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DYNAMICS OF HEART RATE VARIABILITY UNDER THE INFLUENCE OF COURSE YOGA BREATHING EXERCISES ON HEALTHY YOUNG PEOPLE

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ABSTRACT

Introduction: Heart rate variability is a highly informative non-invasive method of research not only for the functional state of the cardiovascular system and also for the integrative regulatory activity of the autonomic nervous system. The positive effect of diaphragmatic breathing is positive in the mode of biological feedback using portable devices, but there is little evidence of the use of yoga breathing gymnastics in order to influence the heart rate variability.

The aim: To compare the possibilities of using courses of breathing gymnastics of yogis and diaphragmatic breathing sessions in the mode of biological feedback using a portable device.

Materials and methods: The study involved 70 practically healthy foreigners, who were divided into 2 groups of 35 people. Participants of the 1st group daily engage in respiratory exercises pranayama for 15 minutes in 1 month. Participants in the 2nd group used the MyCalmBeat portable device. Heart rate variability was registered by using the computer diagnostic complex "CardioLab" ("KhAI-Medika", Ukraine).

Results: In both groups there was similar dynamics of heart rate variability indices, but its severity was different. The common integral effect was a significant growth of heart rate variability both according to statistical and spectral indicators – total power increased, as well as high-frequency component. The power of the very-low frequency waves has probably decreased only in the group with the device. In the percentage structure of the cardiac rhythm spectrum, the specific weight of very-low frequency component and the percentage of high-frequency component increased.

Conclusions: Respiratory gymnastics yoga for 15 minutes daily contributes to the growth of heart rate variability through the suppression of the central link (very-low frequency component) of regulation of cardiac rhythm and increased activity of parasympathetic influences (high-frequency component), as well as the redistribution of regulatory activity of the central nervous system between the central and peripheral links of regulation of the cardiac rhythm in favor of the latter.

KEY WORDS: heart rare variability, yoga, diaphragmatic breathing, biological feedback

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INTRODUCTION

It is known that the regulation of cardiac rhythm and respiration is closely linked to physiological processes, the coordination of which is an important condition for the adaptation of the human body to metabolic needs [1]. It manifests itself as a sinus respiratory arrhythmia - physiological fluctuations in the duration of the heart cycle associated with respiratory periodicity. When inhaling, the acupuncture part of the autonomic nervous system is activated, and when exhaled, on the contrary, the tone of the parasympathetic link of the autonomic nervous system increases. It is alternate activation of the autonomic nervous system units that causes dynamic changes in the heart rate from acceleration to slowing it down. These variations of heart rate contribute significantly to the overall heart rate variability, in particular in the high frequency region of its spectrum in the range of 0.15-0.4 Hz (HF). Therefore, the spectral energy of the heart rate variability curve in this frequency range is usually used as a non-invasive indicator of the activity of the parasympathetic chain of the autonomic nervous system [2,3]. According to many authors, a large heart rate variability is associated with an increase in the adaptive capacity of a person and has a positive effect on the course of various diseases and pathological conditions, such as stress, depression, autonomic dysfunction, bronchial asthma, etc.

According to a number of studies, the severity of respiratory sinus arrhythmia positively correlates with the tone of the parasympathetic link of the autonomic nervous system and is capable of modulating the psycho-physiological responses to mental stressors, as well as correcting a large number of pathological conditions and diseases. Therefore, the search for non-invasive methods of influencing the functional state of the autonomic nervous system seems physiologically grounded.

In recent years, special interest in this context is respiratory gymnastics. Deep breathing, which is consistent with the natural fluctuations of the heart rate, can substantially enhance both respiratory sinus arrhythmia and general heart rate variability [2,3,4]. Proved positive effect has diaphragmatic breathing in the mode of biological feedback using portable devices. However, there is little data of using yoga breathing gymnastics in order to influence the heart rate variability. With the development of civilization, the rhythm of life accelerated and breathing became consistent with him. The doctrine of yogis argues that nature has defined the number of respiratory cycles for each person and the more often it breathes, the earlier it dies. A slow, deep breath, on the contrary, lengthens it. Therefore, yogis consider only deep and rhythmic breathing as our ancestors breathed [5].

THE AIM

Compare the possibilities of using the courses of breathing gymnastics of yogis and diaphragmatic breathing sessions in the mode of biological feedback using a portable device.

