The Development of LF/HF Ratio and its Dependence on the Mean Heart Rate in Children and Adolescents

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Abstract

We have shown previously how the dependency of the baroreflex sensitivity on the inter-beat intervals (IBI) can cover up the developmental changes. Therefore we decided to analyse LF/HF ratio.

We have calculated mean IBI and heart rate (HR) and their power spectra in 424 subjects (11 - 20 years) from the 5-min continuous blood pressure monitoring at rest. LF/HF ratios of IBI and HR spectra were determined. The statistic was done for a whole group (WG), and for subgroups of older children (C:11-15 years), adolescents (A:16-20 years), and for 10 particular age-subgroups.

In the WG and the A, we shown significant relationship between age and mean IBI or HR, but LF/HF_{IBI} *or* LF/HF_{HR} *were age-independent.* LF/HF_{IBI} *or* LF/HF_{HR} *was also significantly age-dependent. Negative correlation of IBI vs.* LF/HF_{IBI} *and a positive correlation of HR vs.* LF/HF_{HR} *in the WG and in C or A was found. Relationship IBI vs.* LF/HF_{IBI} *and HR vs.* LF/HF_{HR} *were in particular age-subgroups from 11 to 14 years, but it was insignificant in subgroups from 15 to 20 years.*

Our analysis showed the increase of LF/HF ratio up to the age of 15 years when the development of sympatho-vagal balance seems to be finished. Strong relationship between IBI or HR and LF/HF ratios could cover the development changes.

1. Introduction

The LF/HF ratio is often used in studies for the description of sympathovagal balance. The reason is that heart rate power spectrum at the high frequency range (HF, 0.15-0.4) evaluates cardiac parasympathetic activity [1;2] but the power spectrum at the low frequency range (LF, 0.05-0.15 Hz) is a composite parameter of both sympathetic and parasympathetic activity. Therefore LF/HF ratio is used to provide an evaluation of the relative contribution of the sympathetic and parasympathetic components of the autonomic control of heart rate [2; 3].

An important thing is that these parameters are calculated mainly form IBI, only occasionally from HR. It is based on studies that have shown that the frequency of the stimulation of the vagal nerve to the heart rate is hyperbolic but linear to the value of inter-beat intervals (IBI) [4;5]. In our previous study [6], we have worked with two parameters of baroreflex sensitivity: classical BRS [ms/mmHg] for whose calculation the IBI was used, and BRSf [Hz/mmHg] calculated from heart frequency. While BRS was IBI- dependent and do not respond on the development of baroreflex sensitivity and autonomous nervous system, contrary BRSf, IBI-independent, reflected development changes.

2. Aims

In our previous study [6], we shown how the dependency of the baroreflex sensitivity on the inter-beat intervals (IBI) can influence the results of a study and cover up the developmental changes. Therefore we decided to analyze another parameter – LF/HF ratio that assesses sympatho-vagal balance.

3. Methods

3.1. Subjects

We have addressed healthy participants in several basic and secondary schools and two universities in the city of Brno. The informed consent to the examination was obtained from all subjects and also from parents of under-aged adolescents.

We examined 424 healthy older children, adolescents and young adults (212 males and 212 females) between

11 – 20 years of age (15.44 ± 2.85 years). The structure of this population is shown in table 1:

Table 1: Structure of the population

		Text	Σ No.	Male No.	Female No.
whole group (WG)	older children	11 years	28	12	16
		12 years	50	26	24
		13 years	61	36	25
		14 years	45	31	14
		15 years	42	21	21
	adolescents	16 years	39	20	19
		17 years	31	14	17
		18 years	45	18	27
		19 years	34	18	16
		20 years	49	16	33
Σ			424	212	212

3.2. Data collection

In each subject, blood pressure was noninvasively continuously measured by photopletysmographic method of Peňaz. The measuring cuff was placed on the second phalanx of the middle or ring finger of the subject's dominant hand. The subjects were sitting at rest for 15 min prior to the measurement; thereafter blood pressure was measured for 5 min. All participants breathed at a rate of 0.33 Hz in accordance with bar-led metronome, and they adjusted their tidal volume according to their own comfort.

