

ARTIGO ORIGINAL

**Efeito do Yoga na taxa de pulso e saturação de oxigênio: análise dos parâmetros psicofisiológicos**

***Effect of Yoga on Pulse rate and Oxygen Saturation: Analysis of Psychophysiological Parameters***

ABSTRACT

**Introduction** Pranayamic breathing is a process of continuous, regularity of inhalation, holding of breath and exhalation. All venous blood is converted to oxygenated blood. However, does deep breathing in which oxygen is inhaled in large amounts increase oxygen saturation or does the saturation decrease due to anaerobic metabolism associated with yoga? Does the psycho-physiological parameters of stress index, power, vegetative index & regulation, neurohumoral regulation, psycho-emotional state, energy resources, complex index, harmonization, biological age and energies in the spine get affected after a yogic intervention? **Methods** 52 subjects of age range from 15-70 years performed “Yoga module for the Healthy Heart” for 45 minutes at AYUSH, AIIMS, Bhopal. Pulse rate and oxygen saturation was measured by pulse oximeter after initial rest of ten minutes and after 45 minutes of yoga. A pilot study was conducted using the DINAMIKA HRV for ten yogic practitioner who were regular in their practice for last 10-15 years. Their psycho-physiological parameters were measured before and after their yogic routine of 35 to 40 minutes by Dinamika Heart rate variability (HRV) instrument. **Results** The readings were analysed using paired t test. The pulse rate dropped from  $81.98 \pm 13.05$  to  $74.98 \pm 11.64$  at p value  $<0.0001$  indicating a shift towards parasympathetic dominance. Oxygen saturation dropped from  $97.40 \pm 1.11$  to  $97.21 \pm 1.30$  at p value of 0.2736, indicating a shift to anaerobic metabolism during yoga practice. The psychophysiological parameters of pulse rate, stress index, power, vegetative index & regulation, neurohumoral regulation, psycho-emotional state, energy resources, complex index, harmonization, biological age and energies in the spine were statistically significant post yogic intervention. By the power of will the yogic practitioner is able to draw cosmic energy in the spine which helps to renew it. The mind is able to overcome strong physical distractions, the body is relaxed and calm. Relaxation is achieved by stilling of muscles, calming and slowing down the activity of heart, respiration and circulation.

**Keywords:** Pulse oximeter. pulse rate. oxygen saturation. Yoga. Asana. psychophysiological Parameters.



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## RESUMO:

**Introdução:** A respiração pranayâmica é um processo contínuo e regular de inspiração, retenção da respiração e expiração. Todo o sangue venoso é convertido em sangue oxigenado. No entanto, a respiração profunda, na qual o oxigênio é inalado em grandes quantidades, aumenta a saturação de oxigênio ou a saturação diminui devido ao metabolismo anaeróbico associado à ioga? Os parâmetros psicofisiológicos de índice de estresse, potência, índice vegetativo e regulação, regulação neuro-humoral, estado psicoemocional, recursos energéticos, índice complexo, harmonização, idade biológica e energias na coluna são afetados após uma intervenção yogue? **Métodos:** 52 indivíduos de 15 a 70 anos realizaram o “Módulo de Yoga para o Coração Saudável” por 45 minutos na AYUSH, AIIMS, Bhopal. A frequência de pulso e a saturação de oxigênio foram medidas por oxímetro de pulso após o descanso inicial de dez minutos e após 45 minutos de ioga. Um estudo piloto foi conduzido usando o DINAMIKA HRV para dez praticantes de ioga que eram regulares em sua prática nos últimos 10-15 anos. Seus parâmetros psicofisiológicos foram medidos antes e depois de sua rotina de ioga de 35 a 40 minutos pelo instrumento Dinamika Heart rate variability (HRV). **Resultados:** As leituras foram analisadas por meio do teste t pareado. A taxa de pulso caiu de  $81,98 \pm 13,05$  para  $74,98 \pm 11,64$  em valor de  $p < 0,0001$  indicando uma mudança em direção à dominância parassimpática. A saturação de oxigênio caiu de  $97,40 \pm 1,11$  para  $97,21 \pm 1,30$  no valor  $p$  de  $0,2736$ , indicando uma mudança para o metabolismo anaeróbico durante a prática de ioga. Os parâmetros psicofisiológicos da pulsação, índice de estresse, potência, índice vegetativo e regulação, regulação neuro-humoral, estado psicoemocional, recursos energéticos, índice complexo, harmonização, idade biológica e energias na coluna foram estatisticamente significativas na intervenção pós-ioga. Pela força da vontade, o praticante de ioga é capaz de atrair energia cósmica para a coluna, o que ajuda a renová-la. A mente é capaz de superar fortes distrações físicas, o corpo está relaxado e calmo. O relaxamento é alcançado acalmando os músculos, acalmando e diminuindo a atividade do coração, respiração e circulação.

