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HEART RATE VARIABILITY IN THE ASSESSMENT AND BIOFEEDBACK TRAINING OF COMMON MENTAL HEALTH PROBLEMS IN CHILDREN

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Abstract

Heart rate variability (HRV) is a measure of the beat-to-beat variations in heart rate related to the work of autonomic nervous system.

HRV is indicative psychophysiological measure for arousal, emotional state and stress level.

We used this parameter in both: the assessment and biofeedback training for common mental health problem in school children.

Obtained results showed that HRV biofeedback is especially good choice for introvert children, but not for children manifesting ADHD.

Key words: mental health problems, children, heart rate variability, biofeedback

Introduction

Heart rate variability (HRV) is a measure of the beat-to-beat variations in heart rate. The sympathetic and parasympathetic branches of the autonomic nervous system antagonistically influence the lengths of time between consecutive heartbeats. HRV is direct psychophysiological measure for arousal, emotional state and stress level. ш1ќ

There are two major theories related to autonomic flexibility, represented by HRV, and the capacity for regulated emotional responding: Polyvagal Theory and Neurovascular Integration Theory. Both theories are similar in that they (1) accentuate

a critical role of parasympathetically mediated inhibition of autonomic arousal in emotions and (2) maintain that HRV measures are informative about individuals' capacity of regulated emotional responding. [2]

Some empirical research with HRV [3, 4, 5] showed that:

- Low HRV is an independent risk factor for several negative cardiovascular outcomes
- Low HRV is a proxy for underlying cardiovascular disease processes
- Higher levels of resting HRV have been associated with effective coping strategies
- Attention control is associated with higher HRV
- Patients with generalized anxiety disorder show lower HRV than controls
- Low HRV has been associated with depression.

In clinical practice HRV training was used for prevention of cardiac diseases, to control high anxiety, depression and stress level, as well as to evaluate the stages of sleep ш6-17ќ

Various measures of heart rate variability have been proposed, which can roughly be subdivided into *time domain*, *frequency domain* and *non-linear measures*. ш18, 19ќ

The calculation of the standard deviation of beat-to-beat intervals is an example of a time domain measure. In other words, the time intervals between heart beats can be statistically analyzed to obtain information about the autonomic nervous system. Other time domain measures include root mean square of the differences between heart beats (rMSSD), the number of normal to normal complexes that fall within 50 milliseconds (NN50), and the percentage of total number beats that fall with 50 milliseconds (pNN50).

A common frequency domain method is the application of the discrete Fourier transformation to the beat-to-beat interval time series. This provides an estimation of the amount of variation at specific frequencies. The similar procedure is used for calculation of EEG spectral power in the assessment of children with ADHD ш20ќ. In this context, concerning ECG spectra, several frequency bands of interest have been defined in humans. (Fig.1)
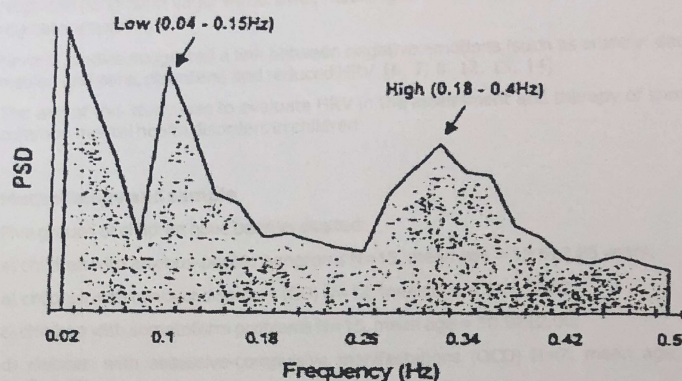
Figure 1. *Power spectrum of HRV (PSD = power spectral density)*

Short-term (two to five minute) electrocardiogram (ECG) recordings for spectral analysis tend to produce three peaks, a high frequency (HF) peak between 0.15 and 0.40 Hz, a low frequency (LF) peak between 0.04 and 0.15 Hz, and a very low frequency (VLF) peak below 0.04 Hz. HF power reflects HRV attributable to respiratory sinus arrhythmia, and is regarded as a marker of vagal modulation of R-R intervals and a cardiac parasympathetic effect. Spectral analysis of short-term, two to forty minute ECG recordings provides information about the autonomic status of the heart, reflecting mainly vagal activity.

Several factors influence the accuracy and usefulness of the measured HRV components. These include the duration of the recording and the effect of the various physical and physiological changes that occur during the recording period [21, 22].

In sum, the analysis of HRV (whether by time-domain or spectral approaches) offers a non-invasive method of evaluating vagal input into cardiac rhythm.

As a *dynamic* marker HRV appears to be sensitive and responsive to acute stress. As a marker of *cumulative* life experience, HRV has also been shown to decline with the aging process. In short, HRV appears to be a marker of two processes: (1) *frequent activation* (short term dips in HRV in response to acute stress); and (2) *inadequate*

response (long-term vagal withdrawal, resulting in the over-activity of the counter-regulatory system).

