AUTONOMIC RESPONSES TO BREATH HOLDING AND ITS VARIATIONS FOLLOWING PRANAYAMA

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Summary : Autonomic responses to breath holding were studied in twenty healthy young men. Breath was held at different phases of respiration and parameters recorded were Breath holding time, heart rate systolic and diastolic blood pressure and galvanic skin resistance (GSR). After taking initial recordings all the subjects practised Nadi-Shodhana Pranayama for a period of 4 weeks. At the end of 4 weeks same parameters were again recorded and the results compared. Baseline heart rate and blood pressure (systolic and diastolic) showed a rendency to decrease and both these autonomic parameters were significantly decreased at breaking point after pranayamic breathing. Although the GSR was recorded in all subjects the observations made were not conclusive. Thus pranayama breathing exercises appear to alter autonomic responses to breath holding probably by increasing vagal tone and decreasing sympathetic discharges.

Key words : pranayama breaking point heart rate blood pressure (BP) galvanic skin reflex (GSR) breath holding time (BHT) electrocardiogram (ECG) sympathetic parasympathetic

INTRODUCTION

The Yogic discipline of Pranayama is claimed to have a toning effect on cardio-respiratory system (12, 16) and creates an equilibrium between psychic and somatic aspects of bodily functions (1, 16). Some Yogis practising pranayama are able to stay in closed chambers for a long perićd and can alter the cardiac rhythm (1, 2, 3, 22). Pranayama has been shown to improve the vagal tone and decrease sympathetic activity (9, 15). Various other workers have also recorded significant variations in different autonomic parameters and improved cardio-respiratory efficiency following pranayamic breathing exercises (5, 6, 8, 9-13, 16-21, 23). The present study is an attempt to observe the changes in heart rate, B. P.,

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G.S.R. and Breath holding time during breath-holding before and after pranayamic breathing exercises.

Breaking point after voluntary breath holding is reached when the ventilatory drive exceeds the cortical inhibition of ventilation exerted wilfully by the subject. Breath-holding is a stress and will induce autonomically invoked cardiovascular responses. It is possible that the practice of 'Pranayama' beneficially alters the autonomic drive during a breath-hold and this may be reflected as an alteration in the cardiovascular function, breath-holding time and in the galvanic skin response (GSR). The present stuny investigates this hypothesis.

MATERIAL AND METHODS

Ten young male subjects (19-28 years) participated in this study. All of them were healthy and non-smokers. During the period of this study, the subjects did not undertake any other physical activity, such as sports or athletic training. Recordings were made during morning hours with the subject sitting in an arm chair in an air conditioned room. After reassurance, the procedure of breath holding was explained to the subject. In relaxed state, baseline, heart rate, ECG, Breath holding times and GSR were recorded and recording was continued throughout the procedure on a 4-channel polyrite (Medicare). Baseline blood pressure was recorded by the auscultatory method.

The subject was then told to hold breath till the breaking point was reached and then let go, avoiding any extraneous movements. All parameters were recorded again at breaking point. The subject was made to hold the breath after normal inspiration, normal expiration, deep inspiration. deep expiration, and finally after deep inspiration preceded by hyperventilation for 5 times over a period of 15 seconds. Readings of different parameters were taken thrice at each phase.

After initial recordings all subjects were put through daily practice of "Nadi Shodhana Pranayama" (16) for 30 minutes daily for 4 weeks, in a group session, avoiding any spirit of competitiveness. Subjects practised at the same hour daily after bowel, bladder evacuations, on empty stomach. They were asked to assume Padmasana (Lotus posture), keep the spine erect and immobile and regulate the alteration of breathing as follows :—

Open the right hand and bend index and middle fingers against the palm. The thumb is used for closing the right nostril while 4th and 5th fingers are used for the left nostril.

Place the right thumb against the ala at the end of the nostril to close it. Similarly press the 4th and 5th finger-tips against the left nostril.

Next begin the exercise in the usual posture, with relaxed attitude, Concentrate,

1. Exhale slowly and deeply without closing the nostrils but be ready to do so.
2. Inhale slowly and quietly through the left nostril while closing the right.
3. At the end of the inhalation close both nostrils. Hold the breath for not more than 1-2 seconds.
4. Keep the left nostril closed and exhale through the right as quietly as possible.
5. After exhaling completely, inhale slowly and quietly through the right nostril.
6. Close both nostril and wait for a second, then open the left nostril and exhale slowly and silently.
7. Inhale through the same nostril and continue.

Initially there was no attempt to establish a ratio of inspiration and expiration but later they were made to practice "Bhastrika" (accelerating the rhythm without reducing volume of air inhaled keeping forced inspiration and expiration of equal length, glottis being kept open) (14). The recordings of various parameters were again repeated thrice at each phase of respiration as done prior to the training. The mean values of various parameters before yoga training were compared with the mean values of the same parameters after training (both baseline and at "breakpoint") using paired 't' test. P values of < 0.05 was considered significant. Similarly the changes produced by breath-holding at break point for the various parameters in the pre-and post-yoga training phases were also compared. Each subject acted as his own control.