**Palavras-chave:** Oxímetro de pulso. taxa de pulso. saturação de oxigênio. Ioga. Asana. Parâmetros psicofisiológicos

## INTRODUCTION

Patanjali, foremost exponent of Yoga, described pranayama as the gradual unforced cessation of breathing. Pranayama is derived from two Sanskrit words-prana (life) or yama (control). Pranayam or control of prana or life force yields heart beat pulse and mind control. Yoga combines scientific technique of right behavior (Yama-Niyama), proper posture (asana), life force control (pranayama), interiorisation of the mind (pratyahara), concentration (dhyana), developing intuition (dharna) and Samadhi (ultimate realization) (1,2).

Pranayamic breathing is a process of continuous, regularity of inhalation, holding of breath and exhalation. It charges the body with an increased supply of oxygen through the lungs, this oxygen “burns” or oxidizes the waste impurities, chiefly carbon, in

the venous blood. This process of purification is enhanced by an accompanying large increase in expulsion of waste carbon dioxide from the lungs during exhalation. As a consequence, very little of the tissue remains in the blood as waste material. There is less need for the breath, as the flow to the lungs of blood for purification slows down. The heart and lungs are given extraordinary rest. The inactivity of the muscles and limbs during meditation lessens bodily carbon production, and is conducive to the restful state of heart and lungs. Rest given to the heart helps in increasing longevity. (1)

Calmness is essential control of the heart. Estimating four ounces the amount of blood expelled by each contraction of the two ventricles of the heart, the weight of blood output during one minute will

amount to eighteen pounds. In a day it will be about twelve tons, in a year, four thousand tons. These figures indicate the enormous amount of labor performed by the heart. Many persons believe that rest is received by the heart during diastolic period of expansion, totalling about nine hours out of twenty four each day. This period is not true rest; it is only preparation for the systolic movement. The vibrations caused by the contraction of the ventricle reverberate through the tissue of the heart during its relaxation; hence the heart is not at rest. Rest to these muscles would consequently be of great value in maintaining health. The rest and renewed energy given to the body by sleep is only a pale reflection of the wonderful calmness and strength that comes with conscious control of the motion of the heart. In 1837, in India, a noted *fakir* by name of Sadhu Haridas was buried underground in a controlled experiment at the order of Maharajah Ranjit Singh of Punjab. The yogi remained buried for forty days inside a walled enclosure under constant military guard. At the end of that time he was exhumed in the presence of many dignitaries of the *darbar*, together with Colonel Sir C.M. Wade of London and several other English men from the vicinity. Sadhu Haridas resumed breathing and returned to normal life. Sadhu Haridas had mastered the art of controlling and resting the heart [2,3,4].

Yoga and pranayama give excellent benefits for those suffering from high pulse rate. Yoga practice has provided sufficient beneficial effects on cardiovascular system i.e Heart rate and pulse rate. Yoga and Pranayam is the perfect solution to manage and control pulse rate. Benefits of yoga for controlling high pulse rate are that it relaxes body, mind and soul, controls pulse rate cures depression, stress and anxiety, Improves blood circulation in the body, reduces heart problems like heart attack and strokes, strengthens the mind, cures insomnia (Sleeping Disorder), removes toxins from the body, gives positive energy, helps to control anger, supplies more oxygen and blood to various organs of the body, helps to manage your lifestyle, increases positive thinking, improves immunity, improves concentration (5,6,7).

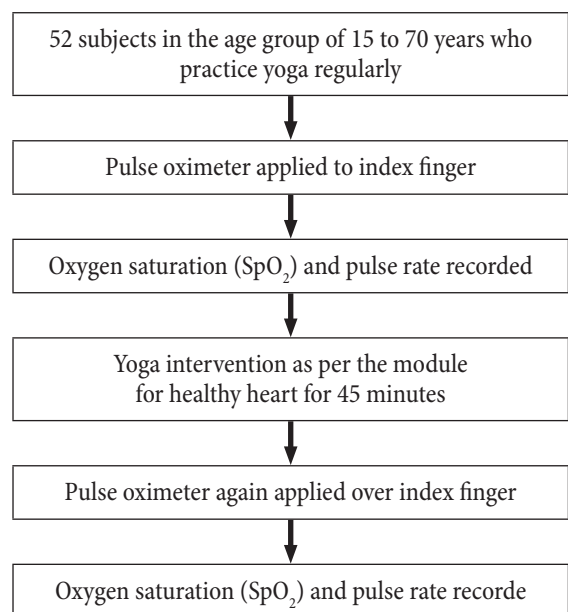
Does deep breathing in which oxygen is inhaled in large amounts increase oxygen saturation or does the saturation decrease due to anaerobic metabolism associated with yoga?

