

## Assessment of Metabolic Status in Yoga and in Vigorous Physical Exercise

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**Abstract:** The aim of this study was to assess various metabolic changes after yoga and physical exercise and compare them. The effect of yoga in the form of Suryanamaskar was compared with that of vigorous physical exercise in the form of shuttle running. For this study 10 healthy male volunteers in the age group of 25 - 44 years who practiced yoga were selected. All volunteers performed Suryanamaskar on the first day and vigorous physical exercise on the second day. Vitals, physiological, biochemical and blood gas parameters were analyzed in arterial blood samples collected before and after yoga and exercise. The results showed that pulse, respiration rate and systolic blood pressure were significantly higher after exercise but not after yoga. Yoga caused greater reduction in sugar levels without significant lactate accumulation when compared to vigorous physical exercise. Yoga did not cause any electrolyte imbalance whereas exercise caused significant reduction in sodium and chloride levels. Creatinine levels increased after exercise but not after yoga whereas total carbon dioxide content decreased significantly after physical exercise but not after yoga. These results demonstrated that yoga was more effective than physical exercise in stimulating the metabolic rate and reducing blood sugar levels. At the same time yoga unlike physical exercise did not place any stress on the heart, overload on the kidneys or cause lactic acidosis and electrolyte imbalance. It can be concluded that regular practice of yoga will serve as an ideal physical work out to modify cardiovascular risk factors like hypertension and diabetes mellitus and thereby maintain good physical health and well being.

### INTRODUCTION

Yoga is a physical, mental, and spiritual practice that aims to transform the body and the mind. Yoga has been in existence since 3000 BC. Some of the archeological evidences from the Stone Age depict various yoga postures and yogis. The word yoga originated from the Sanskrit word "Yuj" which means to unite and integrate. The belief of ancient yogis was that yoga could integrate emotions, actions and intelligence in a balanced way through exercise. The practice of yoga stimulates blood circulation, improves physical fitness, concentration, mental stability and spiritual development<sup>1</sup>. It stimulates endocrine organs, viscera of the abdomen and thorax by which a better state of health is achieved. It is documented that yoga stimulates physical and mental health via down regulation of hypothalamic-pituitary-adrenal axis and sympathetic nervous system.

Exercise, breathing and meditation are the three main pillars of the yoga structure. By meditation which is an integral part of yoga the mind is trained to focus and align with the physic as a result of which one can achieve a quiet and peaceful state of mind and healthy body. The control on breathing achieved through yoga will modulate respiration, pulse rate and blood pressure. Yoga helps to rectify the effects of stress experienced in modern day life by collecting and channeling various energies through endocrine and autonomic nervous system. The physical exercise component of yoga improves the function of body organs and leads to physical and mental fitness.

There are different types of yoga described in literature and all of them have the same effect ultimately i.e., healthy body and mind. We may state that in the last two decades there has been a renaissance of this art especially in the medical and surgical areas. Many of the major cardiac centers globally advise yoga as a post operative rehabilitation therapy. Here the quote of Buddha "Every human being is the author of his own health or disease is worth contemplating<sup>2</sup>. A look into the history of ancient yogis and yoga gurus will show that they seldom suffered from any of the present day metabolic disorders like diabetes mellitus, hypertension, osteoporosis, various forms of malignancies and other degenerative diseases and lived for about 100 years or more<sup>3</sup>.

The general health benefits of yoga and its therapeutic effect in some disease states is available in literature<sup>4,5</sup>. But there have been few studies which compared the health outcomes after yoga and physical exercise<sup>6</sup>. Also detailed studies on

how exactly yoga and physical exercise affect various blood parameters in humans have not yet been reported to the best of our knowledge. As information was found wanting in this area the aim of our investigation was to measure the various physiological, biochemical, electrolyte, acid-base and blood gas parameters before and after yoga and vigorous physical exercise and compare them. This study will throw light on the metabolic changes brought about by yoga when compared to physical exercise and whether yoga is as effective or superior to physical exercise in bringing about beneficial metabolic changes.

### MATERIAL & METHODS

This pilot study was carried out by K J Research Foundation, Chennai in collaboration with the Centre for Yoga Studies at Annamalai University, Chidambaram. The study was cleared by respective institutional ethical committees and proper informed consent was obtained from the participants in the study. A total number of 10 healthy adult male volunteers in the age group of 25 - 44 years participated in the study (mean age 25, SD  $\pm 7.13$ ). Their Body Mass Index (BMI) ranged between 17 - 28. All volunteers in this study went through clinical examination including cardiac work up before enrolling in the programme and participated in the study for two consecutive days early in the morning. At 6am on the first day volunteers who were fasting were clinically examined and their vitals were recorded. Blood samples were collected for the measurement of various biochemical parameters, electrolytes and blood gases. Then on the first day all volunteers did Suryanamaskar for 45 minutes and then their vitals were recorded followed by blood sample collection for post yoga analysis of parameters mentioned below. At 6am on the second day the same volunteers on fasting state performed vigorous exercise by shuttle running for 5 minutes continuously between a distance of 10 meters which is equivalent to vigorous exercise for 45mins. The vitals of all volunteers were recorded and blood samples were collected from them for post exercise analysis.

