the sympathetic and parasympathetic system. Malfunction of the autonomic nervous system can be reflected as a reduction in HRV value, which can have pathological effects on organism in long-term. In the context of anxiety and allergy, dysregulation of autonomic nervous system was discovered by numerous studies (Emin *et al.* 2012; Ishman *et al.* 2007; Narita *et al.* 2007; Buske-Kirschbaum *et al.* 2003). Stress research in The Psychophysiology Laboratory (Department of Psychology, Faculty of Art, Comenius University in Bratislava) also supported these findings of foreign studies. Using available data from long-term research of HRV, the research team revealed reduced heart rate (HR) and increased HRV in subjects with a positive history of allergic anamnesis (Rajcani *et al.* 2016). Based on further research, we consider the lower levels of sympathetic activation in allergic and highly anxious individuals, and at the same time express the intention of further monitoring and investigation of this phenomenon (Rajcani *et al.* 2016) In Solarikova *et al.* (2016), we described an important phenomenon of positive correlation between allergy symptoms and high trait-anxiety. Because of this, there is problem to asses which one of the mentioned factors is more involved in stress reaction dysregulation that is found in both allergy and trait-anxiety. Researcher recommends isolating allergy from trait-anxiety when forming a research sample, which can be reliable in solving of mentioned problem.

HRV can be expressed in time-domain, frequency-domain and nonlinear parameters. Time-domain analysis of HRV is considered to be the simplest way to assess HRV, calculating the variation of RR intervals (Task Force 1996). Frequency-domain or spectral analysis provides information about the dynamic and spectral components of HRV representing the defined frequency bands. These bands include high frequency (HF) associated with parasympathetic modulation of heart, and low frequency (LF) associated with the activity of baroreceptors and both parasympathetic and sympathetic influences (Kuusela 2013).

HRV biofeedback is a method based on the graphic display of information about heart rate and its variability to an individual through a computer program in an interactive and comprehensible form, so that an individual can train to condition their autonomic functioning. It appears to be effective both in medicine according the prevention of cardiovascular diseases, and also in relation to the emotional and cognitive functioning (Moss 2004). An important term connected to HRV biofeedback is "coherence", which is understood as synchronized interaction within the body systems and systems such as the autonomic nervous system, respiratory and cardiovascular system (McCraty & Childre 2003). Achieving and training coherence is the main principle in HRV biofeedback, aiming for consistency between the sympathetic and parasympathetic system, resulting in greater adaptability of the body mentally and physically. The positive effect of HRV feedback training on the function of the autonomic nervous system is grounded in current research (Lehrer *et al.* 2003; Lehrer & Gevirtz 2013) and it also appears as effective method in relation to trait-anxiety (Reiner 2008). In connection with allergies, however, research does not show a direct effect of HRV feedback training on the autonomic nervous system, but it studied the effect of this method on presence of the allergic symptoms, which were reduced after HRV feedback training (Lehrer *et al.* 1997, 2004; Arndt *et al.* 2008).

Given the research demonstrated connection between allergies and dysregulation of the autonomic nervous system we consider desirable to study the effect of HRV biofeedback in people with a positive allergic history, focusing on the function of the autonomic nervous system.

METHOD

Subjects

The research sample consisted of 20 subjects (women n = 12, men n = 8), divided into 4 groups: allergic patients, anxious subjects, control group (without allergy, low anxiety) and anxious subjects with allergy. It was important to exclude subjects with any acute or chronic disease, sleep disorders or premenstrual syndrome. Groups had to fulfill these requirements:

Profile of subject with positive allergic anamnesis:

- Allergy diagnosis (allergic rhinitis, bronchial asthma, atopic dermatitis)
- Presence of allergic symptoms for minimum 2 years

Profile of anxious subject:

- Raw score in STAI (scale of trait anxiety) more than 49 points
- Without allergic symptoms in anamnesis