In the present study we attempted to assess the effect of yoga asanas and pranayamic breathing practice on the oxygen saturation using a pulse oximeter. The parameters measured included pulse rate as an index of autonomic balance and on oxygen saturation among yoga practitioners. The beneficial effect of Yoga on Autonomic nervous system is assessed by non-invasive pulse-oximetry likewise the effect  $O_2$  saturation is also assessed. We also wanted to assess how the parameters of pulse rate, stress index, power, vegetative index & regulation, neurohumoral regulation, psycho-emotional state, energy resources, complex index, harmonization, biological age and energies in the spine are affected post yoga.

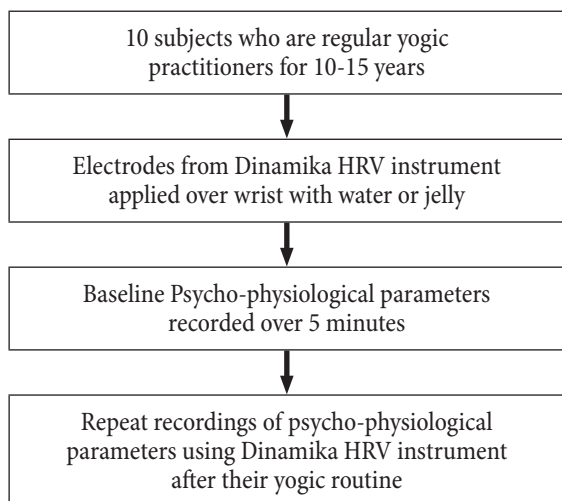
## METHODOLOGY

### STUDY DESIGN

The study was an interventional follow up and non-invasive in nature. The duration of the study was about one month. The study was conducted at Yoga unit, AYUSH, AIIMS, Bhopal.



**Fig1** - Study Design for measuring Effect of Yoga Intervention on Oxygen Saturation and Pulse Rate



**Figure 2** - Study Design for measuring Effect of Yoga intervention on Psycho-physiological parameters

### STUDY SUBJECTS

52 subjects of age range from 15-70 years who were willing to participate in the study were selected at AYUSH, AIIMS, Bhopal. Informed consent was sought from them. The study was approved by the Institutional Human Ethical Clearance. A pilot study was conducted using the DINAMIKA HRV for ten yogic practitioners. The yogic practitioners were regular in their practice for last 10-15 years. Their psycho-physiological parameters were measured before and after their yogic routine of 35 to 40 minutes by Dinamika Heart rate variability (HRV) instrument

#### Inclusion criteria

Male and female subjects in age range of 15-70 years. Subjects who were regularly practising yoga at least for 45 minutes.

For the pilot study healthy male volunteers practicing yoga regularly for over ten years

#### Exclusion criteria

Patients with nervous disorder who could not perform the asanas, fracture, infectious disease, unsteady blood sugar levels, glaucoma, arrhythmias, respiratory illness and chronic co-morbidities were excluded from the study

#### Procedure:

Pulse Oximetry is a non-invasive method that enables rapid measurement of the oxygen saturation of haemoglobin in arterial blood and arterial pulse rate. (8) Pulse oximeter is measured by Oxee Check machine of Ramsons. It is portable, light weight and a convenient way to measure pulse rate and oxygen saturation by the side of the yoga practitioner.

After verbally confirming the identity of the subject by asking for their full name and date of birth the procedure including risks and benefits was explained to the patient to gain their valid consent. The patient was made comfortable and warm enough. The respiratory condition including their ability to talk in full sentences, the colour of their skin, whether they appeared to be in distress or not, and whether they are alert and orientated was noted. Hands were decontaminated using antiseptic prior to procedure. Before proceeding it was ensured that the pulse oximeter probe was clean and in good working order. Index finger was used to put the probe for recording.

Pulse-oximeter was switched on and it was made sure that the probe sensor was detecting the pulse. Once oxygen saturation monitoring and Pulse rate recording was complete, the probe was removed and ensured the patient was comfortable.

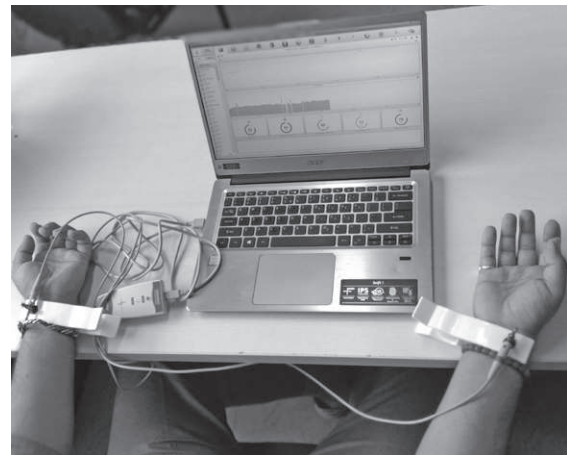
Recording of Pulse rate (resting pulse rate) and oxygen saturation parameters was done before initiating yoga session after giving initial rest of 10 minutes. Immediately after Yoga session approximate duration 45 minutes pulse rate and SpO<sub>2</sub> will be measured.

