REACTION OF HEART RATE VARIABILITY ON ENDURANCE TRAINING LOAD

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Summary

The aim of the study was to assess the effect of endurance training session on activity of autonomic nervous system monitored by means of spectral analysis of heart rate variability. 16 flat water canoeists (mean age 28,3 ± 2,23 years, height 177 ± 8,22 cm and weight 79,4 ± 10,1 kg) underwent simulated endurance training session. SAHRV was monitored prior to start of training session, in early phase of recovery and in the morning on the second day. The results showed that endurance training session reduced total spectral power, power VLF (very low frequency) and power HF (high frequency). The results of our study are in accordance with actual knowledge in this field and the results may be useful for further investigation.

Introduction

Spectral analysis of heart rate variability (SAHRV) enables researchers to quantify the activity of autonomic nervous system (ANS) quickly and easily. Methodic stems from following oscillations of intervals between adjoin heart rates. On electrocardiogram they are express by distance of R-R intervals, and we used to for them term heart rate variability.

Monitoring of SAHRV is accomplished of short-term collecting data (300 rates or 5 minutes) by means of telemetric system VariaCardio TF4. Standard examination is feasible in three positions – supine – standing – supine, also called orthoclinostatic test. It is functional exam with minimal load on organism. We compare course of heart rate before change of position and after it (Stejskal, Salinger, 1996).

Position of specifically oscillations which gives periodicity HRV, together with amplitude of frequency spectrum HRV enable characterize sympathic and vagal activity and their mutual ratio (Salinger et al., 1998).

Method of SAHRV characterizes only components of frequency spectrum which are harmonically. The number of data about amount of R-R intervals is transformed to frequency figure in range from 0,02 Hz to 0,5 Hz (it means 0,5 – 30 periodical changes per minute) (Šlachta, 1999).

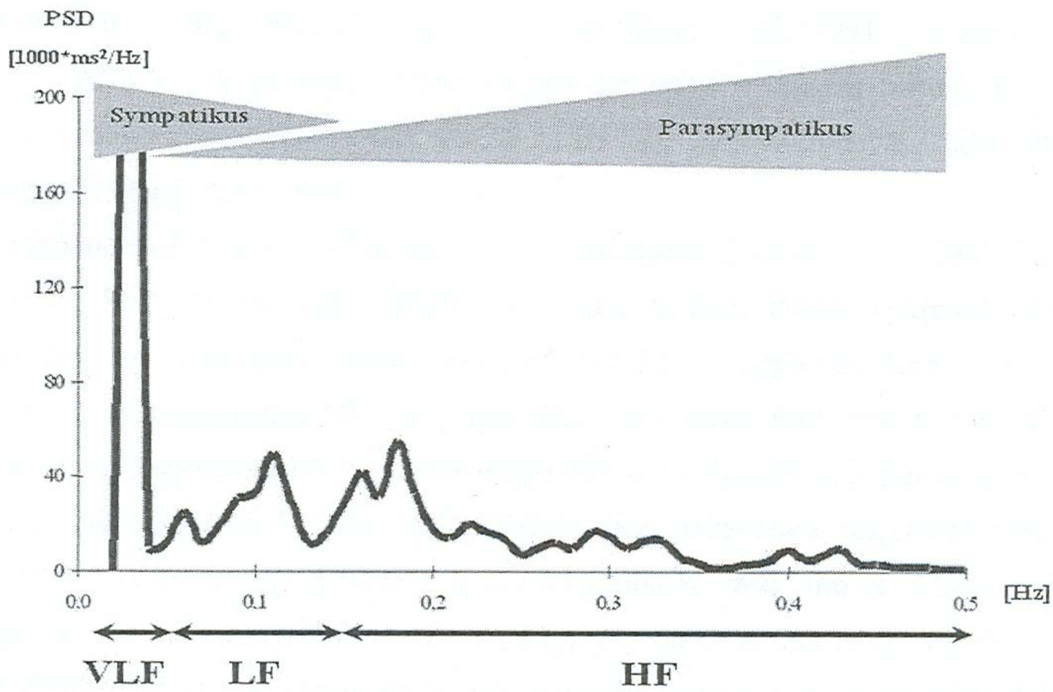
Analysis of short-term records enable to distinguished three main spectral components:

VLF – very low frequency in zone 0,02 – 0,05 Hz, characterize mainly sympathic activity. It correlate to level of circulate catecholamine and activity of rennin – angiotenzin system. It represents least cleared up component, despite of that it compose as many as 95% of overall spectral power. This component correlate with malignant arrhythmias and it has close relation with heart rate according to changes of body positions and according to load and relaxation. Frequency of oscillations is too slow (0,2 – 2,4 oscillate cycle per minute).