MATERIALS AND METHODS

The study involved 70 healthy young men aged 18 to 25 years old, who were randomly divided into 2 groups of 35 people. All participants in the experiment did not complain about their health, had no deviations from the norm according to the data of the medical examination and professionally not engaged in sports and yoga. Participants of the first group daily engage in respiratory exercises of pranayama for 15 minutes (3 periods of 5 minutes, separated by 3 spontaneous breathing cycles) within one month. Participants in the second group used a portable biological feedback device MyCalmBeat, which after calculating the individual optimal respiratory rate on the basis of free breathing and pulse detection within 15 minutes provided the appropriate instructions for the beginning of inhalation and exhalation on the screen of the smartphone.

Heart rate variability was registered by using the computer diagnostic complex "CardioLab" ("KhAI-Medika", Ukraine). In particular, the mean square deviation of the duration of cardiointervals (SD, ms), which characterizes the total heart rate variability, is the square root of the mean square of the differences in the values of successive pairs of cardiointervals (RMSSD, ms), reflecting the influence of the parasympathetic link of the autonomic nervous system and the activity of the peripheral links of it - the number of consecutive pairs RR intervals with a duration of more than 50 ms (pNN50). Also the following spectral parameters of heart rate variability such as TP (ms^2), were determined - total energy of the heart rate spectrum, reflecting the total influence on the cardiac rhythm of all regulatory systems; HF (ms^2) is a high-frequency component of the heart rhythm spectrum in the range of 0.15-0.4 Hz, which mainly reflects the vagal effect on the heart rhythm associated with breathing; LF (ms^2) is a low-frequency component of the heart rhythm spectrum in the range of 0.04-0.15 Hz, which mainly reflects the effect of the sympathetic autonomic nervous system on the heart rhythm, including - activity of the vascular motor center and VLF (ms^2) - very-low frequency component of the heart rhythm spectrum in the range 0,003-0,04 Hz, reflecting the total activity of the supersonic sections of the nervous system and neurohumoral effects on the heart rhythm. In addition, the sympathetic-parasympathetic balance (LF/HF) and the percentage contribution of each of the frequency components of the spectrum in TP (HF%, LF% and VLF%) were calculated.

The obtained numerical data were processed by methods of variation statistics using Student's criterion. The dynamics of the heart rate variability indices were estimated by using the paired comparisons, and intergroup differences were determined using a single-factor dispersion analysis.

RESULTS

To assess the effect of deep diaphragmatic breathing, both in the breathing gymnastics of yoga, and in the mode of biological feedback on the heart rate variability index, 2nd ECG withdrawal was recorded in all subjects under investigation using the computer diagnostic complex "CardioLab" ("KhAI-Medika ", Ukraine) in a position lying after a 10-minute adaptation to the conditions of registration. As background indicators data from the last 5 minutes of registration were used. Subsequently, during the course of a month, a session of respiratory gymnastics lasted for 15 minutes, which included 3 periods of 5 minutes, during which the subjects performed 5-6 respiratory cycles per minute. Each period was completed by 3 spontaneous breathing cycles. The participants of the second group followed the instructions of the portable biological feedback device once daily and adjusted the withdrawal ratio of inhalation and exhalation. In both cases, after completing a 30-day course of diaphragmatic breathing, ECG was continued for 5 minutes. The efficacy of diaphragmatic breathing in both cases was evaluated by comparing the first and second 5-minute intervals. The results are shown in the table I.

In both groups there was similar dynamics of heart rate variability indices, however, its severity was different. The overall integral effect was a significant increase in heart rate variability, both in terms of statistical and spectral indices - in particular TP increased (total energy of the heart rate spectrum (CR) in both groups by 927 ± 231 ms^2 ($p<0.01$ MyCalmBeat) and 835 ± 154 ms^2 ($p<0.05$ respiratory gymnastics) .This was mainly due to the increase of the HF index by 993 ± 198 cm^2 ($p<0.05$ MyCalmBeat) and 784 ± 173ms^2 ($p<0.05$ respiratory gymnastics).The power of the ultrasonic waves of the VLF band decreased significantly only in the group with the device at 252 ± 33 ms^2 ($p<0.05$), while LF has not statistically significantly changed. In the structure of the cardiac rhythm spectrum, the specific gravity of VLF% decreased by 10.7 ± 1.8% ($p<0.05$) in the group with the device and by 5.8 ± 2.6% ($p<0.05$) in the group, yoga, etc. It is commonly believed that the increase in this index and its specific gravity in the cardiac rhythm

Table I. Dynamics of HRV indices under the influence of the course of yoga breathing gymnastics and in the mode of biological feedback by using the portable device MyCalmBeat