During yoga sessions, the following YOGA MODULE: FOR HEALTHY HEART was administered as detailed in Table 1(9-15).

**Table 1** - module: for healthy heart:

S.NO.	PRACTICES	DURATION (45 MIN)
1.	<b>Sukshmayayama:</b> a. Loosening of neck- up, down, sideward bending, sideward seeing) b. Shoulder rotation (front and back) c. Loosening of wrist (up, down, side to side movement, rotation) d. Drill walking (10-15 steps forward and backwards)	08 MIN. (5 repetitions each movement, slow and controlled movements without jerks )
2.	<b>Breathing exercises:</b> a. Hand stretch breathing (front, slanting, vertical) b. Ankle stretch breathing c. Trikonasana breathing d. Tiger breathing e. Straight leg breathing f. Setubandhasana breathing	07 MIN (5 repetitions each movement, the movements are synchronized with breathing)
3.	<b>Yogasana:</b> a. Ardhakatichakrasana b. Vrikshasana c. Garudasana d. Vakrasana e. Gomukhasana f. Bhujangasana	10 MIN (performing the asana symmetrically both sides of body, maintaining 10-30 seconds in the final position; by increasing the maintenance duration 10 second each week)
4.	<b>Relaxation technique</b> (Deep Relaxation Technique in Shavasana )	07 MIN
5.	<b>Pranayama:</b> a. Vibhagya Pranayama/ (sectional breathing; abdominal, thoracic and clavicular breathing) b. Chandranuloma viloma c. Nadishuddhi Pranayama d. Ujjai Pranayama e. Sitali Pranayama	07 MIN Vibhagya pranayama- 5 repetitions each (2 min) Chandranulomvilom- 9 repetitions (1 min) Nadishuddhi Pranayama- 9 repetitions (2 min) Ujjai pranayama- 9 repetitions (1 min) Sitali pranayama- 9 repetitions (1 min)
5.	<b>OM kara Dhyan</b> (OM Meditation)	06 MIN

A pilot study was conducted using the DINAMIKA HRV for ten yogic practitioners. They were regular in their practice for last 10-15 years. Their psycho-physiological parameters were measured before and after their yogic routine of 35 to 40 minutes by Dinamika Heart rate variability (HRV) instrument.

**Figure 3** - Dinamika mobile HRV unit measuring Psycho-physiological parameters

The Dinamika HRV is a digital analyzer designed to study the functional state of a person based on neuro-dynamic HRV analysis. It monitors one's functional status and also determine physiological outcomes of any intervention. It includes: electrocardiogram, monitor the patient's functional state, assess the patient's cardiovascular system, estimate the body's current available energy resource, assess emotional states, monitor the dynamic state of the patient, calculate a biological age of the patient and give a forecast of total health. This technology is designed to analyze the human heart and brain rhythms extracted from an electrocardio signal in the broad range frequency band and is based on the new science of Fractal Neurodynamics. The advantage of this system of analysis is its objectivity, speed, accuracy and ease of interpretation. The psycho-physiological parameters can be assessed within 5 minutes. The software and the hardware of Dinamika meets the standard of measurement, physiological interpretation and clinical use of cardiac intervalometry indices, adopted by European society of cardiology and North American association of electrophysiology.

The devices used were 2 electrodes for wrist and a laptop with software 'Dinamika' mobile HRV unit that is available at Department of Physiology, AIIMS, Bhopal. The electrodes are placed on the wrist with water or jelly. The baseline record of the subject was taken for 5 minutes. The record of the following parameters was taken again after the yogic practitioner completed the meditation session :

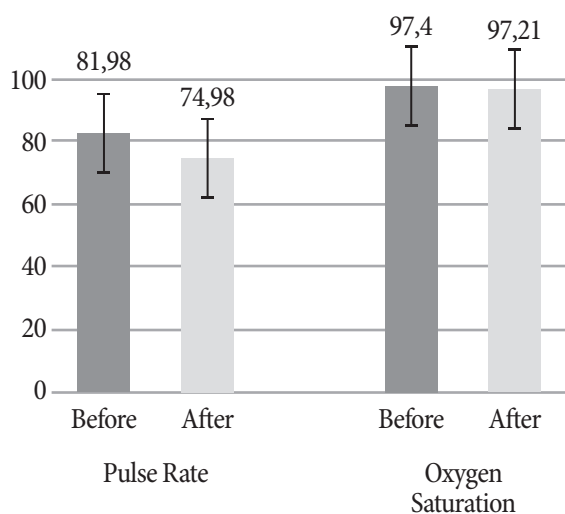
- » Stress Index
- » Autonomic Nervous System parameters- HE,LF,VLF %
- » Which indicates, parasympathetic, sympathetic and neurohormonal balance
- » Cardio vascular adaptation
- » Hormonal Regulation Index
- » Metabolic Energy Resources
- » Psycho Emotional Index