LF – low frequency in zone 0,05 – 0,15 Hz, it is characterize for sympathic and vagal activity and it reflect activity of baroceptor reflexes and regulative mechanism of blood pressure. It is called Mayer pressure wave. Number of oscillations cycle is 2,4 – 9 per minute. Component VLF should not be considered like overall indicator of sympathicus activity.

HF – high frequency in zone 0,15 – 0,5 Hz is influenced mostly by vagal activity. Number of oscillations cycles is 9 – 24 per minute, which consistent with breath frequency. That is why HF component is called respiration wave. Increasing of tidal volume increase size of HF component, but increasing of breath frequency is reducing it. So breath frequency and tidal volume directly influence power spectral of HRV.

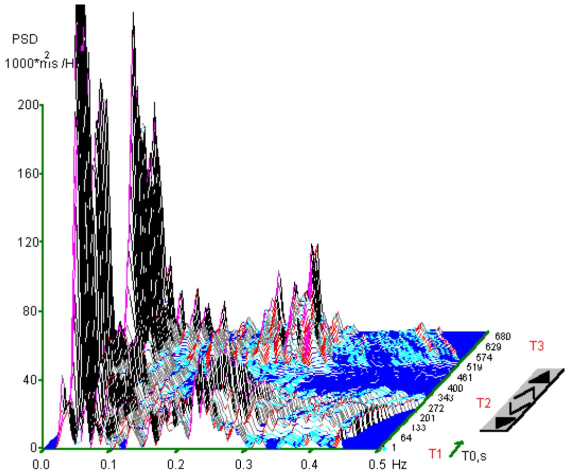
Figure 1 Distribution of spectral power of HRV

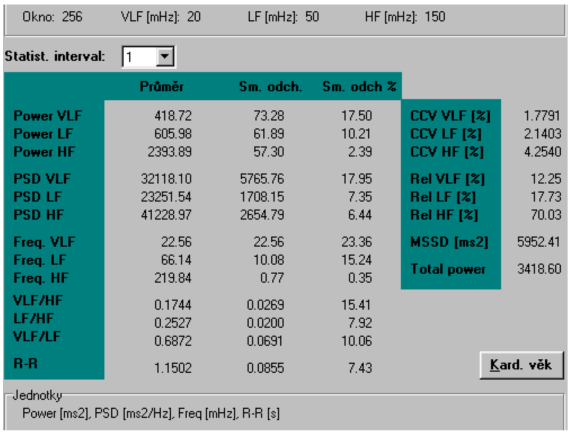


Measurements were done by means of original software and hardware VariaCardio TF4. Output of this program is three dimensional graph and amount numeric figures (figure 2).

Figure 2 Outcomes of SAHRV: three positions test supine – standing – supine

a) example of 3-dimensional graph
b) example of outcome power spectral density




Okno: 256   VLF [mHz]: 20   LF [mHz]: 50   HF [mHz]: 150

Statist. interval: 1

	Průměr	Sm. odch.	Sm. odch %		
Power VLF	418.72	73.28	17.50	CCV VLF [%]	1.7791
Power LF	605.98	61.89	10.21	CCV LF [%]	2.1403
Power HF	2393.89	57.30	2.39	CCV HF [%]	4.2540
PSD VLF	32118.10	5765.76	17.95	Rel VLF [%]	12.25
PSD LF	23251.54	1708.15	7.35	Rel LF [%]	17.73
PSD HF	41228.97	2654.79	6.44	Rel HF [%]	70.03
Freq. VLF	22.56	22.56	23.36	MSSD [ms2]	5952.41
Freq. LF	66.14	10.08	15.24	Total power	3418.60
Freq. HF	219.84	0.77	0.35		
VLF/HF	0.1744	0.0269	15.41		
LF/HF	0.2527	0.0200	7.92		
VLF/LF	0.6872	0.0691	10.06		
R-R	1.1502	0.0855	7.43		

Kard. věk

Jednotky
Power [ms2], PSD [ms2/Hz], Freq [mHz], R-R [s]

Basic parameter is Power spectral density (PSD) of particular spectral components PSD_{VLF}, PSD_{LF}, PSD_{HF} [$ms^2.Hz^{-1}$]. Other parameters of SAHRV are derivate from PSD.