The physiological parameters analyzed in this study were pulse, temperature, blood pressure and respiration rate before and after yoga and exercise. Similarly biochemical parameters such as blood glucose, lactate, urea, creatinine, sodium, potassium, chloride, calcium, phosphorus, blood gases, as well as acid base status like pH, base excess or deficit were also analyzed in all blood samples. The results were analyzed statistically using Bonferieri Test using two way ANOVA with Graph Pad Prism (Version 6.04) software.

### RESULTS & DISCUSSION

Some studies have reported the extent to which yoga was effective for managing diseases and they include ailments from lower back pain to degenerative scoliosis

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and cancer-related symptoms<sup>7, 8</sup>. Some groups have suggested that yoga may reduce insulin resistance syndrome (IRS) and related risk factors for cardiovascular disease (CVD)<sup>9</sup>. But how exactly yoga will have an impact on cardiovascular risk factors can be understood only if the physiological and biochemical changes that happen after yoga are determined. Therefore in this study metabolic changes in the body were determined before and after doing a prototype of yoga, i.e., 3 times Suryanamaskar which lasted for about 45mins. To assess whether yoga was as effective or better than physical exercise the results were compared to those obtained after the same set of volunteers performed vigorous physical activity in the form of shuttle running for 5mins.

Suryanamaskar known variously as prostrations to sun or sun salutation's, is one of the best yoga exercises that people can perform<sup>3</sup>. The benefits accruing from this exercise are unique and excellent. It is a yoga based exercise and it is customary to perform Suryanamaskar after performing muscle loosening yoga exercises. The namaskar is performed usually early in the morning facing the rising sun. It is done in 12 steps, each step having its own posture (including position and form) with its own breathing pattern (inhalation or exhalation) and its own mantra (Figure-1). To the best of our knowledge this investigation is the first of its kind in selecting Suryanamaskar for studying the effect of yoga on physiological and biochemical outcomes and other metabolic changes in the body.

The results obtained in this investigation comparing the metabolic changes brought about after yoga and vigorous physical exercise is shown in Table-1. The results showed that temperature decreased significantly both after yoga and exercise. Pulse and respiration rate did not show significant increase after yoga but increased significantly after exercise and the differences between the two groups were also statistically significant. Diastolic blood pressure was not altered after yoga as well as physical exercise. But systolic blood pressure which did not show significant increase after yoga, increased significantly after exercise and the difference between the two groups was also statistically significant. These results indicated that doing yoga did not exert any stress on the cardiovascular system whereas physical exercise did exert significant stress on the same. This was due to the control achieved on breathing by yoga and highlighted the cardio protective effect of yoga.

Yoga caused more reduction in sugar levels than exercise although this reduction was not significant. However the results showed that sugar levels decreased markedly by almost 10 mgs after yoga when compared to exercise after which sugar level decreased by 5mgs only. Yoga brought about twice as much reduction in sugar levels than exercise which indicated that the metabolic rate was stimulated more by yoga than vigorous physical exercise. Lactate levels in the blood did not increase significantly after yoga but increased significantly after exercise and the difference between the two groups was statistically significant. This could be due to the fact that vigorous physical exercise like running promoted anaerobic oxidation of glucose resulting in high amounts of lactate accumulation (lactacidosis). Lactacidosis can also explain the lowering of blood pH after physical exercise which was not observed after yoga. It can be that yoga stimulated the metabolic rate via oxidative pathways (oxygen saturation increased after yoga) as a result of which there was no significant lactate accumulation after yoga. The fact that while doing yoga glucose is utilized without significant lactacidosis will

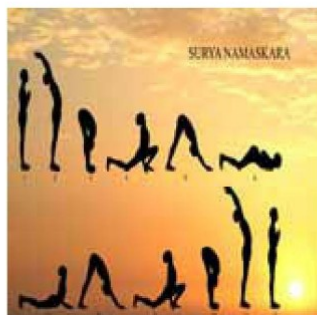


Figure 1: Various steps and postures involved in Suryanamaskar.



