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EFFECT OF TWO SELECTED YOGIC BREATHING TECHNIQUES ON HEART RATE VARIABILITY

P. RAGHURAJ, A. G. RAMAKRISHNAN*, H. R. NAGENDRA AND SHIRLEY TELLES**

Vivekananda Kendra Yoga Research Foundation,
19, K.G. Nagar,
Bangalore – 560 019

and

**Department of Electrical Engineering,*
Indian Institute of Science,
Bangalore – 560 012

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Abstract : The heart rate variability (HRV) is an indicator of the cardiac autonomic control. Two spectral components are usually recorded, viz. high frequency (0.15–0.50 Hz), which is due to vagal efferent activity and a low frequency component (0.05–0.15 Hz), due to sympathetic activity. The present study was conducted to study the HRV in two yoga practices which have been previously reported to have opposite effects, viz, sympathetic stimulation (kapalabhati, breathing at high frequency, i.e., 2.0 Hz) and reduced sympathetic activity (nadisuddhi, alternate nostril breathing). Twelve male volunteers (age range, 21 to 33 years) were assessed before and after each practice on separate days. The electrocardiogram (lead I) was digitized on-line and off-line analysis was done. The results showed a significant increase in low frequency (LF) power and LF/HF ratio while high frequency (HF) power was significantly lower following kapalabhati. There were no significant changes following nadisuddhi. The results suggest that kapalabhati modifies the autonomic status by increasing sympathetic activity with reduced vagal activity. The study also suggests that HRV is a more useful psychophysiological measure than heart rate alone.

Key words : heart rate variability high frequency breathing alternate nostril breathing autonomic status

INTRODUCTION

Ancient yogic texts have described a rapid breathing cleansing practice (kapalabhati) as stimulating, and slow regulated breathing, particularly through alternate nostrils (nadisuddhi pranayama) as calming (1). These descriptions have been substantiated by scientific studies. Kapalabhati was found to cause "autonomic activation". This was observed as an immediate effect during three contiguous

**Corresponding Author

sessions of 5 min each, in terms of an increased heart rate and systolic blood pressure during kapalabhati (2). In contrast, nadisuddhi pranayama practised for four weeks, caused decreased heart rate, as well as systolic and diastolic blood pressure levels (3).

The heart rate is controlled by neural as well as other factors (4). Hence a decrease in heart rate may be related to an increase in vagal tone, a decrease in cardiac sympathetic activity, as well as other, non–autonomic factors. In contrast, the heart rate variability (HRV) spectrum has been established as a probe of beat–to–beat autonomic control (5). The influences of the sympathetic and parasympathetic innervation on modulation of the heart rate are quantified by the power of the heart rate variability spectrum in specific frequency bands. Hence the present study aimed at analyzing the heart rate variability spectrum related to the practice of both kapalabhati and nadisuddhi pranayama to get a better understanding about the immediate effects of these practices on the autonomic status.

METHODS

Subjects : They were 12 normal, healthy male volunteers in the age range of 21 to 33 years (mean±SD, 25.6 ± 3.1 years) who were familiar with both kapalabhati and nadisuddhi practices and had experience of the practices ranging from 6 months to 3 years (group average experience, 19.7 ± 12.8 months).

Design of the study : Recordings were made on separate days for the two different practices, maintaining the same time of recording of the day for each subject. The subject was seated in a dimly lit, sound attenuated chamber. Recordings, each lasting 5 min, were obtained before as well as immediately after each practice. The subject was seated in a comfortable sitting posture with the back straight, for both practices. The practices were performed at least 3 hours following the last meal.

Parameters studied: The electrocardiogram was recorded using standard bipolar limb lead I configuration and an AC amplifier with 1.5 Hz high pass filter and 75 Hz low pass filter setting (Medicaid, Chandigarh, India). The ECG was digitized using a 12 bit analog–to–digital convertor (ADC) at a sampling rate of 500 Hz and stored on the hard disk of a PC / AT 486 system COMPTECH (Bangalore, India) for analysis (6). The R waves were detected to obtain a point event series of successive R–R intervals, from which the beat to beat heart rate series was computed. The data recorded were visually inspected off–line and only noise free data were included for analysis.

Frequency domain analysis : The mean values were removed from the heart rate series to obtain the HRV series. The HRV power spectrum was obtained using fast Fourier transform analysis (FFT). The energy in HRV series of the following specific frequency bands was studied, viz, the very low frequency component (0.0–0.05Hz), low frequency component (0.05–0.15 Hz, and high frequency component (0.15–0.50 Hz). The low frequency and high frequency values were expressed as normalized units (7).