Research design

We administered the questionnaire The Symptom Checklist-90 (SCL-90) before and after HRV feedback training with the intention of monitoring the effect of training. For this purpose we used global severity index (GSI), which is considered to be the most sensitive single quantitative indicator concerning subjectively experienced distress. Subjects attended introductory training instruction, which includes information about impact of emotions, stress and slow and smooth breathing on autonomic nervous system, heart rate and its variability and also demonstration of software and HRV feedback device emWave. After that, they practiced first pretest session during which they used basic technique of increasing in coherence by breathing, so called The Coherence Coach. Then, they were divided into two groups based on achieved score. Maximum score achieved during this pretest session was 1278 and minimum achieved score was 123. Subjects with score less than 450 were assigned to the group with the low challenge level (N = 10) (and subjects, who achieved more than 450 score, were assigned to the group with the medium challenge level (N = 10). The HRV feedback training consisted of eighteen 20-minutes exercises during 4–5 weeks. We left choice of form of training (game/animation/The Coherence Coach) to subject's discretion. Subjects also took notes about every exercise to a diary. Parameters of HRV were recorded before, during (10th exercise) and after training, using portable ECG devices FAROS. During these ECG measurements, subjects were in rest sitting position for 6 minutes. 5-minute time windows were selected from records for analysis of data.

RESULTS

Parameters of HRV

We focused on these selected parameters of HRV: mean RR interval, standard deviation of RR intervals (SDNN), square root of the mean differences of successive RR intervals (RMSSD), high frequency HRV band 0.15–0.4Hz (HF), ratio of low frequency 0.04–0.15Hz and high frequency band (LF/HF) and standard deviation SD1 from Poincaré plot. These HRV measures were recorded before, during (10th exercise) and after training. Effect of the training on HRV changes was compared within groups as well as between groups. The multivariate repeated measures analysis did not demonstrate significant changes in HRV parameters due to training (See *Table 1*): p(Mean RR) = 0.127, p(SDNN) = 0.136, p(RMSSD) = 0.489, p(HF) = 0.158, p(LF/HF) = 0.199, p(SD1) = 0.117. The values of the Pillai's trace (F(16,44) = 1.438, $p = 0.169$, See *Table 2*), which represent total within-subjects effect of repeated measures, demonstrate nonsignificant effect ($p > 0.05$). Effect of the group also is not significant F(48,156) = 0.732 and $p = 0.895$.

Table1: MANOVA.RM for effect of training on parameters of HRV

	df	M	F	p
Mean RR	2	14618,15	2,224	0,127
SDNN	2	1292,729	2,143	0,136
RMSSD	2	771,206	0,734	0,489
HF	1,879	3887948	1,995	0,158
LF/HF	2	2,732	1,71	0,199
SD1	2	1044,154	2,318	0,117

Table 2: Pillai's Trace for group x session

	Value	F	Hypothesis df	Error df	p-value	Partial Eta Squared
session x group	1,103	,732	48	156	,895	,184

Psychological distress

The Wilcoxon signed-rank test was used in the context of psychological distress because of non-normal data. The average value of GSI before training is 0.52 and after training 0.50, which means a certain decrease in a perceived psychological distress as a result of training. However, no significant changes were observed in psychological distress after training, because $p = 0.433$ (See *Table 3*).

Mean BPM (beats per minute)

The results of the paired t-test (p = 0,121) show a nonsignificant difference in the average BPM between repeated measures despite the fact that the average value decreased after the training: M= 74.4, M= 71.8 (See *Table 3*).

The low coherence

The low coherence represents a low level of overall HRV and low respiratory sinus arrhythmia indices (RMSSD, HF, SD1). Average values (before training: M = 11.37, after training: M = 14,65) indicate moderate increase of the percentage representation of low coherence, but this increase is nonsignificant ($p = 0.121$) (See Table 3).