Figure 2: Stretching periosteum leads to better bone haemodynamics – no question of osteoporosis.

Table 1: Changes in metabolic parameters after yoga and exercise.

S.No	PARAMETERS	PRE TEST (Mean ± S.D)	POST YOGA (Mean ± S.D)	POST EXERCISE (Mean ± S.D)
1	Temperature (°F)	98.40±0.00	96.97±1.10	96.02±1.19
2	Blood Pressure (Systolic)-mmHg	123.80±9.77	128.60±8.79	143.80±16.31
	Blood Pressure (Diastolic)-mmHg	76.40±4.69	77.90±9.45	77.80±6.68
3	Pulse (per min)	75.80±2.39	78.40±11.42	97.40±17.84
4	Respiration (per min)	18.20±0.13	19.10±2.33	28.00±7.54
5	Sugar (mgs/dl)	86.90±23.14	77.30±6.73	81.00±6.83
6	Lactate (mmol/L)	1.24±0.38	1.84±1.54	6.57±4.55
7	Urea (mgs/dl)	25.60±6.72	23.20±5.08	23.70±5.14
8	Creatinine (mgs/dl)	0.94±0.06	0.85±0.07	1.04±0.25
9	Sodium (mmol/L)	142.20±2.82	141.90±3.38	131.60±5.64
10	Potassium (mmol/L)	4.40±0.22	4.49±0.32	4.18±0.28
11	Chloride (mmol/L)	108.70±5.27	105.90±3.57	98.90±11.32
12	HCO <sub>3</sub> (mmol/L)	22.98±0.77	23.24±1.62	19.10±3.36
13	Calcium (mgs/dl)	9.53±1.51	9.39±1.04	10.42±0.59
14	Phosphorous (mgs/dl)	4.88±0.56	5.02±0.76	5.37±1.38
15	pH	7.39±0.09	7.38±0.02	7.31±0.04
16	pO <sub>2</sub> (mmHg)	92.60±15.20	93.60±9.34	97.60±24.83
17	SpO <sub>2</sub> (%)	96.70±1.88	97.00±0.81	94.80±8.52
19	pCO <sub>2</sub> (mmHg)	37.20±1.84	39.30±1.22	35.80±2.23
19	TCO <sub>2</sub> (mmol/L)	25.00±1.24	23.90±3.10	18.70±3.33
20	BEecf (mmol/L)	-2.00±1.40	-2.20±0.83	-6.80±4.40

Table 2: Comparison of the metabolic effects of yoga and exercise.

S.No	PARAMETERS	PRE TEST Vs POST YOGA	PRE TEST Vs POST EXERCISE	POST YOGA Vs POST EXERCISE
1	Temperature (°F)	s**	s***	ns
2	Blood Pressure (systolic)-mmHg	ns	s**	s*
	Blood Pressure (diastolic)-mmHg	ns	ns	ns
3	Pulse (per min)	ns	s**	s**
4	Respiration (per min)	ns	s***	s***
5	Sugar (mgs/dl)	ns	ns	ns
6	Lactate (mmol/L)	ns	s**	s**
7	Urea (mgs/dl)	ns	ns	ns
8	Creatinine (mgs/dl)	ns	ns	s*
9	Sodium (mmol/L)	ns	s***	s***
10	Potassium (mmol/L)	ns	ns	ns
11	Chloride (mmol/L)	ns	s*	ns
12	HCO <sub>3</sub> (mmol/L)	ns	ns	s*
13	Calcium (mgs/dl)	ns	ns	ns
14	Phosphorous (mgs/dl)	ns	ns	ns
15	pH	ns	ns	ns
16	pO <sub>2</sub> (mmHg)	ns	ns	ns
17	SpO <sub>2</sub> (%)	ns	ns	ns
19	pCO <sub>2</sub> (mmHg)	ns	ns	s*
19	TCO <sub>2</sub> (mmol/L)	ns	s***	s***
20	BEecf (mmol/L)	ns	ns	ns

s=significant, ns=non significant, \*=*pd*"0.05, \*\*=*pd*"0.01, \*\*\*=*pd*"0.001  
 pCO<sub>2</sub> (Partial Pressure of Carbon Dioxide); pO<sub>2</sub> (Partial Pressure of Oxygen)  
 BEecf ( Base Excess or Base Deficit); SpO<sub>2</sub> (Oxygen Saturation)  
 TCO<sub>2</sub> (Total Carbon Dioxide Content);HCO<sub>3</sub> (Bicarbonate)

be beneficial to persons with hyperglycemia and the need for blood sugar control. Blood urea levels showed insignificant changes after both yoga and exercise. Creatinine levels decreased insignificantly after yoga and increased insignificantly after exercise. However the difference in creatinine levels post yoga and post exercise was significant. The increase in blood creatinine after vigorous physical exercise could place an extra load on the kidneys which does not happen after the practice of yoga.

