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Peculiarities of male and female heart rate variability

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Abstract. In 118 healthy men and women parameters of wave structure of heart rate at rest in the lying position, during tilt-test and psychoemotional load were determined. In 32 women the registration was realized three times, namely during follicular phase, ovulation and luteal phase of ovarian-menstrual cycle. It was observed that variability of male and female heart rate at rest in the lying position is substantially different due to greater general power of R-R-interval oscillation spectrum in men. In vertical position and under psychoemotional load the decreasing of general spectrum power in women was greater than in men. Also the power reactivity and its distributions in heart rate low frequency range considerably differ in direction and amplitude. Observed during the repeated measurements female lower reproducibility of the parameters of heart rate wave structure can be explained by changes in female organism that depend on ovarian-menstrual cycle.

Keywords: *heart rate variability, tilt-test, psychoemotional load.*

Introduction. It is well known that the heart rhythm is the universal indicator of the organism reaction on the influences of external and internal environment. It contains information about functional human state both under normal and pathologic conditions [9, 12]. Analysis of the heart rate variability can be used in order to estimate vegetative balance, homeostasis self-regulation system. Moreover the high level of heart rate variability also has to be a subject of special analysis for the purpose of elimination of probable heart activity disorders [11, 19].

Papers [4, 5, 8, 10] contains the information about the age and gender changes of some heart rate variability parameters. In Ketel et al [16] investigations, that were realized for randomized group of 149 mean age men and 137 mean age women, was revealed that level of heart rate variability is inversely proportional to age and cardiac rhythm in subjects of both gender. The level of LF is higher in men compared to women. Similar gender and age peculiarities of the wave structure of heart rate were observed in investigations of other researchers, namely, Bai X et al [13] (group of 302 men and 312 women), Aubert et al [12] (653 subjects) and Barrett et al [14] (276 subjects).

Also the significant distinctions exist between reactivity of power of R-R interval length oscillations and arterial pressure in women and in men in case of physical, intellectual and cold loads. It was shown [8] that centralization of mechanism of regulation of cardiovascular system is higher in women while the increasing of the activity of sympathetic chain of vegetative nervous system is more typical for men.

It should be noted that question about gender differences in heart rate variability parameters is not enough studied. Also the manifestation of reactivity of organism characteristics under the different loads is not investigated.

The aim of the investigation is the study of the peculiarities of male and female heart rate variability at rest in the lying position, during tilt-test and psychoemotional load.

Materials and methods. The 118 men and women between 18 and 23 years of age took part in the investigation. The investigation was realized with adherence of the main bioethics condition of Council of Europe Convention on Human Rights and Biomedicine (04.04.1997), World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects (1994-2008). In 32 women the registration was realized three times – during follicular phase (I), ovulation (II) and luteal phase (III) of ovarian-menstrual cycle. Determination of cycle phases was realized by using anamnesis, basal body temperature measuring and set of stream ovulation test "Solo" (IND Diagnostic, Inc. Canada).

In the morning (from 8 to 11 hours) after the 15-minutes rest in the lying position the 5-minuties registration of the electrocardiogram and differential impedance rheogram (rheoanalyser PA-5-01, Kyiv Research Institute of the Radio-Metering Equipments) had been realized. Analogous registration was realized for the case of tilt-test (5 minutes) and under psychoemotional load (10 minutes).

Statistical and spectral analysis of the cardiointervalgram was realized by using the software "CASPICO" (a/s of Ukraine №11262). The power of the spectrum oscillation R-R in the standard frequency ranges: 0-0,04 Hz (VLF), 0,04-0,15 Hz (LF), 0,15-0,4 Hz (HF), 0-0,4 Hz (TP) and normalized power in range 0,15-0,4 Hz (HF_{norm}) were estimated [10]. In order to the investigation of the wave structure detail peculiarities the median spectrogram in this range were drawn (with the step 0,01 Hz) [3]. Psychoemotional load was simulated by 10-minutes neurodynamic testing in feedback mode according to the M.V. Makarenko technique.

On account of the non-normal distribution of most parameters the median and ranges of top and bottom quartiles were estimated. Scattering probability was determined by Wilcoxon paired comparison criteria.