The instrument software measures the following parameters automatically

- » ECG recording with real-time monitoring of functional state indices
- » Assessment of the state of cardiovascular and vegetative nervous system by means of variance analysis
- » Heart rhythm oscillations by means of spectral analysis.
- » Hormonal regulation assessment by means of neurodynamic analysis.
- » Psycho-emotional state assessment by means of brain biorhythm mapping.
- » Body's adaptation level and is used to determine biological age by means of fractal analysis.
- » Determination of patient's biological age

## RESULTS

52 paired before and after readings of subjects doing yoga were taken and analysed using paired t test. The pulse rate dropped from  $81.98 \pm 13.05$  to is  $74.98 \pm 11.64$  at p value  $<0.0001$  (highly statistically significant) and oxygen saturation dropped from  $97.40 \pm 1.11$  to  $97.21 \pm 1.30$  at p value of 0.2736 as detailed in **Figure 4**



**Figure 4** - Effect of youga on Pulse rate and O2 Saturation

The parameters of pulse rate, stress index, power, vegetative index & regulation, neurohumoral regulation, psycho-emotional state, energy resources, complex index, harmonization, biological age and energies in the spine were statistically significant as detailed in **Table 2**.

**Table 2** - Comparison of Psychophysiological Parameters Before and After Yogic Practice

Parameters	Before	After	p Value
Pulse Rate	$76.9 \pm 5.7$	$65.6 \pm 6.22$	0.0011*
Autonomic Nervous System parameters-			
LF %	$48.7 \pm 16.41$	$55.70 \pm 28.29$	0.444
HF %	$30.9 \pm 18.5$	$22.7 \pm 20.94$	0.502
VLF %	$20.6 \pm 3.69$	$18.8 \pm 9.9$	0.662
Stress Index	$131.1 \pm 38.29$	$45 \pm 21.1$	0.0001*
Power	$1670.8 \pm 896.76$	$4903.9 \pm 1423.4$	0.0001*
Vegetative Index	$0.276 \pm 0.06$	$0.387 \pm 0.097$	0.0158*
Vegetative Regulation	$60.3 \pm 15.04$	$95 \pm 6.88$	0.0001*
Psycho-Emotional Index	$63 \pm 12.78$	$85 \pm 8.84$	0.0003*
Neuro-Hormonal Regulation Index	$70.90 \pm 12.88$	$87.6 \pm 10.65$	0.0014*
Complex Index	$63.4 \pm 11.51$	$90.7 \pm 6.29$	0.0001*
Metabolic Energy Resources	$216.4 \pm 53.33$	$345.1 \pm 77.88$	0.001*
Energy Balance	$0.80 \pm 0.07$	$0.863 \pm 0.156$	0.3564
Biological Age	$40.90 \pm 2.6$	$31.5 \pm 1.35$	0.0001*
Spinal Energies			
Cervical	$71.2 \pm 12.98$	$88.7 \pm 9.26$	0.0014*
Thoracic	$56.5 \pm 17.8$	$94.9 \pm 6.92$	0.0001*
Lumbar	$72.9 \pm 12.12$	$90.70 \pm 6.0$	0.0038*
Sacral	$47.2 \pm 14.62$	$76.9 \pm 7.69$	0.0001*
Coccyx	$62.1 \pm 10.67$	$93.4 \pm 6.1$	0.0001*
Harmonization	$62.7 \pm 10.59$	$93.8 \pm 6.01$	0.0001*

\* Statistically Significant

## DISCUSSION

Hypoxemia is decrease in oxygen saturation  $<90\%$  or  $\text{PaO}_2 <60\text{mm Hg}$ . Though we did not take invasive arterial blood gas (ABG) samples the oxygen saturation was measured using pulse oximeter. The patients did not have hypoxemia as oxygen saturation was  $>94\%$ . The results post yoga is not statistically significant.

The slight decrease in oxygen saturation indicates a shift towards anaerobic metabolism. The yoga routine for 45 min to 1 hour was done indoors at AYUSH building, AIIMS, Bhopal campus in a group of about 6 to 15 subjects at a time. It is possible that if the study were done by yoga practitioners outdoors the oxygen saturation would be different. This needs to be tested in a subsequent study and is a lacuna of the present study as our results remain inconclusive regarding how the oxygen saturation may be affected.

The heart pumps life force in the blood to all its body parts and sense faculties. The heart is the dynamo, or the life of the muscles, the cells and the five sense telephones. In sleep, the heart action slows down and this helps to withdraw the life force from the five sense telephones, as well from the motor nerves. The yogis of India anciently found that it is possible, by calmness, and at will, to switch off the energy from the heart without causing death. Many illustrations could be given of the mathematical relationship between man's respiratory rate and the variations in his states of consciousness. A person whose attention is wholly engrossed, as in following some closely knit intellectual argument, or in attempting some delicate or difficult physical feat, automatically breathes very slowly. Fixity of attention depends on slow breathing; quick or uneven breaths are an inevitable accompaniment of harmful emotional states: fear, lust, anger. The restless monkey breathes at the rate of 32 times a minute, in contrast to man's average of 18 times. The elephant, tortoise, snake and other animals noted for their longevity have a respiratory rate which is less than man's. The tortoise, for instance, who may attain the age of 300 years, breathes only 4 times per minute. We found the pulse rate decreases after yoga practice indicating a mechanism to conserve energy and promote longevity (16)