Several studies suggested a link between negative emotions (such as anxiety, depression and panic disorders) and reduced HRV. [6, 7, 8, 12, 13, 14]

The aim of this study was to evaluate HRV in the assessment and therapy of some common mental health disorders in children.

Methodology and sample

Five groups of children have been evaluated:

a) children with anxious-phobic symptoms N=15, mean age = 12.5±2.25 years;

b) children with conduct disorders (CD) N=12, mean age = 11.5±1.52;

c) children with somatoform problems N=15, mean age = 10.92±2.06;

d) children with obsessive-compulsive manifestations (OCD) N=7; mean age = 14.5±2.20;

e) children with ADHD N=10, mean age = 10.5±1.80 and

f) control group N=15 children, mean age = 10.18±1.33; (total number of examined children N=74)

In the assessment procedure interviews with parents and children and psychometric evaluation with Eyzenck Personality Questionnaire (EPQ) are used. EPQ [23, 24] is used for discriminating four main psychological characteristics of the personality: extroversion/introversion; neurotic tendencies/ stability; psychopathologic traits/ normal behavior and control lye-scale. Most important for the study was to discriminate extrovert/introvert children which is significant for mental arousal. ш25к As biofeedback instrumentation we used Heart Math Freeze- Framer System, (1998). This system is constructed to help in following area: to shift intentionally to more positive emotional state; to help in better problem solving; to maintain general health and physical resilience; to transform the stress into positive relationships and to help in effective dealing with stress. It is supposed that effective emotional regulation depends on being able to flexibly adjust the physiological response to a changing environment.

Results and discussion

For all children we applied EPQ as a standardized, psychometric test. Obtained results are presented on Table 1.

Table 1: Results obtained for EPQ

Score	Anxious-phobic	CD	ADHD	Somatoform disorders	OCD	Control
P	5.82±2.12	6.37±2.34	5.37±1.86	8±4.66	6.25±2.94	4.86±2.09
	p=0.27	p=0.34	p=0.004**	p=0.05*	P=0.3	
E	14.36±5.15	15.25±4.29	17.75±3.11	11.2±2.95	14.75±2.27	17.2±1.42
	p=0.062	p=0.3	p=0.63	p=0.0004**	p=0.72	
N	14.45±3.79	13.62±4.99	15.37±2.86	14.4±4.22	13±4	12.2±3.38
	p=0.13	p=55	p=0.11	p=0.11	p=0.02*	
L	14.27±3.0	12.8±4.0	11.5±3.39	15.3±2.7	11.5±2.69	16.13±2.29
	p=0.098	p=0.11	p=0.003**	p=0.46	p=0.03*	

$p < 0.05$; ** $p < 0.005$

Generally, all evaluated children manifesting some mental health problem in this study showed lower scores for extroversion and higher scores for neuroticism than control. It can be supposed that all these children have higher inner mental arousal compared with healthy children. It means that brain-rate (spectrum-weighted frequency) is higher in eyes closed than in eyes open condition [25]. This finding is important for the choice of biofeedback therapy. In addition, the comparison of EPQ scores between groups showed significant difference in P score between anxious-phobic and ADHD group (p=00022); and CD and ADHD (p=0.03). Children with ADHD and group with somatoform problems differs significantly in L scores (p = 0.007); as well as in N scores (p = 0.007).

In our previous study [26] we concluded that introvert personalities manifested inner arousal (calculated with brain-rate formula) for which it is better to apply peripheral biofeedback modalities. In this context peripheral biofeedback based on HRV is supposed to be a good choice. Consequently, for all mentioned groups, HRV training was performed. The aim of HRV training is to obtain higher HRV or to diminish the low spectral power. The number of training sessions is 15 (one per week).

In the following we present results obtained with biofeedback HRV in different gro-up of children. On the Figure 2, heart rate for first and last session for differrent groups is presented. It can be seen that maximal changes are obtained for OCD, conduct disorders and anxiety. It means that with training children learned to diminish heart rate.
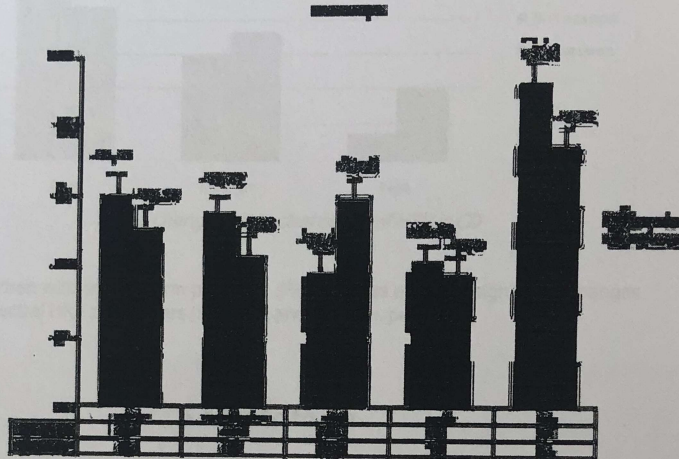