RESULTS AND DISCUSSION

The results have been presented in Tables 1, 2a, 2b and 3, and a typical reconrding has been shown in Fig. 1.

TABLE I : Mean value and chance in Heart Rate breaking point in Subject Practising Pranayama (Beats/Min).

N=10	*Baseline resting*	*Normal inspiration*	*Normal expiration*	*Deep inspiration*	*Deep expiration*	*Hyper-ventilation*
Before Pranayama	70.8 ±10.16	68.8 ±11.31	68.8 ±10.37	73 6 ±10.78	74.0 ±13.13	75.2 ±9.57
Change from baseline HR.		−2.2	−2.0	+2.8	+3.2	+4.4
After Pranayama	70.4 ±7.351	66.6* ±9.4	66.0*** ±11.03	72.4*** ±9.78	69.4** ±10.91	73.2*** ±8.06
Change from baseline HR.		−3.8**	−4.4***	+2.0**	−1.0**	+2.8***

Values are Mean±S.E. *=P<0.05 **=P<0.01 ***=P<0.001

− indicates decrease from baseline HR
+ indicates increase from baseline HR

TABLE II (a) : Mean value in blood pressure at breaking point in Subjects Practising Pranayama (mm Hg.).

N=10	*Basal resting*	*Normal inspiration*	*Normal expiration*	*Deep inspiration*	*Deep expiration*	*Hyper-ventilation*
SYSTOLIC						
Before Pranayama	120.4 ±8.36	136.1 ±12.54	138.97 ±11.59	143.9 ±12.70	145.29 ±13.05	154.31 ±23.82
After Pranayama	111.6** ±7.10	125.25* ±11.4	125.9** ±13.49	138.07** ±17.67	131.14** ±12.27	136.7** ±18.18
DIASTOLIC						
Before Pranayama	73.2 ±6.05	78.37 ±10.32	81.24 ±16.05	79.09 ±9.69	79.14 ±8.82	83.21 ±10.17
After Pranayam	68.04* ±5.8	75.44*** ±5.78	74.31** ±10.23	72.72*** ±8.71	76.63** ±8.21	75.44*** ±7.73

Values are Mean±S.E. *=P<0.05 **=P<0.01 ***=P<0.001

TABLE II (b) : Mean changes in Systolic and Diastolic Blood Pressure at breaking point in Subjects Practising Pranayama (mm Hg.)

N=10	*Normal inspiration*	*Normal expiration*	*Deep inspiration*	*Deep expiration*	*Hyper-ventilation*
SYSTOLIC					
Before Pranayama	+15.7	+18.5	+23.5	+24.9	+33.91
After Pranayama	+13.6**	+14.3**	+26.4**	+19.54**	+25.1**
DIASTOLIC					
Before Pranayama	+5.17	+8.04	+5.89	+5.94	+10.01
After Pranayama	+7.04*	+5.91**	+4.32**	+8.23**	+7.04***

Values are mean change from baseline.
+ indicates an increase.
*=P<0.05 **=P<0.08 ***=P<0.001

TABLE III : Effect of Pranayama Training on Breath Holding time (in seconds)

N=10	*Normal inspiration*	*Normal expiration*	*Deep inspiration*	*Deep expiration*	*Hyper-ventilation*
Before Pranayama	33.87 ±8.11	31.11 ±5.86	73.31 ±22.6	40.64 ±21.80	96.47 ±30.93
After Pranayama	42.82* ±12.46	40 33* ±18.84	89.00* ±43.24	53.58** ±30.75	120.03* ±49.06

*=P<0.05 **=P<0.01
Values are Mean ± S.E.