Yoga by deep breathing in pranayama helps convert the deoxygenated venous blood to oxygenated blood, giving extraordinary rest to the heart. The minimum production of carbon dioxide in the body through *yoga asanas* and meditation results in slowing the activity of the lungs and the heart. Besides, as the individual is relaxed in pranayamic breathing,

the basic need of oxygen decreases. There occurs neither oxygen debt nor increased levels of lactic acid as is otherwise associated with heavy exercises. Carbon dioxide accumulation makes the mind restless. Carbon dioxide levels in the blood can very easily increase in pranayamic breathings but it will always remain below the maximum allowable level. The gradual rise in carbon-dioxide levels also has psychophysiological effects on the individual as compared to a sudden rise or fall of Carbon dioxide levels that may occur during exercise (17).

During Pranayama, breathing out forcefully decreases the  $p\text{CO}_2$ , which acts on chemoreceptor area of the brain to modify which acts on chemoreceptor area of the brain to modify activity of the generator neurons of the respiratory centres and an overall improvement of pulmonary function, strengthening of respiratory muscles. The maximum inflation and deflation is an important physiological stimulus for the release of surfactants and prostaglandins into the alveolar spaces, which thereby increase the lung compliance (18,19). The stretch receptors reflexly decrease the trachea-bronchial smooth muscle tone activity, which leads to decreased air flow resistance and increased airway caliber, which causes the dynamic parameters of the lung function test to improve. Pranayama training causes an increase in the voluntary breath holding time (20, 21). This may be due to acclimatization of the chemoreceptors to hypercapnia. Breathing is an autonomic function that can be consciously controlled, regulated and it is the key in bringing the sympathetic and the parasympathetic nervous system into harmony (22).

In our previous studies with Suryanadi, Chandranadi, anulomaviloma pranayama, kapalhatti the subjects were calmer as it stills the restless mind (23). They were more attentive and alert as shown by a decreased reaction time indicating an improved sensory motor performance and enhanced processing ability of the central nervous system. The subjects felt happy due to release of endorphins. The autonomic balance shifts to parasympathetic dominance leading to a decrease heart rate, stable calm mind. They have lower scores of excitabilities.

Changes of heart rate and respiration accompanying a *Yogic* subjective activity is intended to alter the state of the mind alone (24-29). Parasympathetic balance is essentially concerned with conserving and restoring bodily resources and energies. This is achieved by inhibiting the heart and alimentary activities promoting secretions (30). The relaxing stretch exercises also result in a relative hypometabolic state and improvement of physical and mental efficiencies. Meditation often helps relax the small vessels that control the blood pressure wall and would help reduce the pressure inside them (31).

*Shavasana* is the asan recommended for reducing high blood pressure along with *Pranayama* (left nostril breathing or *Chandranadi* Pranayama) and *Shitkari Pranayama* (32). It was a part of the yoga routine followed by the subjects. By doing *Shavasana* the person relaxes with slow diaphragmatic breathing. The frequency and intensity of both proprioceptive and enteroreceptive impulses is thus reduced. While doing *Shavasana* the person is less conscious of external environment but is alert inwardly. It appears that the yogic exercise influences the hypothalamus through continuous feedback of slow rhythmic proprioceptive and enteroreceptive impulses. This sets the regulatory mechanism in the hypothalamus at a lower level and thereby helps in reduction of blood pressure and pulse rate that may be high in anxious, stressed people (33, 34). In our previous studies among diabetic Type 2 patients, we found that the patients oxidative stress as measured by MDA levels decreased, Blood pressures fell, biochemical parameters in terms of blood sugar fell, lipid profile, Nerve conduction velocity and Pulmonary Functions improved. The subjects felt relaxed. The patients had lower scores in excitability, aggressiveness, openness, emotionality and somatic complaints. Yoga asanas along with meditation provides a better metabolic control giving a general well-being, alertness and attentiveness without any side effects and can be utilised in the present concept note along with the DASS Score in patients with mild severity depression, anxiety or stress. It was suggested that combined beneficial effects could be utilized by performing asanas with conventional antidiabetic regimen (35-39).