Yoga practices : For the practice of rapid yoga breathing (kapalabhati), the subject was instructed to inhale deeply and start exhaling forcibly at the rate of 120 breath cycles per min (2.0 Hz frequency). The rapid active exhalations are accomplished by rapid, forceful movements of the abdomen followed by passive, effortless inhalation. The duration of practice was prescribed as 1 min (8). Alternate nostril breathing (nadisuddhi pranayama) starts with exhalation through both nostrils, followed by closing the right nostril with the thumb of the right hand and inhaling slowly through the left nostril. After complete inhalation, the left nostril is closed with the little and ring fingers of the right hand followed by opening the right nostril and exhaling through it. The subject next inhales through the right nostril and then exhales through the left nostril. This forms one round of nadisuddhi pranayama. This was continued for fifteen minutes, which is the recommended duration of practice (8).

Statistics : The values of derived parameters obtained before the practices and the ones obtained after the practices were compared using the t–test for paired data.

RESULTS

After kapalabhati, there was a significant reduction in high frequency power and an increase in low frequency power expressed in normalized units compared to the 'pre' value (P<0.01, paired 't' test in both cases). This contributed to a significant increase in low frequency/high frequency power ratio (P<0.05, paired 't' test, one tailed) following kapalabhati practice (Fig 1). Following nadisuddhi pranayama, there was no significant change, though a non–significant trend towards increase in high frequency power and low frequency power was observed (Fig 2). The baseline low frequency power value before nadisuddhi was higher than before kapalabhati (P<0.05). However, the baseline high frequency power before nadisuddhi was lower than that before kapalabhati (P<0.05).

The heart rate did not show a significant change after either practice. The group average values±SEM are given in Table I.

TABLE I : Heart rate variability spectral components measured pre and post high frequency (kapalabhati) and alternate nostril (nadisuddhi) breathing. Values are group mean ± SEM.

Practice	*Low frequency Power (n. units)*		*High frequency Power (n. units)*		*Low frequency/ High frequancy*	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
Kapalabhati (n = 12)	35.4 ± 3.0	50.7 ± 6.8**	64.2 ± 3.0	49.3 ±6.8**	0.6 ±0.1	1.5 ± 0.5*
Nadisuddhi (n = 12)	49.3 ± 4.2	40.8 ± 6.9	49.9 ± 4.1	61.2 ±6.6	1.3 ±0.3	1.3 ± 0.6

*P<0.05, **P<0.01, post versus pre, t–test for paired data.

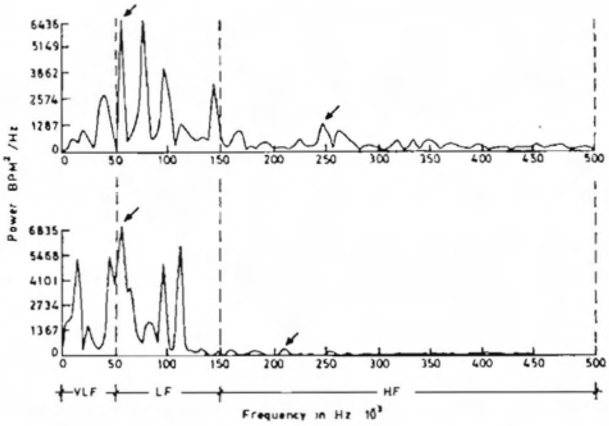

Fig. 1:Sample records of heart rate variability spectrum made before (upper record) and after (lower record) kapalabhati in a single subject (VN/31/M). The vertical axis gives the power values in BPM²/Hz. The two vertical dotted lines separate the three frequency components, viz very low frequency (VLF), low frequency (LF) and high frequency (HF). The arrows indicate the highest peak in each range. The present record shows an increase in low frequency power and a decrease in high frequency power following kapalabhati, even though the actual scales (on the vertical axis) are different for the two records.

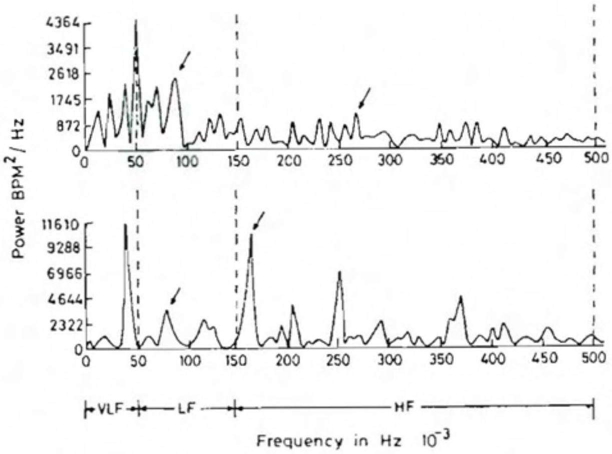

Fig: 2: Sample records of heart rate variability spectrum made before (upper record) and after (lower record) nadisuddhi pranayama in a single subject (VN/31/M). The details of the records are the same as for Fig 1. The present record shows an increase in high frequency power as well as a smaller increase in low frequency power following nadisuddhi pranayama, even though the actual scales (on the vertical axis) are different for the two records.

