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Circadian rhythm of spectral indices of heart rate variability in healthy subjects

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Abstract Circadian pattern of heart rate variability spectral indices, including hourly, 24-hour, night, day, morning, and sex-adjusted measures of low frequency (LF), high frequency (HF), and LF/HF, was evaluated in healthy persons in 24-hour 3-lead electrocardiogram. HF showed circadian pattern with the greatest night values and LF/HF with the smallest night values. Peaks of hourly LF were found between 5 and 9 AM and between 4 and 6 PM. The smallest LF was between 11 PM and 3 AM. Hourly HF peaked between 11 PM and 5 AM. The smallest HF was observed between midday and 2 PM. LF/HF peaked between 6 and 9 AM as well as between 4 and 6 PM with the smallest values between midnight and 5 AM. Sex adjustment was of no significance.In healthy subjects, HF and LF/HF have circadian pattern. Evaluation of all 5-minute intervals of 24-hour period seems to be a precise method of heart rate variability analysis.

Keywords: Heart rate variability; Circadian pattern

1. Introduction

In healthy people, the heart rate changes according to respiratory cycle, thermoregulation, baroreceptor activity, and most of all, autonomic tone fluctuations. The phenomenon is called heart rate variability (HRV) [1]. HRV reflects, to some extent, changes in one of the most important cardiovascular modulator, which is the autonomic nervous system [2-4]. The circadian variation of autonomic tone is well known [5].

Two methods of HRV analysis, in time domain and frequency domain, were invented [6]. Spectral analysis can be performed for short 5- to 10-minute recordings. Time domain evaluation requires long recordings, performed for at least several hours, and the best assessment can be obtained for the whole 24-hour electrocardiogram (ECG) recordings. Spectral analysis with the use of fast Fourier transform or autoregression formula reveals periodicity of heart rate changes.

The purpose of our study was to evaluate diurnal fluctuations of frequency-domain HRV measures in healthy people.

2. Methods

2.1. The study group

The study group comprised 76 healthy volunteers aged 35 to 55 years, including 41 men at the age of 40 ± 6 years and 35 women at the age of 38 ± 8 years. No significant findings were found in medical history of all subjects; no abnormalities on physical examination, normal resting 12-lead ECG, arterial blood pressure, resting echocardiography, as well as laboratory tests, including blood cell count, serum total cholesterol, fasting glucose, and electrolytes, were seen.

2.2. Holter recordings

Twenty-four–hour ambulatory ECG monitoring was performed with Oxford Medilog FD 3 digital recorders. The positions for 3 leads were as follows: (1) the right manubrial border of the sternum (negative) and the sixth rib

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Table 1
24-Hour HRV parameters

	Mean	Median	Minimum	Maximum	SD
Mean 24-h LF (ms^2)	986	799	81	2630	640
Mean 24-h HF (ms^2)	321	204	52	1173	293
Mean 24-h LF/HF	5.04	4.64	2	9.50	2.0
SD 24-h LF (ms^2)	872	663	65	3388	710
SD 24-h HF (ms^2)	296	190	42	2103	357
SD 24-h LF/HF	3.64	3.48	1.32	7.16	1.42
SD/mean 24-h LF	0.863	0.794	0.569	1.65	0.246
SD/mean 24-h HF	0.895	0.804	0.550	1.79	0.272
SD/mean 24-h LF/HF	0.732	0.731	0.493	1.18	0.134

at the left anterior axillary line (positive), (2) the subclavicular region at the left anterior axillary line (negative) and V_2 lead (positive), and (3) the fifth rib at the right anterior axillary line (negative) and the fifth rib at the left middle axillary line (positive). Recordings were analyzed automatically with the version 8.5 of the software by Oxford Medilog Excel 2. Every subject was told to write down the time when going to bed and waking. We could then select the period when all study subjects were asleep to evaluate HRV in the same conditions for all persons. Night period was established from midnight to 6 AM, morning period from 6 to 10 AM, and day period from 3 to 8 PM. Recordings of low technical quality as well as with more than 10 ectopic beats per hour or conductibility disorders were rejected. Because we planned to use these recordings for other evaluations, we also did not include those with ST deviations.

2.3. HRV analysis

Spectral analysis of HRV was computed by autoregression formula for each 5-minute interval of 24-hour recording. Only recordings in which HRV could be evaluated in at least 270 consecutive 5-minute intervals were included. Finally, 48 recordings met the criteria and underwent analysis.

We measured the power of 2 spectral bands, LF (low frequency) component at 0.04 to 0.15 and HF (high frequency) component at 0.15 to 0.4. Then LF/HF ratio was calculated.

2.4. Statistical analysis

Statistical analysis was performed with the use of Statistica 5.5 (Stat Soft, Tulsa, OK, USA) package. Mean value, SD, and index of variability expressed as SD/mean ratio of 24-hour HRV, as well as of HRV for selected day, night, and morning periods, were calculated for each study subject. Mean hourly values were calculated to select hours in which HRV reached the greatest values and the smallest ones. Shapiro-Wilks test was applied to test whether the distribution was normal. Mean values and SDs for selected periods were compared with Newman-Keuls test and analysis of variance. Sex differences were evaluated with Wald-Wolfowitz test with Siegal correction for continuity. The HRV variability was evaluated for each person separately in all 3 periods with Kruskal-Wallis

Table 2
LF parameters for 3 periods: morning, day, and night

Mean LF					
Morning	1018	972	138	2294	571
Day	933	664	81	3589	753
Night	1125	721	44	6303	1070
SD of LF					
Morning	827	692	90	2814	642
Day	713	411	33	4641	928
Night	898	581	34	4527	806
SD/mean LF					
Morning	0.804	0.671	0.500	2.07	0.338
Day	0.706	0.601	0.339	1.42	0.276
Night	0.807	0.800	0.502	1.16	0.173

Table 3
HF parameters for 3 periods: morning, day, and night

	Mean	Median	Minimum	Maximum	SD
Mean HF					
Morning	286[a]	201	55	816	214
Day	232[b]	131	39	1298	281
Night	496[a,b]	268	44	3914	659
SD of HF					
Morning	230	170	37	795	189
Day	145[b]	91	25	761	176
Night	358[b]	227	29	2692	456
SD/mean HF					
Morning	0.82[b]	0.751	0.498	1.74	0.280
Day	0.636[b]	0.595	0.439	1.35	0.188
Night	0.749	0.674	0.500	1.28	0.196

[a] Statistically significant differences, $P < .001$.
[b] Statistically significant differences, $P < .002$.

Table 4
LF/HF parameters for 3 periods: morning, day, and night

	Mean	Median	Minimum	Maximum	SD
Mean LF/HF					
Morning	5.37[a]	5.17	2.54	10.22	2.25
Day	5.82[b]	6.49	1.61	9.85	2.14
Night	3.73[a,b]	3.16	1.12	8.61	1.99
SD of LF/HF					
Morning	3.43[a]	3.05	1.34	6.82	1.60
Day	3.38[b]	3.47	1.08	5.39	1.29
Night	2.85[a,b]	2.76	0.71	6.7	1.54
SD/mean LF/HF					
Morning	0.64[a]	0.60	0.378	1.36	0.168
Day	0.594[a,b]	0.557	0.396	0.913	0.146
Night	0.766[b]	0.761	0.575	1.11	0.126

[a] Statistically significant differences, $P < .001$.
[b] Statistically significant differences, $P < .002$.