Results and discussion. It should be noted that results of spectral analysis of male and female heart rate at rest in the lying position considerably distinguish. So values of following parameters were higher in men compared to women: LF (781 [426; 1285] ms^2 and 607 [251; 874]ms^2, respectively), HF (1165 [620; 1908] ms^2 and 795 [342; 1564] ms^2, respectively), TP (2816 [1784; 4787] ms^2 та 2143 [1099; 4104] ms^2) with reliably ($p<0,01$). There were no significant gender differences in HF_{norm} та VLF parameters.

In vertical position values of almost all parameters substantially decreased (p<0,001) both in men and women. So VLF became equal 670 [348; 1453] ms^2 ans 512 [313; 937] ms^2, respectively, LF – 932 [487; 1458] ms^2 and 521 [289; 771] ms^2, HF – 266 [128; 577] ms^2 and 192 [108; 344] ms^2, HF_{norm} – 23,9 [14,3; 35,5] ms^2 and 28,5 [20,1; 36,6] ms^2, TP – 2089 [1115; 3358] ms^2 and 1286 [778; 2243] ms^2. Such changes of heart rate variability is related to changing of body position and redistribution of blood to lower extremities. Accordingly the vessel tone rises in order to provide blood return to heart and the acceleration of heart rhythm by activation of sympathetic nervous system is observed. At the same time the heart rate variability decreases [9, 10].

It is interesting that reactivity of several parameters of heart rate was higher in women (p<0,01) in comparison with men. For example value TP changed on -39,98 [-29,19; 45,33] % and -25,8 [-37,5; -29,9] % respectively. Amplitude of LF and HF_{norm} changes was lower (p<0,01) in women compared to men (Table. 1).

Table 1

Reactivity (%) of the parameters of heart rate variability during tilt-test and psychoemotional influence in men and women (median, 25 and 75 percentile)

Parameters	Conditions			
	Tilt-test		Psychoemotional load	
	Men	Women	Men	Women
VLF	-10,5 [-22,2; 17,9]	-12,01 [-16,05; -14,58]	2,4 [-10,9; 19,5]	0,06 [-3,9; -22,96]**
LF	19,3 [14,4; 13,4]	-14,16 [15,37; -11,77]**	17,3 [25,9; 2,2]	-24,63 [19,62; -6,46]**
HF	-77,1 [-79,3; -69,7]	-75,83 [-77,99; -68,27]	-54,4 [-56,8; -46,2]	-68,03 [-60,64; -53,48]**
HFnorm	-60,7 [-71,0; -49,4]	-53,10 [-60,46; -49,51]**	-37,0 [-50,3; -25,7]	-37,89 [-51,36; -26,27]
TP	-25,8 [-37,5; -29,9]	-39,98 [-29,19; -45,33]**	-15,0 [-5,3; -19,7]	-28,42 [-12,41; -44,77]**

Note: ** - p<0,01 during comparison parameters of men and women.

Under psychoemotional load also the changes of heart rate parameters both in men and women were observed. So values of following parameters were higher in men compared to women: VLF – 767 [398; 1472] ms^2 and 582 [359; 845] ms^2, LF – 916 [536; 1314] ms^2 and 458 [300; 818] ms^2, HF – 531 [268; 1027] ms^2 and 254 [134; 727] ms^2, TP – 2394 [1690; 3843] ms^2 and 1534 [962; 2266] ms^2. There were no significant gender differences in HF_{norm} parameter – 37,7 [24,7;53,4] % та 38,3 [24,4;52,2] % respectively. It should be noted that reactivity of heart rate variability parameters under psychoemotional load maintains the gender differences in TP and LF values typical for tilt-test, in HF_{norm} such differences value vanished and in HF - arised (Table 1).

Attention is drawn to the fact that maximal deviation of the reactivity of heart rate variability parameters under load (tilt-test, neurodynamic) is typical for the factors of frequency range from 0,04-0,15 Hz. As a result the detailed analysis of the distribution of power of heart rate waves by normalized spectrogram was realized.