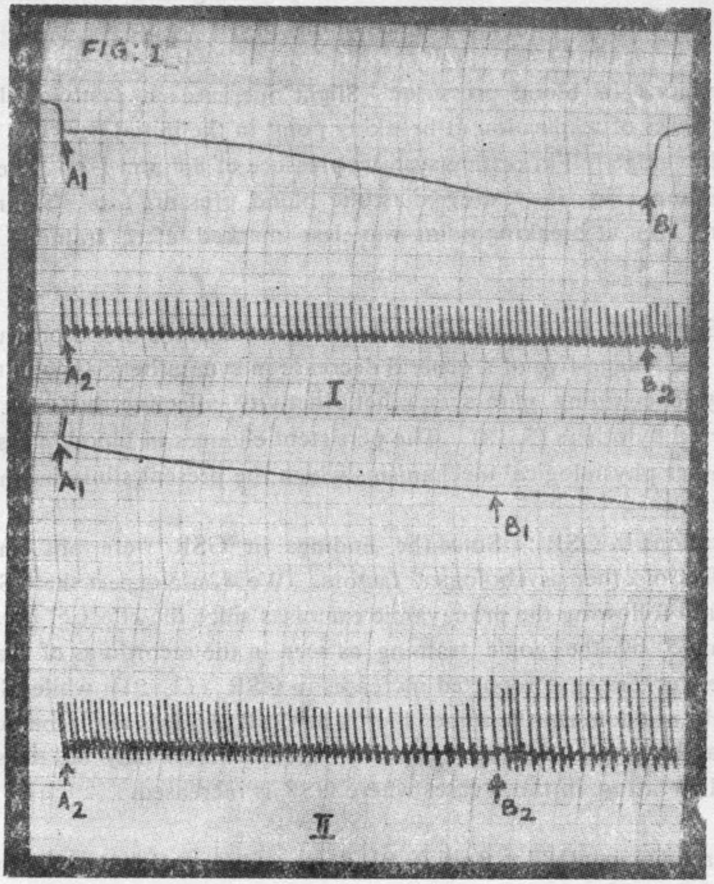

Fig. 1 : Showing a representative tracing of GSR and ECG recording before (I) and after 4 weeks of pranayama training (II) in the same subject. A_1, A_2 denote GSR and ECG at the beginning of breath holding and B_1, B_2 at the breaking point respectively.

1. Alterations in heart rate and ECG pattern : There was no changc in baseline resting heart rate with training. Significant bradycardia was observed at breaking point in almost all phases of respiration in all subjects after pranayama training. This change was probably due to increased vagal tone together with decreased sympathetic discharges. Such decreasss in heart rate in subjects practising yoga have been described by other workers also (6, 20). Decreased sympathetic discharges to skeletal muscle vasculature may allow significant vasodilation to improve peripheral circulaticn. Subjects were not told to concentrate on reducing heart rate and blood pressure as is done in transcandental meditation but were asked to hold the breath. There were no changes in ECG pattern except the change in heart rate.

This and the fact that the subjects remained healthy during and after the training indicate that the alterations were within physiological limits.

2. Alterations in blood pressure : Slight increase in systolic blood pressure was recorded at all phases of respiration at breaking point in the initial period. Training brought about a marked average fall in resting systolic pressure of 8 8 mm Hg. There was an average decrease of 4.8 mm Hg in resting diastolic blood pressure too The rise in systolic and diastolic pressures seen at breaking point was less marked after training than pre-training values.

At breaking point, there was a significant fall in diastolic blood pressure, at all phases. These changes are suggestive of a general decrease in sympathetic tone in the body probably accompanied by over-riding para-sympathetic activity affecting the heart. Similar changes have been reported by others (5, 18). The persistent changes in blood pressure values could also be due to other physiological mechanisms which the present study has not investigated.

3. Alterations in GSR : Since the findings in GSR were not uniform, they may indicate the effect of other psychological factors. We would expect the GSR during breath holding to increase following the pranayamic exercisas since the effect of breath holding as a stress is minimised by the yogic training as seen in the recordings of heart rate and blood pressure. Some workers have reported increases in GSR (13, 21) while Schwartz et al in their studies could not confirm the same (17). The GSR changes could be non-specific regardless of training and increase of GSR reported by some workers may be off-set by peripheral vasodilation and sweating, in those cases where GSR is increased.

4. Alterations in BHT : Initial BHT was observed to be the lowest after normal expiration and highest after hyper ventilation Moses has observed BHT in some phases of respiration and his readings are much lower compared to the present study except after hyper ventilation. After 4 weeks BHT was significantly increased at all phases of respiration. Similar increase in BHT after yogic exercises has been observed previously (6, 15, 18 & 20). Cyclic waning of the senstivity of respiratory centre is determined by afferent rhythmic discharges modified not only by pCO_2 and pO_2, but also by impulses from higher centres and stretch receptors in the lungs and thoracic parietes. The respiratory centre as a group is under voluntary control and the respiration can be voluntarily arrested for a variable period during any phase of respiratory cycle by inhibitory impulses from higher eentres which are able to balance excitatory effect of other afferents At the end of breath holding these excitatory impulses increase the senstivity of the centre to such a level that the voluntary control finally breaks and the respiration commences. Increased tolerance to higher $p\,CO_2$ and low pO_2 achieved due to training could also prolong BHT in these subjects.

During pranayamic breathing exercises the subject kept his voluntary muscles relaxed and immobile while at the same time exercising a close and continuous voluntary control over respiratory muscles, thus consciously and persistently over-riding the usual excitatory stimuli to respiratory centres. The alterations in autonomic functions recorded in the subjects in the present study indicate that they could not have been brought about by stress.

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