The findings of our study are similar to other researchers who have applied its beneficial effect in various diseases. Even short-term Yoga practise tilts Autonomic balance toward parasympathetic system dominance. Similarly, these shifts may be also be attributed to inhibition of posterior or sympathetic area of the hypothalamus which optimizes the body's sympathetic responses to stressful stimuli which otherwise help restore autonomic regulatory reflex mechanisms associated with stress. However, they report non-significant change in HR before and after Yoga (40). Krishna et al recommended in addition to standard medical therapy for Heart failure 12 weeks of yoga practice has beneficial effect in terms of reduction in BP, work load on heart and improvement in parasympathetic activity in heart failure patients (41). Significant reduction in resting pulse rate, systolic blood pressure, diastolic blood pressure, and mean arterial blood pressure after practicing pranayama and meditation for 15 days were noted and also the similar response was noted irrespective of age, BMI, gender (42). Joseph CN et al found that slow breathing improves arterial baroreflex sensitivity and decreases blood pressure in essential hypertension (43)

The postulated mechanisms of the decrease in heart rate is due to autonomic modulation in yoga which is mediated through modification of breathing patterns which triggers various central and autonomic mechanisms as well as mechanical and hemodynamic adjustments causing both tonic and phasic changes in cardiovascular functioning (44). Similarly deep and slow breathing cause maximum lung inflation which stimulates the pulmonary stretch receptors. During slow and deep breathing lung inflates to the maximum. This stimulates pulmonary stretch receptors which alters the sympathetic tone in skeletal muscle blood vessels and causes widespread vasodilatation and decrease in peripheral resistance and thus decrease diastolic blood pressure(27). During pranayama practise concentration is on the act of breathing which distances one from worries and "de-stresses" the subject. The stress free state of mind could evoke relaxed responses in which parasympathetic activity



overrides sympathetic activity (45). Yoga relaxes, relieves stress and makes the subject feel good, alert, active and exhilarated by releasing opioids and altering adrenocortical activity that gives pleasurable sensations and keeps body fit (46).

#### **Parameters studied using HRV Dinamika (Table 2)**

*Stress Index* (normal range 10-100)-indicates how hard the body is working to maintain balance and equilibrium or homeostasis. Stress, if remains for longer period and not managed appropriately can leads to negative physical, mental and cognitive impact. In our study post yoga there was a significant reduction in stress index. This could be attributed to the yogic practitioners becoming habitually calm through scientific concentration and meditation that helped control the life-force (*pranayama*). This is due to shift towards a parasympathetic balance.

#### *Autonomic nervous system regulation (LF/HF ratio and VLF)*

High frequency normal is 15-20% indicates parasympathetic, low frequency or sympathetic normal is 30-50%, and very low frequency normal is 15-35%. Heart rate Variability is the cardiac beat to beat variation; a physiological phenomenon that occurs mainly due to variation in cardiac activity during the respiratory cycle at rest. The changes in HF, LF and VLF are not statistically significant. HRV reflects regulation of autonomic balance, blood pressure (BP), gas exchange, gut, heart, and vascular tone, which refers to the diameter of the blood vessels that regulate BP, and possibly facial muscles (47). Studies show that having high heart rate variability (HRV) is associated with higher emotional well-being and is correlated with lower levels of worry and rumination, lower anxiety, and better regulated emotional responding.(48-52). Studies suggest that yoga can affect cardiac autonomic regulation with increased HRV and vagal dominance during yoga practices. Regular yoga practitioners were also found to have increased vagal tone at rest compared to non-yoga practitioners. (53). HRV was

used to measure stress in sub-junior cyclists performing integrated yoga module, results showed that yoga practice decreased sympathetic activity and shifted the autonomic balance towards parasympathetic dominance indicating a reduction in stress. In conclusion, yoga practice helps to reduce stress by optimizing the autonomic functions. (54-55). Practice of pranayama naturally slows the breathing, which in turn makes the heart calmer and calmer as demonstrated by a statistically significant decrease in heart rate. Even a little calming of the heart allows some of the immense quantity of life force required for its work- moving twelve tons of blood or more a day!- to withdraw into the spine and brain The energy thus freed gradually awakens the centres of life and consciousness in the cerebrospinal axis. This helps draw an increased supply of cosmic energy through the medulla centre. This is seen by a statistically significant increase in overall energy in the spine and in the individual centres of the cerebrospinal axis in our study. Low Frequency are a band of power spectrum range between 0.04 and 0.15 Hz. This measure reflects both parasympathetic and sympathetic activity. Generally, it is a strong indicator of sympathetic activity. Parasympathetic activity is represented by LF when respiration rate is lower than 7 breaths per minute or during taking a deep breath.. Thus, when the subject is in the state of relaxation with a slow and even breathing, the LF values can be very high indicating an increase in parasympathetic activity rather than an increase in sympathetic regulation. Low frequency band is calculated in millisecc squared ( $ms^2$ ), with normal value being 754-1586. High frequency is a band of power spectrum range between 0.15 and 0.4 Hz. This measure reflects parasympathetic activity (vagal activity). HF is also known as "respiratory band" because it corresponds to NN variations caused by respiration (this phenomenon is known as respiratory sinus arrhythmias (RSA)). Heart rate is increased during inhalation and dropped during exhalation. High frequency band is calculated in millisecc squared ( $ms^2$ ), with normal value being 770-1078. Very low frequency is a band of power