Fig.2: Changes of HR (first and last session) for different groups

On the Fig. 3 changes obtained in HRV with the training for CD are divided in relation to spectra. It is important that we obtained significant improvement of high HRV ($p < 0.05$) which is very good from clinical aspect. In addition the low HRV is statistically lower ($p < 0.05$) than during the assessment (first occasion).
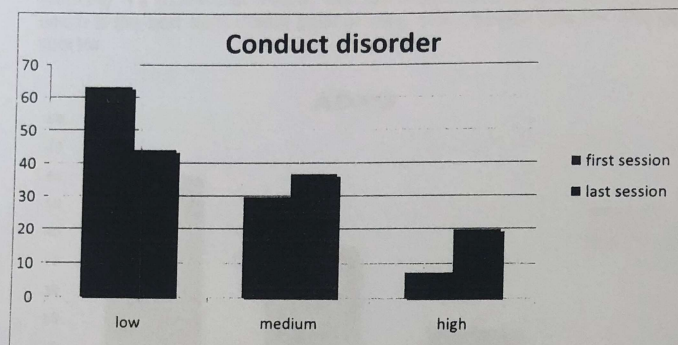
Conduct disorder

Fig. 3: Changes of spectral power of HRV in CD

For children with somatoform problems (Fig. 3) it was obtained significant changes in all spectral HRV parameters (low, high and medium, p< 005)
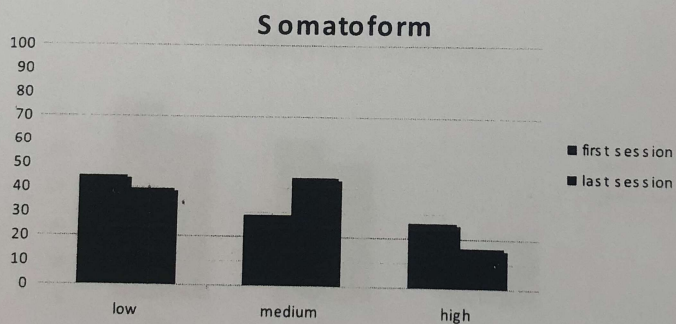
Somatoform

Fig. 4: First and last session for low, medium and high HRV in somatoform group

From Fig. 4 it is clear that children with ADHD did not obtained to change high HRV which is the best from clinical point of view, they changed only low and medium spectra.
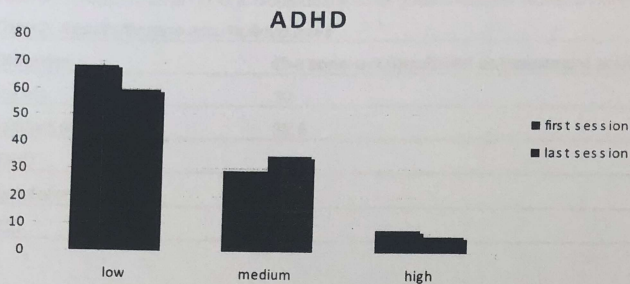

Fig.5: HRV for children with ADHD

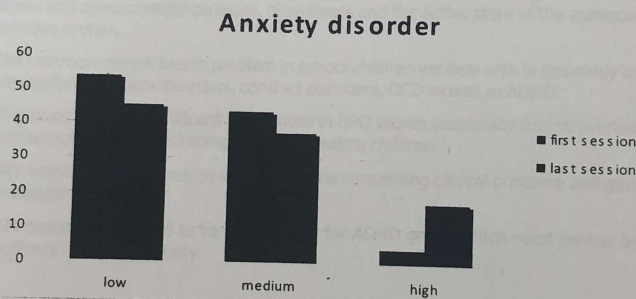Anxiety group (Fig. 5) showed the best results concerning HRV: diminish the low and rise the high HRV scores.

Fig.6: HRV for children with anxiety

The zone-accumulated entrainment score (Table 2) obtained with biofeedback cal-culated directly through the instrument happen to be the best in the group with CD as well as for children with general anxiety (32.5 and 30 respectively over 100), but it is also good for OCD and somatoform disorders. For ADHD group this parameter is minimal. It means that peripheral biofeedback is not good choice for ADHD children.

Table 2: Results for zone-accumulated score

Disorder	the zone-accumulated entrainment score
Anxiety	30
Conduct disorders	32,5
ADHD	10,62
Somatoform disorders	20
OCD	20

This study shows that HRV as a peripheral biofeedback could be good choice especially for introvert children manifesting common mental health problems. The application is non-invasive, has good cost-benefit and is the included games are very interesting for children.

Conclusion

Heart rate data reflects various physiological states such as biological workload, stress and concentration on tasks, drowsiness and the active state of the autonomic nervous system.

The common mental health problem in school children we deal with in this study are: somatoform, anxiety disorders, conduct disorders, OCD as well as ADHD.

All groups showed significant differences in EPQ scores (especially for introvertsion and neurotic tendencies) compared with healthy children.

HRV training showed very positive influence concerning clinical outcome and gene-ral mental health.

HRV training happened to be not efficient for ADHD group which need central bio-feedback i.e. neurotherapy.

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