3.3. Data analysis

The values of systolic and diastolic blood pressure (unused for this article), inter-beat intervals (IBI) and heart rate (HR) were detected from the recorded blood pressure signal beat-to-beat. These data sets were used for IBI and HR power spectra calculation in low frequency range (LF: 0.05 - 0.15 Hz) and high frequency range (0.15 – 0.5 Hz). The LF/HF ratio was calculated as the ratio between the both parts of IBI power spectra (LF/HF_{IBI}) and HR power spectra (LF/HF_{HR}). Mean IBI and HR were also calculated for each recording.

3.4. Statistics

The statistic was done firstly for a whole group (WG), secondly for subgroups of older children (C:11-15 years), and adolescents (A:16-20 years), and thirdly for 10 particular age-subgroups. Statistical analysis was performed by the STATISTICA, v. 12 (StatSoft, Inc.).

4. Results

We have studied in this work development of the LF/HF indices calculated from the IBI or HR power spectra. First of all we have done classical Pearson correlation between age and studied parameters. In the whole group and the subgroup of adolescents, we have seen significant relationship between age and mean IBI or HR, but LF/HF_{IBI} or LF/HF_{HR} was age-independent. The analysis of the subgroup of children shown, that not only IBI and HR but also LF/HF_{IBI} or LF/HF_{HR} were significantly age-dependent. However LF/HF_{IBI} or LF/HF_{HR} was in group of adolescent age-independent (table 2).

Table 2. Pearson correlation (R) between age and followed parameters.

Variable	Group	Median (Q25 – Q75)	R p-level
Age [years]	WG	15 (13 – 18)	
	C	13 (12 – 14)	
	A	18 (17 – 19)	
IBI [ms]	WG	749.5 (663 – 839)	0.442***
	C	702 (628 – 793)	0.281***
	A	802 (718 – 894)	0.244***
LF/HF_{IBI} [n.u.]	WG	0.616 (0.292 – 1.107)	0.044
	C	0.656 (0.314 – 1.072)	0.234***
	A	0.570 (0.269 – 1.118)	0.029
HR [Hz]	WG	1.34 (1.20 – 1.51)	-0.448***
	C	1.43 (1.27 – 1.60)	-0.274***
	A	0.59 (0.28 – 1.15)	-0.262***
LF/HF_{HR} [n.u.]	WG	0.621 (0.297 – 1.136)	0.043
	C	0.636 (0.320 – 1.123)	0.229***
	A	0.586 (0.277 – 1.145)	0.035

The further analysis showed a negative significant correlation of IBI vs. LF/HF_{IBI} and a positive correlation of HR vs. LF/HF_{HR} in the whole group and in children or adolescents. Significant relationship IBI vs. LF/HF_{IBI} (table 3) and HR vs. LF/HF_{HR} (table 4) was in particular age-subgroups from 11 to 14 years, but it was insignificant in subgroups from 15 to 20 years.

5. Discussion

Group of parameters describing heart rate variability are affected by the influence of the sympathicus and parasympathicus on the heart pacemaker. However interpretation of the results is in some cases controversial because the studied parameters could depend on another ("third") variable. Therefore we analysed two parameters that could affect the studied LF/HF ratio: age and mean

inter-beat intervals/mean heart frequency.

There are several studies using LF/HR ratio for the evaluation of the autonomous nervous system development. Seppala et al. [7] reported no association between childhood age (6- 8 years) and LF/HF ratio, whereas Kazuma et al. [8] have found significant increase, and Massin et al. (0-14 years) [9] or Michels et al. (5-10 years) [10] have identified only slight reduction of LF/HF ratio [3]. Our own results have imply that simple correlation have shown no changes of LF/HF ratio with age, but further analysis have uncovered increase of both LF/HF ratios (calculated from IBI or HR) between ages 11 to 15 but around age of 15 the development stopped.