spectrum range between 0.001 and 0.04 Hz. Generally, it is known that this parameter indicated overall activity of various slow mechanisms of sympathetic function (mediated by renin-angiotensin system). Very low frequency band is calculated in millisecond squared ( $\text{ms}^2$ ), with normal value being 600-1500. LF/HF ratio. This is the ratio between the power of low frequency and high frequency bands. This measure indicates the overall balance between sympathetic and parasympathetic systems. Higher values represent dominant sympathetic system which was indicated in our study. It shows that the balance shifted from parasympathetic to sympathetic system during the yogic breathing as shown by a low HF%, high LF and LF/HF ratio. Its normal value is  $1.5 \pm 2$ . Yogic slow spinal breathing can voluntarily regulate their autonomic functions.

*Cardiovascular adaptation (it is determinant of blood pressure stability)*

Hormonal regulation index (normal range is 50-100) shows how the body uses its energy and physiology resources as an index of how synchronized the hormones are. In our study Neurohumoral regulation significantly increased post yoga to an optimum and stable balance  $p < 0.0014$ . (Table 2).

*Psych emotional state or Brain Activity* normal range is between 50-100 and looks at the total power of the spectral density of the frequencies that regulate brain function such Delta, Theta, Alpha, Beta. This is not an EEG of the brain but comes from mathematical calculation from the heart electrical cardiogram or ECG. The brain waves are calculated from a mathematical algorithm & are derived from extrapolation of ECG. In our study Psychoemotional state significantly increased post yoga to a maximal functional condition showing a balanced state of electrical activity. Post yoga the mind is able to overcome strong physical distractions, the body is relaxed and calm. Relaxation is achieved by stilling of muscles, calming and slowing down the activity of heart, respiration and circulation as shown by a statistically significant reduction in pulse rate  $p < 0.0011$  (Table 2)

*Functional State Indices*

Indicates how well the body is able to compensate under stress using all its regulatory resources as below

A - Adaptation Level (Cardiovascular)

B - Vegetative Regulation  
(Autonomic Nervous System)

C - Neurohormonal Regulation

D - Psycho-Emotional State

*Complex State Index*

The screen is the total of A-B-C-D to give percentage of total health. It indicates the standard for an average individual of the subject's age

In our study we found a statistically increased Complex State index  $p < 0.0001$  (Table 2) indicating an optimal, balanced, stable regulation of health post yogic practice.

*Metabolic Energy Resource*

Normal range 150-600. In our study there was a statistically significant in energy resources  $p < 0.001$  (Table 2), indicating an unhindered flow of metabolic energy throughout the body to optimize body functions post yogic practice.

*Gerontological Performance Curve*

Scientist took a population of 10,000 healthy people of different ages with a variety of healthy conditions and plotted this information on a bell shaped curve according to their age and where optimum would be for their age. This curve shows what the actual age is compared to biological age. If it is above actual age, it shows premature aging and if below actual age it shows anti-aging. In our study there was a statistically significant reduction of biological age after yogic practice ( $p < 0.0001$ ) Table 2. By yogic practice the body battery is replenished and recharged by channelizing the cosmic energies and tapping the inexhaustible inner source.

*Functional Condition of the Spine*-the screen displays areas of the spine in segments and the energy in them. It depends on the energy flow and the activ-

ity of the relevant departments of the autonomic system, connected to the spine. In our study the energy flow significantly increased post yoga (Table 2) in cervical, thoracic, lumbar, sacral and coccygeal regions. By the power of will the yogic practitioner is able to draw cosmic energy in the spine which helps to renew it.

*Harmonization* is the mean value of the energies in various regions of the spine. In our study there was a statistically significant increase in harmonization  $p < 0.0001$  (Table 2)

## CONCLUSION

We found a statistically significant decrease in pulse rate indicating a shift towards parasympathetic dominance as assessed by non-invasive pulse-oximetry. The oxygen saturation decreases insignificantly indicating a shift to anaerobic metabolism during yoga practice. The parameters of pulse rate, stress index, power, vegetative index & regulation, neurohumoral regulation, psycho-emotional state, energy resources, complex index, harmonization, biological age and energies in the spine were statistically significant post yogic intervention. By the power of will the yogic practitioner is able to draw cosmic energy in the spine which helps to renew it and amplification of energy reserves. Post yoga the mind is able to overcome strong physical distractions, the body is relaxed and calm. Relaxation is achieved by stilling of muscles, calming and slowing down the activity of heart, respiration and circulation. This is due to shift towards a parasympathetic balance.

## LIMITATIONS AND FUTURE STUDIES

Reduction in Heart rate noted after Yogic intervention could be complemented by estimation of estimation of plasma catecholamines or metabolites of catecholamines in urine like vanillylmandelic acid (VMA), metanephrine, and normetanephrine before and after intervention. More number of studies of HRV after yoga intervention are planned accordingly to get evidence of such activity.

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