During the training load the heart rate is increasing by influence of decreasing of vagal activity and increasing of sympathic activity. Influence of this two control mechanism is independent of intensity of training load. At the beginning of training load heart rate is increasing by reduction of vagal activity (Perini et al., 2002).

Methods

We followed up reaction HRV on single endurance training session on group A (experimental group) and group B (control group).

Experimental group consisted of 16 volunteers, trained flat water canoeists, average age 28,3 ± 2,23 year table 1. All of them underwent standard medical examination, and there were no health problem found. Each volunteer underwent simulated endurance training session and three examinations SAHRV.

Table 1: Basic statistical characteristic of experimental group A

Parameter		Whole group (n=16)	Men (n=12)	Women (n=4)
age (years)	ẋ	28,3	28,6	27,5
	s	2,23	2,32	1,65
	min	25	25	25
	max	33	33	29
high (cm)	ẋ	177	181	167
	s	8,22	6	3,48
	min	164	175	164
	max	191	191	174
weight (kg)	ẋ	79,4	84,3	64,7
	s	10,1	5,06	5,38
	min	60	76	60
	max	95	95	75

Volunteers absolved training session at the same time. First examination was done closely before the start of training load, second examination in early phase of recovery, within ten minutes from the end of training load. Last measurements were done in the morning on the next day, at the same time (± 1 hour) on hungry stomach without previous physical or psychical demanding activities.

Control group consisted from 16 volunteers, average age 29 ± 2,5 year (table 2). Volunteers absolved 3 examinations SAHRV at the same time like experimental group, but without previous training load.

Table 2: Basic statistical characteristic of control group B

Parameter		Whole group (n=16)	Men (n=12)	Women (n=4)
age (years)	ẋ	29	29	29
	s	2,5	2,54	2,34
	min	25	25	27
	max	33	33	33
high (cm)	ẋ	176	180	167
	s	7,03	4,92	1,34
	min	165	174	165
	max	189	189	169
weight (kg)	ẋ	70,7	74,8	58,5
	s	9,47	6,65	3,43
	min	52	65	52
	max	85	85	62

Our volunteers got ear – phones and listened to the calming music and we covered their eyes.

Examinations, within which we got our evaluated records SAHRV, were done during months June – August 2010 with relative standard conditions.

For the reason to get most standardized measurements we provide relatively the same conditions for all measured volunteers.

We watched HRV in position at supine – at standing- at supine, where the first supine serve to calm the person, standing serve like standardized ortostatic load which stimulated symphaticus and second supine represents clinostase stimulated vagus. Commonly used test at supine – at standing – at supine, where at supine alternate prevail activity of vagus with prevail symphaticus at standing. We used this in all our examinations ANS.

For most precise evaluation of vagus activity is recommended evaluation of spectral indices from the repeated position at supine (Opavský, 2004). We respected these recommendation an all SAHRV figures and we evaluated only from this position.

Simulated endurance training represented special training on flat water, which consisted from 4x2000 m with 4 minutes break. Main phase of training session proceeded 15 minutes of easy paddling. After the main phase followed 15 minutes of paddling to cool down. Volunteers realized this training with maximum effort, willing to get the best time for each distance.

We compared parameters SAHRV of experimental group with parameters of control group. We compared figures before conducting training, in early phase of recovery and on the day after.

We used Student t-test to compare differences between groups and t-test for pair samples for comparison between particular measurements within groups.

Beside basic parameter SAHRV (Power spectral density – PSD VLF, PSD LF and PSD HF) which provide software VariaCardio TF 4 we evaluated also other derived parameters (Freq. VLF/LF/HF, Power VLF/LF/HF, Total power, Rel. VLF/LF/HF, VLF/HF, VLF/LF and LF/HF), and complex indices (total score, VA, symphatico –vagal balance).

To process measured data and to evaluate results we used basic statistical characteristic for all measured parameters. Heart rate variability reaction on single endurance training load, we evaluated by means of T-test for pair samples.