Between-subjects differences in total achieved score during the training

a. Control and experimental groups

Total score was compared between all groups – allergic patients, anxious subjects, control group (with no allergic symptoms in anamnesis and low trait anxiety) and anxious subjects with allergy (See *Table 4*). Between-subjects differences are expressed by the value of Kruskal-Wallis test: $p = 0.350$, therefore the difference is not significant. Despite this, the highest average score was noticed in the control group: M = 13199. Allergic patients achieved M = 11153, anxious and allergic subjects had average score M = 6677 and anxious subjects had M = 12764.

b. Sex

Average values point out that men (M = 12765) achieved higher average score than women (M = 10824). But result of the nonparametric Mann-Whitney U test shows a nonsignificant effect of sex in total score of training (See *Table 4*).

c. The challenge level of training

Division of the research sample in terms of the challenge level of training led us to assumption that subjects who have achieved high score in the first exercise, therefore being able of optimize their HRV effectively, also achieved a higher score at medium-challenge level training, in comparison to the group who scored low in the first exercise and therefore attended training at a low challenge level. Average values of total score show marked between-subjects difference, because the group with the low challenge level achieved average score M = 7864,56, while average score of the group with medium challenge level was M = 14656,82. This difference was statistically significant (Mann-Whitney U test, p = 0.009) (See *Table 4*).

DISCUSSION

The results do not support our basic hypothesis that HRV will be increased after HRV biofeedback training. These findings do not correspond to the bulk of previous studies that show changes in the function of the autonomic nervous system after HRV biofeedback training (Del Pozo *et al.* 2004; Lehrer *et al.* 2003; Lehrer & Gevirtz 2013). However, there are studies which also did not find effect of HRV feedback on HRV. Dudášová (2008) investigated effectiveness of HRV biofeedback in specific sample after acute myocardial infarction. HRV biofeedback training consisted of five 15-minutes sessions during 2–3 weeks. She did not notice any sig-

Table 3: Effect of HRV feedback training on psychological distress, mean BPM and the low coherence

	Before training		After training		p-value
	M	SD	M	SD	
Psychological distress (SCL-90)	,52	,34889	,50	,36339	,433
Mean BPM	74,4240	9,11789	71,8080	7,28765	,156
The low coherence	11,37	12,26	14,65	15,49	,121

Table 4: Between-subject effect in total score x groups

	Group	M	SD	p-value
Control and experimental groups	Allergic subjects	11153,00	5741,73	,350
	Anxious subjects	12764,20	3516,55	
	Control group	13198,57	7117,54	
	Allergic + anxious subjects	6676,67	1864,01	
Sex	Women	10823,75	6100,94	,589
	Men	12765,13	4826,91	
The challenge level	Low	7864,56	4131,33	,009
	Medium	14656,82	4750,90	

nificant difference in HRV parameters before and after training. No changes in mood nor HRV parameters were observed in healthy subjects after HRV biofeedback treatment by Siepmann *et al.* (2008), what support a limitation of efficacy of HRV biofeedback. Whited *et al.* (2014) investigated if the HRV biofeedback training using emWave device affected physiological reactions in rest and stress conditions. In their research, treatment group attended 32-minutes long sessions once weekly for 4–8 times. They also did breathe techniques with the device at home for 10 minutes daily, so it was relative intensive training. Physiological data were collected in rest, during stress (arithmetic task) and following stress in two assessment sessions – pre-treatment and post-treatment. The results of this study did not show any significant difference between measurement before and after training in rest and recovery from a stressor. However, during stress, the treatment group showed increased parasympathetic responses (i.e., pNN50) in post-treatment session. In this context, authors mentioned that it is important to measure HRV not only in rest, but also in stress conditions. They presented that HRV biofeedback training does not seem to affect resting levels of HRV and criticized studies in which researchers measure only tonic level of HRV after HRV biofeedback treatment. They also added that changes in HRV in reaction to stressor may have more important significance in connection with HRV biofeedback than any modification in HRV in rest. Another study (Swanson *et al.* 2009), which focused on investigation of effect of HRV biofeedback training in patients with heart failure, have also failed to find significant changes in HRV. However, there was a significant clinical change in treatment group – increased exercise tolerance. Many studies are concentrated on clinical outcomes (Lehrer *et al.* 2003, 2004; Reiner 2008), which are undoubtedly important in connection with investigation of effect of HRV biofeedback. But Wheat & Larkin (2010) emphasize a need to focus on physiology treatment effect, which should be more considered.