Indexes	First group (Yoga breathing gymnastics) n=35		Second group (MyCalmBeat) n=35	
	Background	After a training course	Background	After a training course
SDNN, ms	61± 6,5	72,3±2,6*	59,3± 7,2	70,1±2,3*
RMSSD, ms	43± 2,4	44,9±1,8*	45,1± 2,2	46,8±1,7*
pNN50, %	22± 1,5	26,2±1,8	20,7± 1,6	25,2±1,6*
TP, ms 2	3601± 245	4436±218*	3594± 245	4521±207**
HF, ms 2	797± 117	1581±142*	815± 113	1808±119*
LF, ms 2	1451 ± 212	1442±209	1462 ± 201	1617±187
VLF, ms2	1353± 121	1413±135	1348± 134	1096±113*
LF\HF	1,82± 0,1	0,91±0,05*	1,79± 0,1	0,89±0,05**
HF,%	22,1±1,6	35,6±1,4*	22,7±1,5	39,9±0,9*
LF,%	40,3±2,9	31,8±3,7*	40,7±2,6	35,7±2,5
VLF,%	37,6±3,1	32,6±0,7*	36,6±2,0	24,4±1,1*

* - statistically significant difference compered to background index p <0,05

** - statistically significant difference compered to background index p <0,01

spectrum (VLF%) means "centralization" of heart rate control and is a sign of reducing the adaptive capacity of the body. The data obtained suggest that the 30-day A training course using deep diaphragmatic breathing reduces VLF and VLF% against the background of the overall heart rate variability growth. This indicates the redistribution of the autonomic nervous system activity in favor of its peripheral divisions and therefore means an increase in the regulatory reserve of the organism. Also the sympathetic-parasympathetic balance of LF/HF decreased by 0.83 ± 0.12 ($p<0.01$ MyCalmBeat) and 0.77 ± 0.16 ($p<0.05$ respiratory gymnastics). Such dynamics of heart rate variability indices can be interpreted as enhancement of the tonus of the parasympathetic link of the autonomic nervous system with simultaneous reduction of upersegmental regulation of the cardiac rhythm from the higher vegetative centers and humoral mechanisms.

DISCUSSION

By comparing the integral effect on heart rate variability of yoga breathing exercises and diaphragmatic breathing using the MyCalmBeat handheld device according to SD and TP it can be noted that it was more pronounced in the group that worked with this device and smaller in the second group, the participants which was used for respiratory gymnastics (see Table I). The mechanism of the positive influence of deep diaphragmatic breathing on the physiological state of the organism is seen in the redistribution of the activity of the peripheral parts of the autonomic nervous system in favor of the parasympathetic link, which manifests itself in increasing the overall heart rate variability and parasympathetic indexes [6,7]. The findings confirm these beliefs as evidenced by the likely increase in SD and TP in both groups.

In conditions of relatively slow diaphragmatic breathing, whose frequency (5-7 respiratory movements per minute) is close to the low-frequency range of the heart rate rhythm LF (0.1 Hz), the LF index does not reflect the activity of the sympathetic link, but the coordination of the baroreceptor reflex with the frequency of respiration and cardiac rhythm The frequency of breathing at which this agreement is achieved is called the resonant frequency (term proposed by Lehrer) [8]. It is shown that during a long breath (within about 5 seconds), due to the activation of the sympathetic link of the autonomic nervous system, the cardiac rhythm accelerates, while the activation of baroreceptors stimulates the heart rhythm in order to prevent the reduction of blood pressure. During exhalation processes develop in the opposite direction. Reducing the volume of the chest creates a tendency to increase blood pressure, reduces impulse from the baroreceptors and reflexively activates the parasympathetic link, decreasing the heart rate [9, 10]. This explains why during respiration with the resonant frequency, heart rate variability increases. Exact synchronization of the cardiovascular, respiratory and autonomic nervous system creates a state of physiological coherence. The use of portable electronic biological feedback devices allows a person to visually observe the coherence of these systems during training and make the necessary adjustments to patterns of their own breathing. However, in the absence of a portable device, it is possible to regulate the functional state of the autonomic nervous system by breathing gymnastics of yoga, which is also based on deep diaphragmatic breathing.

CONCLUSIONS

Respiratory gymnastics yoga for 15 minutes contributes to the growth of heart rate variability through the suppression of the central link (VLF) of regulation of cardiac rhythm and increased activity of parasympathetic influences (HF), as well as the redistribution of regulatory activity of the central nervous system between the central and peripheral links of regulation of the cardiac rhythm in favor of the latter. This technique can be used in the absence of portable devices for visualizing heart rate variability in order to improve it.

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