To evaluate influence of physical training load on HRV we proceed following parameters:

- total power
- power very low frequency (VLF), power low frequency(LF) power high frequency(HF)
- ratio VLF/LF, VLF/HF, LF/HF
- frequency of partial spectral components – freq. VLF, freq. LF and freq. HF
- index of time domaine MSSD mean square succesive differences, which define overall heart rate variability
- index of heart rate frequency R-R
- functional age
- complex indices of vagal activity (VA), symphato-vagal balance (SVB) and total score (TS)

Results and discussion

By influence of endurance training became statistically significant decrease of indices Power VLF, R-R, MSSD and VA, and increase of functional age (table 3a). Figures of HRV, which was reduces by influence of training load significantly increased 14 ours after it in parameters Total Power, Power VLF, Power HF, VLF/LF, R-R, MSSD, TS, VA and SVB and significantly decreased in parameters LF/HF and Functional age (table 3b). Comparing start figures and figures 14 ours after training became significantly increase in parameters Power HF, MSSD, TS, VA and SVB, and significantly decrease in parameters LF/HF and functional age (table 3c).

Table 3: Statistical significant difference of parameters SAHRV

Legend

Fat face: Parameters, which characterize sympathicus

Underline: Parameters, which characterize sympatho-vagal balance

a **before and after trainig load**	b **after training load and the next day**	c **the next day and before training load**
	Total power	
Power VLF	Power VLF	
	Power HF	**Power HF**
	VLF/LF	
	<u>*LF/HF*</u>	<u>*LF/HF*</u>
R-R	**R-R**	
MSSD	**MSSD**	**MSSD**
Functional age	Functional age	Functional age
	Total score	Total score
VA	**VA**	**VA**
	<u>*SVB*</u>	<u>*SVB*</u>

Duration of recovery after intensive training load is in dependence on conditions (level of training, health condition, heredity, intensity of training load and others) individual variables and in several indices may last more than 24 hours (Hautala et al., 2001). We can not eliminate, that among some volunteers may occur influences of intensive exercises from previous days and this may caused decrease of spectral power.

Important factor, which influences differences of HRV in course of recovering is intensity of preceding training load. Commonly known is, that increasing of training load reduces vagal activity, and to certain level increases sympathicus activity. According to Stejskal et al., (2001) intensity of training load has dominant influence to activity of both systems of ANS, which is secondary expressed in differences in spectral power.

By influence of endurance training total spectral power and spectral powers of all three components of HRV was reduced. Parameters, which are characteristic for vagal activity was reduced too. Activity of sympathicus was increased, which confirm significant decrease of complex index VA.

Forteen hours after training load was finished increased parameters characterized for vagal activity and sympatho-vagal activity. Here becomes shift of balance from sympathicus to vagal nerve. Dynamics of some indices continue in its trend also after getting initial level before training load. So figures of these indices were in 14 hours of recovering above (eventually below) start level.

According to Pober, Braun and Freedson (2004) changes in HRV after single shot sub maximum training load are similar to differences after long-term training. This differences shows to shift of autonomic functions to vagal nerve and to decrease of sympatho-vagal balance.

Commonly known is that influences of factors, which affect on HRV (training load, physical stress and other) are stronger than influence of circadian rhythm. So monitoring of circadian rhythm suppose precise standardization, which we were not able to provide in control group.

Volunteers were learnt that they can not put trough physical and psychical load and drink alcohol for 24 hours before examination, except of regular measurement they had different daily rutine.

Probably caused this we did not record many significant changes in indices of SAHRV. We record changes only in complex indices TS and VA and in index functional age, where we record increasing of sympathicus activity and decreasing of vagal activity in the afternoon. Tendency of decreasing of parameter Power HF during the day was only indication, with minimum figures in the evening, and maximum in the next morning. Such trend of increasing of sympathicus activity in the evening and decreasing of vagal activity till the next day does not correspond with all parameters. The reason probably was not keeping to the rules by some volunteers during the evening or night, what we regretfully did not find out.

Circadian rhythm caused only tiny changes of HRV, but training load caused so great changes, that circadian rhythm is by its influence hidden.

Conclusion

Monitoring influence of endurance training on SAHRV showed that training session reduced total spectral power as well as spectral power of all three components HRV, but statistically significant difference was only in the case of spectral power VLF.

Within 14 hours after the end of training load spectral power of component HF characterizing vagal activity statistically significantly increased above start figures. Figure Power HF increased even so significantly, that difference was demonstrated as well among its figures detected before training load and after 14 hours of recovery.

By the next day after the end of training load parameters LF/HF, VLF/HF, and complex index SVB achieved start level.

We are aware, that HRV is influenced by too many factors, and it often makes interpretation of results quite inconsistence. Evaluation of organism condition, especially in professional athletes should be supported with results of other physiological and biochemical examinations.

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