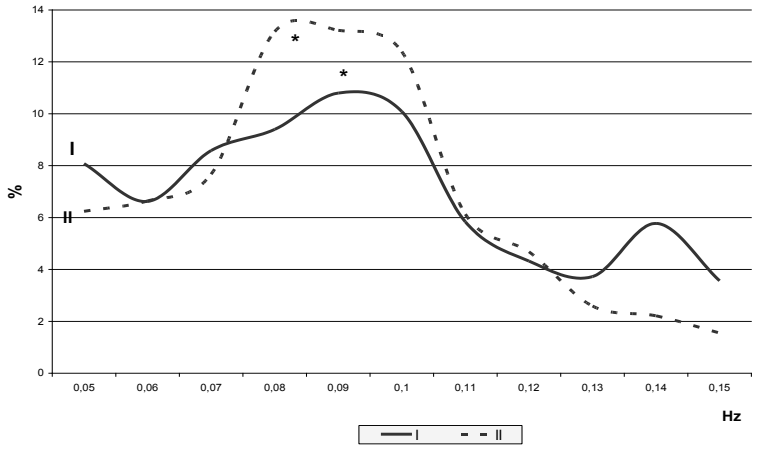

Fig. 1. Normalized median spectrogram of the power of the R-R intervals length oscillations in the range of low frequencies of male and female cardiac rhythm during tilt-test (I – women, II – men; * - p<0,05 during comparison parameters of men and women).

It was shown that male and female normalized spectral intensity in low frequency range during tilt-test has significant differences on 0,08 Hz and 0,1 Hz. The latter fact may indicate that the gender peculiarity of spontaneous baroreflex sensitivity and distinction in wave genesis exists.

At the same time both in men and women the considerable individual peculiarities of heart rate wave structure parameters were observed. In order to investigate stability of such peculiarities the correlation analysis was realized. The measurements with time interval near 40 days for men and 28 days for women were carried out (Table 2). It was defined that at rest, during tilt-test and under psychoemotional load parameters repeatability was higher in men compared to women. An exception was obtained in case of Spearman correlation coefficient for VLF factor. Such results corresponds with other researchers conclusions that heart rate variability is genetic determinate characteristic of human organism [4, 10]. The lower repeatability of heart rate variability in women can be caused by hormonal changes of organism within ovarian-menstrual cycle [2]. Therefore it is appropriate to analyze the parameters of wave structure of heart rhythm separately in different phases of ovarian-menstrual cycle.

There were no significant differences in heart rate variability at rest in lying position in different phases of ovar-

ian-menstrual cycle. At the same time the higher values of HF_{norm} in the phase III in comparison with phase II (65,4 [54,8; 75,0]% and 55,4 [42,6; 68,9]% respectively) and lower aLF (11533 [5449; 23958] $ms^2 \bullet Hz^{-1}$ and 17224 [9769; 26508] $ms^2 \bullet Hz^{-1}$, respectively) were observed. Such results indicate that the level of activation of the parasympathetic branch of vegetative nervous system within the folliculin and luteal phases is higher. During the tilt-test the significant changes of the wave structure of the cardiac rhythm were observed with some peculiarities for the different phases of OMC. So the level of VLF didn't change, LF decreased (with $p<0,05$) from 670 [273; 974] ms^2 to 459 [276; 689] ms^2 in the phase II. With high probability ($p<0,001$) the decreasing of HF, HF_{norm}, TP was observed for all phases. Such changes are typical for such kind of load and connected with dominance of sympathetic chain of vegetative nervous system tone.

Table 2

Correlation coefficients for repeated measurements of the parameters of spectral analysis of male and female heart rate

Parameters	Conditions					
	In lying position		Tilt-test		Psychoemotional load	
	Men	Women	Men	Women	Men	Women
VLF, $мс^2$	0,42	0,50	0,41	0,40	0,46	0,33
LF, $мс^2$	0,72	0,06*	0,58	0,06*	0,76	0,47*
HF, $мс^2$	0,65	0,41*	0,82	0,35*	0,80	0,09*
HFnorm, %	0,69	0,15*	0,64	0,33*	0,79	0,72
TP, $мс^2$	0,37	0,10*	0,19	0,28*	0,76	0,38*

Note: *$p<0,05$ during comparison parameters of men and women

The analysis of the heart rate responsiveness in the case of orthostasis is evidence of the increasing of the power of heart rate low-frequency waves in the luteal phase with the higher probability than for the process of its decreasing in the ovulatory phase. Also in the phase II the significant increasing of the maximum peak in the range 0,04-0,15 Hz (by 60,8%) had been observed.

Under neurodynamic test for different phases of ovarian-menstrual cycle the decreasing of HF, HFnorm, TP was observed ($p<0,001$). Such changes are typical for psychoemotional load and can be explained by significant activation of sympathetic chain of vegetative nervous system. In this case reactivity of LF in phase I (18,1 [-31,6; 75,1] %) differs from value in phase II (-17,6 [-51,7; 50,2] %) and III (-23,9 [-64,6; 69,7] %). Decreasing of HF_{norm} in phase III was lower as compared with phase II and I (-26,6 [-4,3; -10,6] %, -38,3 [-48,9; -21,2] %, -45,0 [-55,9; -20,6] % respectively).