We also did not observe any differences between groups in the effect of this training despite the fact that previous researches described a dysregulation of the autonomic nervous system in allergic and anxious subjects (Emin *et al.* 2012; Ishman *et al.* 2007; Miu *et al.* 2009; Narita *et al.* 2007; Buske-Kirschbaum *et al.* 2003; Rajcani *et al.* 2016). The studies, which deal with feedback's techniques in the context of allergy and trait-anxiety, notice specific modifications after their application either at the level of reduction of symptoms of allergy (Lehrer *et al.* 2004) and trait-anxiety score (Reiner 2008) or within the meaning of increase of HRV (Lehrer *et al.* 1997). In the second case, we perceive limited number of researches that deal with effect of feedback's techniques directly on function of the autonomic nervous system.

Furthermore, HRV biofeedback training did not have any impact on reduction of perceived psychological distress. The only significant effect was noticed in difference of total achieved score between groups with low and medium challenge level. The group with medium challenge level achieved significantly higher score than the group with low challenge level. This result is in compliance with our hypothesis, because the group with medium challenge level has already achieved relative high score during pretest. Despite the fact that groups achieved different score, their basal values of HRV parameters measured before training were not significantly different. This finding indicates that achieved score from the HRV biofeedback do not reflect level of HRV, what we consider noteworthy and required to research in detail in the future.

We reflect some limitations of this study, which include a small sample size and it follows our recommendation of future researches focused on this problem with more extensive sample. Also, diary notes indicate lower motivation of subjects and next limitations are connected with limited control of confounding variables during the training. Wheat & Larkin (2010) point out that it is important to control factors such as alcohol, nicotine, caffeine and intensive exercise, which directly correlate with autonomic activity. They also present the necessity to take into account sex, age and height of subjects during interpretation of results. So future research should secure better control over training (for example by using webcam or training in a laboratory) and reduce factors, which can be related to HRV and have direct impact on autonomic activity.

CONCLUSION

In conclusion, we want to emphasize the need to continue to use HRV biofeedback training in allergic patients and anxious individuals or to research other forms of optimization of function of the autonomic nervous system at this specific research sample because disbalance of the autonomic nervous system appears to be important factor affecting symptomatology, pathogenesis and also their well-being and overall quality of life.

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REFERENCES

1 Arndt J, Smith N, Tausk F (2008). Stress and atopic dermatitis. Curr Allergy Asthma Rep. **8**(4): 312–317.

2 Buske-Kirschbaum A, von Auer K, Krieger S, Weis S, Rauh W, Hellhammer D (2003). Blunted cortisol responses to psychosocial stress in asthmatic children: A general feature of atopic disease? Psychosom Med. **65**: 806–810.

3 Del Pozo JM, Gevirtz RN, Scher B, Guarneri E (2004). Biofeedback treatment increases heart rate variability in patients with known coronary artery disease. Am Heart J. **147**(3): 545.

4 Dudášová A (2008). Použitie biofeedbacku v rámci kardiovaskulárnej rehabilitácie. In Rehabilitácia. **45**(3): 172–183.

5 Emin O, Esra G, Aysegul D, Ufuk E, Ayhan S, Rusen DM (2012). Autonomic nervous system dysfunction and their relationship with disease severity in children with atopic asthma. Respir Physiol Neurobiol. **183**(3): 206–210.