It is known for a very long time development of heart rate. The new-born baby has generally heart rate above 100 beats/min, and with the age the heart rate decrease to 70 beats/min in adult. Because the relationship between HR and IBI is reciprocal and hyperbolic, logically IBI prolonged with the age. In our previous study [6], positive relationship between age and IBI as well as positive correlation between IBI and BRS covered decrease of BRS with age, but index BRSf calculated from instantaneous values of heart frequency was IBI-independent and better reflected the developmental changes. In this study, strong relationship between LF/HF ration and IBI/HR probably also influenced the development of studied parameter but both parameters, LF/HF_{IBI} and LF/HF_{HR}, were affected in the same way this time.

Table 3. Dependance of LF/HFIBI on mean IBI.

Group	IBI median (Q25 – Q75)	LF/HF_{IBI} median (Q25 – Q75)	R p-level
11 y	641 (616 – 729)	0.423 (0.235 – 1.005)	-0,400 p<0.05
12 y	677 (614 – 746)	0.386 (0.209 – 0.704)	-0.288 p<0.05
13 y	692 (628 – 777)	0.687 (0.349 – 1.289)	-0.476 p<0.001
14 y	726 (676 – 802)	0.677 (0.426 – 1.072)	-0.494 p<0.001
15 y	776 (675 – 844)	0.871 (0.470 – 1.540)	-0.050 p=NS
C (11-15y)	702 (628 – 793)	0.656 (0.314 – 1.072)	-0.240 p<0.001
16 y	783 (650 – 843)	0.656 (0.221 – 1.273)	-0.093 p=NS
17 y	759 (675 – 822)	0.446 (0.274 – 0.945)	-0.179 p=NS
18 y	791 (710 – 898)	0.529 (0.253 – 1.397)	-0.251 p=NS
19 y	859 (782 – 926)	0.534 (0.257 – 0.842)	-0.084 p=NS
20 y	825 (764 – 903)	0.659 (0.373 – 1.525)	-0.184 p=NS
A (16-20y)	802 (718 – 894)	0.570 (0.269 – 1.118)	-0.158 p<0.05
WG (11-20y)	749 (663 – 839)	0.616 (0.292 – 1.107)	-0.194 p<0.001

Table 4. Dependence of LF/HF_{HR} on mean HR.

Group	HR median (Q25 – Q75)	LF/HF_{HR} median (Q25 – Q75)	R p-level
11 y	1.57 (1.38 – 1.63)	0.423 (0.256 – 1.055)	0.364 p=0.05
12 y	1.48 (1.34 – 1.63)	0.376 (0.239 – 0.686)	0.282 p<0.05
13 y	1.45 (1.29 – 1.60)	0.668 (0.359 – 1.293)	0.433 p<0.001
14 y	1.38 (1.25 – 1.48)	0.743 (0.421 – 1.129)	0.487 p<0.001
15 y	1.29 (1.19 – 1.49)	0.915 (0.418 – 1.453)	0.084 p=NS
C (11-15y)	1.43 (1.27 – 1.60)	0.636 (0.320 – 1.123)	0.237 p<0.001
16 y	1.28 (1.19 – 1.54)	0.665 (0.179 – 1.304)	0.090 p=NS
17 y	1.32 (1.22 – 1.48)	0.4227 (0.291 – 0.896)	0.258 p=NS
18 y	1.27 (1.12 – 1.41)	0.535 (0.245 – 1.408)	0.217 p=NS
19 y	1.17 (1.08 – 1.29)	0.556 (0.248 – 0.915)	0.042 p=NS
20 y	1.21 (1.11 – 1.31)	0.707 (0.381 – 1.394)	0.187 p=NS
A (16-20y)	1.25 (1.12 – 1.39)	0.586 (0.277 – 1.145)	0.156 p<0.05
WG (11-20y)	1.34 (1.20 – 1.31)	0621 (0.297 – 1.136)	0.196 p<0.001

6. Conclusion

Our analysis showed the increase of LF/HF ratio up to the age of 15 years when the development of sympatho-vagal balance seems to be finished. Strong relationship between IBI or HR and LF/HF ratios could cover the development changes.

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