Therefore under neurodynamic load the significant adaptive changes of vegetative regulation in follicular phase were observed. At the same time the lowest reactivity and inhibition of the organism functional state are typical for luteal phase of OMC.

Table 3

Reactivity (%) of the parameters of heart rate variability tilt-test in the different phases of the women biological cycle

Parameter	Phase		
	I	II	III
VLF	-15,8[-49,5; 43,5]	-20,4[-57,5; 25,8]	-8,9[-46,3; 64,8]
LF	-1,4[-35,6; 60,8]	-21,7[-59,2; 29,7]	27,6[-35; 71,8]$^{\#}$
HF	-73,4[-88,7; -53,5]	-70,8[-85,5; -51,3]	-73,3[-83,4; -45,2]
HFnorm	-56,5[-65,9; -39,2]	-50,8[-60,6; -34,3]	-49,3[-64,3; -40,9]
TP	-38,7[-59,5; 0,0]	-41,3[-71,2; 7,3]	-35,7[-52,6; 32,5]

Note. * - $p<0,05$ in comparison with the parameters of phase I; $^{\#}$ - $p<0,05$ between phases II and III

Privci T. et al [20] maintain that analysis of cardiointervals is more useful to the observation of small variations of heart rate variability activity during menstrual cycle than typical parameters such as cardiac rhythm and arterial pressure. However the results of the investigation of heart rate changes during menstrual cycle still remain questionable. It should be noted that phase of ovarian cycle has an effect on heart rate variability in women of childbearing aged both at rest and under psychoemotional load [7]. Accordingly to [5] the increasing of the activity of sympathetic division of vegetative nervous system at rest during luteal phase in comparison with follicular phase was observed by analysis of the parameters of heart rate variability. However in [15] were no distinctions between parameters of wave structure of arterial pressure and cardiac rhythm

It was found [17] that spontaneous baroreflex sensitivity increases during the luteal phase compared with follicular phase (in 10 healthy women).

Conclusions

1. The value of heart rate variability of male and female heart rate at rest in the lying position is substantially different due to greater general power of R-R-interval oscillation spectrum in men. In vertical position and under psychoemotional load the decreasing of general spectrum power in women was greater than in men. Also the power reactivity and its distributions in heart rate low frequency range considerably differ in direction and amplitude.

2. Observable female lower reproducibility of the parameters of heart rate wave structure may be explained by changes in female organism that depend on ovarian-menstrual cycle.

3. There were no significant differences in heart rate variability at rest in lying position in different phases of ovarian-menstrual cycle; during tilt-test and psychoemotional load the highest changes of parameters of heart rate wave structure correspond to luteal phase.

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Коваленко С.А., Кудий Л.И., Луценко Е.И. Особенности вариабельности сердечного ритма у мужчин и женщин

Аннотация. Проводили измерения показателей волновой структуры сердечного ритма у 118 здоровых молодых мужчин и женщин в покое лёжа, при ортопробе и психоэмоциональной нагрузке. У 32 женщин регистрации осуществлялись трижды - в фолликулиновую, овуляторную и лютеиновую фазы овариально - менструального цикла. Значения вариативности сердечного ритма у мужчин и женщин в покое лежа существенно отличались за счет большей общей мощности спектра колебаний интервала R-R у мужчин. При переходе тела в вертикальное положение и психоэмоциональной нагрузке снижение общей мощности спектра у женщин было больше чем у мужчин, а реактивность мощности и ее распределение в диапазоне низких частот сердечного ритма существенно отличались как по направлению так и по амплитуде. Определена более низкая воспроизводимость показателей волновой структуры сердечного ритма при повторных измерениях у женщин, по сравнению с мужчинами, что может быть обусловлена изменениями в их организме на фоне овариально - менструального цикла. Так показатели волновой структуры сердечного ритма в покое лежа у женщин в различные фазы овариального цикла в основном не отличалась; при ортопробе и психоэмоциональной нагрузки самые большие их изменения происходили в лютеиновой фазе.

***Ключевые слова**: вариабельность сердечного ритма, ортопроба, психоэмоциональная нагрузка*