DISCUSSION

In the present study, following the practice of very rapid yoga breathing, there was an increase in the low frequency power, decrease in the high frequency power and an increase in the low frequency/high frequency power ratio (Table I). There was no significant change following nadisuddhi pranayama. Also, the mean heart rate did not change following either practice. There were baseline differences between low and high frequency power values for the two sessions.

The low frequency band (0.05–0.15Hz) of the heart rate variability spectrum is thought to correspond to sympathetic modulation, especially when expressed as normalized as opposed to absolute units (7). The representation of low frequency and high frequency energy values in normalized units expresses the degree of control exerted and the relative balance of the two branches of the autonomic nervous system. The efferent vagal activity is a major contributor to the high frequency band (0.15–0.50Hz). The low frequency/high frequency ratio is correlated with the sympathovagal balance (9).

Hence the present results suggest that the practice of kapalabhati shifts the sympathovagal balance towards sympathetic activation. Following nadisuddhi pranayama, the change is not as clear, though there appears to be an increased activation of both components.

The differences in baseline values could not be explained. Recordings of kapalabhati and nadisuddhi on each subject were made on separate days at the same time of the day. There was no fixed order for the two types of sessions on different days. However, at the start of each session, subjects were told the practice which was to the tested on that day. It is not known whether this influenced their baseline levels of autonomic activity. In order to understand the contribution of the differences in baseline values to the nature of change following either practice, separate calculations were made as described below. The percentage change in the five *lowest* values of the baseline low frequency (LF) component preceding kapalabhati and the five highest baseline LF values preceding nadisuddhi were calculated. Following kapalabhati, the percentage change was 8.9% for these 5 values. Since the average percentage change for the LF component of the 12 subjects was 43.2%, this suggested that the baseline *low* values of the LF component preceding kapalabhati did not correlate with the increase in this component following the practice. In contrast, following nadisuddhi for the 5 subjects with *highest* LF values preceding the practice, the percentage change was 45.3% (decrease). Since the average percentage change for the LF component of the 12 subjects was 15.5% (decrease), this suggested that the baseline high values of the LF component preceding nadisuddhi was correlated with the decrease in this component following the practice.

While attempting to explain the mechanisms underlying the changes, the respiratory sinus arrhythmia has to be taken into account. At typical respiratory frequencies near 0.20Hz (12 breath cycles per minute), the heart rate increases simultaneously with inspiration (10). Most investigators have found that cardiac vagal efferents are involved in mediating the heart rate fluctuations that occur with respiration at this frequency. It was also observed that the modulation of cardiac sympathetic efferents also plays a role in generating respiratory sinus arrhythmia at lower respiratory frequencies below 0.15Hz (9 breath cycles per min). Separate polygraph recordings of respiration showed that the breath rate values before and after kapalabhati as well as before and after nadisuddhi practice were in the range of 0.20–0.26Hz (11). Within this frequency, the respiratory sinus arrhythmia is correlated with vagal activity. Hence the increase in cardiosympathetic tone following kapalabhati is probably due to other factors. In response to variations in breathing patterns a number of central and autonomic nervous system mechanisms as well as mechanical (heart) and haemodynamic adjustments are triggered, thereby causing both tonic and phasic change in cardiovascular functioning (12).

An association between high frequency breathing and cardiovascular sympathetic activation was demonstrated in an earlier study (2) which reported an increase in heart rate and systolic blood pressure following the practice. However there are two main differences between the present study and the earlier one. In the previous study, there was no change in the frequency components of the heart rate variability spectrum, while the heart rate increased. These changes were reported during the practice, whereas in the present study, the effects reported apply to the period immediately after the practice. The differences may also be related to the fact that subjects of the earlier study practiced kapalabhati for three 5 minute periods, whereas in the present study the duration of practice was 1 minute in keeping with yoga texts (8).

The absence of change following nadisuddhi pranayama, compared to the earlier report (3), could be due to the fact that the earlier study described baseline changes after 4 weeks of practice, whereas in the present study, the immediate effect was assessed.

This difference between the factors determining the changes in heart rate versus changes in the heart rate variability spectral components is already known (4). Additional factors influence the heart rate compared to the HRV. Since the heart rate variability spectral components are determined by the autonomic nervous system, measurement of the heart rate variability may have greater application in assessing autonomic status than recording of heart rate alone. This application has been highlighted in the present study.

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