6 Ishman SL, Martin TJ, Hambrook DW, Smith TL, Jaradeh SS, Loehrl TA (2007). Autonomic nervous system evaluation in allergic rhinitis. Otolaryngol Head Neck Surg. **136**(1): 51–56.

7 Kuusela T (2013). Methodological aspects of heart rate variability analysis. In: Kamath MV editor. Heart Rate Variability (HRV) Signal Analysis. Clinical Applications. London: CRC Press, 9–42.

8 Lehrer PM & Gevirtz R (2013). Heart rate variability biofeedback: how and why does it work? Front Psychol. **5**: 756–756.

9 Lehrer PM, Carr RE, Smetankine A, Vaschillo E, Peper E, Porges S, Edelberg R, Hamer R, Hochron S (1997). Respiratory sinus arrhythmia versus neck/trapezius EMG and incentive inspirometry biofeedback for asthma: a pilot study. Appl Psychophyiol Biofeedback. **22**(2): 95–109.

10 Lehrer PM, Vaschillo E, Vaschillo B, Lu SE, Eckberg DL, Edelberg R, et al (2003). Heart rate variability biofeedback increases baroreflex gain and peak expiratory flow. Psychosom Med. **65**(5): 796–805.

11 Lehrer PM, Vaschillo E, Vaschillo B, Lu SE, Scardella A, Siddique M, Habib R (2004). Biofeedback treatment for asthma. Chest Journal. **126**(2): 352–361.

12 McCraty R & Childre D (2003). The appreciative heart: The psychophysiology of positive emotions and optimal functioning (Publication No. 02-026). Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath.

13 Miu AC, Heilman R, Miclea M (2009). Reduced heart rate variability and vagal tone in anxiety: Trait versus state, and effect of autogenic training. Auton Neurosci. **145**: 99–103.

14 Moss D (2004). Heart rate variability and biofeedback. Psychophysiology Today: The Magazine for Mind-Body Medicine **1**: 4–11.

15 Narita K, Murata T, Hamada T, Takahashi T, Omori M, Suganuma N, Wada Y (2007). Interactions among higher trait anxiety, sympathetic activity, and endothelial function in the elderly. J Psychiatr Res. **41**(5): 418–427.

16 Rajcani J, Solarikova P, Turonova D, Brezina I (2016) Heart rate variability in psychosocial stress: Comparison between laboratory and real-life setting. Act Nerv Super Rediviva. **58**(3): 77–82.

17 Reiner R (2008). Integrating a portable biofeedback device into clinical practice for patients with anxiety disorders: Results of a pilot study. Appl Psychophysiol Biofeedback. **33**(1): 55–61.

18 Siepmann M, Aykac V, Unterdörfer J, Petrowski K, Mueck-Weymann M (2008). A pilot study on the effects of heart rate variability biofeedback in patients with depression and in healthy subjects Appl Psychophysiol Biofeedback. **33**(4): 195–201.

19 Solarikova P, Brezina I, Turonova D, Rajcani J (2016). Anxiety and sympathetic response to stress in allergic patients. Act Nerv Super Rediviva. **58**(3): 88–94.

20 Swanson KS, Gevirtzn RN, Brown M, Spira J, Guarneri E, Stoletniy L (2009). The effect of biofeedback on function in patients with heart failure. Appl Psychophysiol Biofeedback. **34**(2): 71–91.

21 Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology (1996). Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. Eur Heart J. **17**(3): 354–381.

22 Wheat AL & Larkin KT (2010). Biofeedback of heart rate variability and related physiology: A critical review. Appl Psychophysiol Biofeedback. **35**(3): 229–242.

23 Whited A, Larkin KT, Whited M (2014). Effectiveness of emWave biofeedback in improving heart rate variability reactivity to and recovery from stress. Appl Psychophysiol Biofeedback. **39**(2): 75–88.