Between the two important minerals involved in bone metabolism, blood calcium levels decreased after yoga which could be due to the fact that yoga favored transport of calcium from blood to bone. This is beneficial and will cause bone mineralization. Whereas in the physical exercise group an insignificant increase in blood calcium and phosphorous levels were noted this could be due to mobilization of the two minerals from bone to blood.

Among blood gas parameters partial pressure of oxygen did not show significant increase after yoga and exercise, whereas partial pressure of carbon dioxide increased insignificantly after yoga and decreased insignificantly after exercise. The total carbon dioxide content decreased insignificantly after yoga and significantly after exercise which could be due to hyperventilation following vigorous physical exercise. The oxygen saturation increased after yoga and decreased after exercise although these changes were insignificant.

Among electrolytes the amounts of sodium, potassium, chloride and bicarbonate levels reduced more after exercise than yoga. Especially the reduction in sodium and chloride levels after physical exercise was statistically significant. These results demonstrated that yoga did not disturb the electrolyte balance of the body whereas vigorous exercise caused ionic imbalance by promoting intracellular transport of sodium ion. Further the base deficit was more pronounced after exercise but did not change much after yoga.

An earlier study which compared the health outcomes after yoga and exercise had concluded that except physical fitness in all other outcomes yoga was equal or superior to exercise<sup>6</sup>. Our study also demonstrated that yoga was more effective than vigorous physical exercise by bringing out in a detailed manner the metabolic changes that took place during yoga and physical exercise with reference to many physiological and biochemical parameters in human subjects. This study clearly indicated that Suryanamaskar lowered blood sugar levels without placing any stress on the heart and kidneys or disturbing the electrolyte balance of the body. Whereas physical exercise in the form of shuttle running was less effective than yoga in lowering blood sugar levels and that too at the cost of stress on the cardiovascular system, overload on the kidneys, lactic acidosis and electrolyte imbalance. Therefore it can be said that yoga can be employed as a complementary therapy program to enhance the beneficial effects of standard medical management of diabetes mellitus and hypertension.

On analyzing the life of yogis it can be seen that the incidence of metabolic disorders like diabetes mellitus, hypertension, dyslipidemia, cancers, osteoporosis and neurological degenerative diseases were negligible and they had a life span of more than 100 years. Apart from yoga practice they consumed lot of fresh vegetables, fruits, nuts, and cut down on the consumption of animal fat and other foods rich in saturated fat. Yogis did not develop osteoporosis which is widely prevalent in this modern age as they practiced yoga like suryanamaskar. Suryanamaskar contains 62,000 movements including many body stretching

movements. These movements increase the circulation to the bone via periosteum, muscular attachments, ligaments and the nutrient artery which are the chief sources of blood supply to the bone (Figure-2). Moreover when yoga like Suryanamaskar is performed the abdomen region is subjected to squeezing, stretching and other movements that may have a beneficial effect on the internal organs such as pancreas which secrete insulin and also muscle and liver which possess insulin receptors. This leads to improved insulin sensitivity, decreased insulin resistance and increased sensitivity of pancreatic  $\beta$  cells to glucose signals. The net outcome is subsequent reduction in blood glucose levels. Moreover the positive effect of yoga on the immune system cannot be ruled out as a result of which resistance is enhanced giving protection from multiorganisms infections that cause some cancers. Hence if elders and senior citizens practice yoga regularly it will control many diseases to which they are susceptible. As a consequence the burden on their care givers belonging to the younger generation will considerably reduce in terms of cost, time and energy.

## CONCLUSION

This study demonstrated that yoga has the potential to play a therapeutic role in the modification of risk factors of cardiovascular diseases such as hypertension and diabetes mellitus in young and middle aged persons. The promising findings of this pilot study justifies the need to carry out an elaborate controlled trial for a longer time period to analyze the long term effects of yoga on the body. Based on the results of this study it is strongly recommended that yoga should be introduced in the school curriculum at the nursery classroom level itself and taught at high school through collages. Yoga should be imparted in industrial and corporate organizations, private and government offices as well as national services like army, navy, air force and police too. Even a brief but comprehensive lifestyle education program based on yoga will help to reduce the risk factors of cardiovascular diseases and diabetes mellitus. Since the health and psychosocial benefits of yoga are enormous it will have implications in the physical and mental well being of the nation's work force and thereby increase productivity, growth and development.

## ACKNOWLEDGEMENT

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## REFERENCES

1. *Biography of His Holiness Vishwaguru Mahamandaleswar Paramhans*. Available from <http://www.yoga in daily life.org>.
2. *Gautama Buddha quotes (The author of the Dhammapada)*. Available from <http://www.goodreads.com/author/quotes/2167493>.
3. *K.Narayanawamy Ajar: A Translation of Yoga-Vasishtha - Lghu, Thompson and &Co, Madras; modifying cardiovascular risk profile in middle aged men and women. J Assoc Physicians India. 2002, 50(5): 633-40.*
4. *Bijlani RL, Vempati RP, Yadav RK, Ray RB, Gupta V, Sharma R, Mehta N, Mahapatra SC. A brief but comprehensive lifestyle education program based on yoga reduces risk factors for cardiovascular. Minerva Press: 1896.*
5. *Dandekar S, malathi A, Patil N, Shah N, Survasitli Marathe S. Therapeutic potential of yoga practices in diseases and diabetes mellitus. J Altern Complement Med. 2015, 11(2) 267-74.*
6. *Ross A, Thomas S. The health benefits of yoga and exercise: a review of comparison studies. J Altern Complement Med. 2010, 16(1): 3-12*
7. *Kelly B, Smith and Caroline F. Pukall. An evidence-based review of yoga as a complementary intervention for patients with cancer psycho-oncology. 2009, 5: 465-475.*
8. *Fishman IM, Groessel EJ, Sherman KJ. Serial case reporting yoga for idiopathic and degenerative scoliosis. Glob Adv Health Med. 2014, 3(5):16-21.*
9. *Kim E, Innes, Cheryl Bourguignon, and Ann Gill Taylor. Risk Indices associated with the insulin resistance syndrome, cardiovascular disease, and possible protection with Yoga: A systematic review. J Am Board Fam Med. 2005, 18 (6): 491-519.*

## LITERATURE REVIEW

### SERUM CHLORIDE IS AN INDEPENDENT PREDICTOR OF MORTALITY IN HYPERTENSIVE PATIENTS.

McCallum L, Jeemon P, Hastie CE, Patel RK, Williamson C, Redzuan AM, Dawson J, Sloan W, Muir S, Morrison D, McInnes GT, Freel EM, Walters M, Dominiczak AF, Sattar N, Padmanabhan S. *Hypertension*. 2013 Nov;62(5):836-43.

Chloride (Cl<sup>-</sup>) is the major extracellular anion in the body, accompanying sodium (Na<sup>+</sup>), and is primarily derived from dietary sources. Data suggest that increased dietary Cl<sup>-</sup> intake increases blood pressure, yet paradoxically, higher serum Cl<sup>-</sup> appears associated with lower mortality and cardiovascular risk. This implies that serum Cl<sup>-</sup> also reflects risk pathways independent of blood pressure, serum Na<sup>+</sup>, and bicarbonate (HCO<sub>3</sub><sup>-</sup>). We analyzed 12,968 hypertensive individuals followed up for 35 years, using Cox proportional hazards model to test whether baseline serum Cl<sup>-</sup> was an independent predictor of mortality. To distinguish the effect of Cl<sup>-</sup> from Na<sup>+</sup> and HCO<sub>3</sub><sup>-</sup>, we adjusted for these electrolytes and also performed the analysis stratified by Na<sup>+</sup>/HCO<sub>3</sub><sup>-</sup> and Cl<sup>-</sup> levels. Generalized estimating equation was used to determine the effect of baseline Cl<sup>-</sup> on follow-up blood pressure. The total time at risk was 19,7101 person-years. The lowest quintile of serum Cl<sup>-</sup> (<100 mEq/L) was associated with a 20% higher mortality (all-cause, cardiovascular and noncardiovascular) compared with the remainder of the subjects. A 1 mEq/L increase in serum Cl<sup>-</sup> was associated with a 1.5% (hazard ratio, 0.985; 95% confidence interval, 0.98-0.99) reduction in all-cause mortality, after adjustment for baseline confounding variables and Na<sup>+</sup>, K<sup>+</sup>, and HCO<sub>3</sub><sup>-</sup> levels. The group with Na<sup>+</sup> > 135 and Cl<sup>-</sup> > 100 had the best survival, and compared with this group, the Na<sup>+</sup> >135 and Cl<sup>-</sup> <100 group had significantly higher mortality (hazard ratio, 1.21; 95% confidence interval, 1.11-1.31). Low, not high Serum Cl<sup>-</sup> (<100 mEq/L), is associated with greater mortality risk independent of obvious confounders. Further studies are needed to elucidate the relation between Cl<sup>-</sup> and risk.