# Evaluation of Efficacy of Long-term Yogic Training on Vascular Endothelial Function and Cardiovascular Responses in Healthy Individuals

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## Abstract

There are numerous studies confirming the positive effects of physical exercise in improving the functional status of vascular endothelium and cardiovascular parameters. However, there is very less scientific data available showing the efficacy of yoga training on vascular endothelium functions and various cardiovascular parameters with large sample size. Hence the study was intended to measure the change in plasma nitric oxide level (NOx), resting heart rate (HR) and resting systolic (SBP) and diastolic blood pressure (DBP). Yoga intervention was given on age matched 200 healthy individuals of both the gender. NOx, Resting HR, SBP and DBP were measured at Baseline and after six months. Data collected was analyzed statistically showed significant elevation in NOx, reduction in HR, SBP and DBP. Positive findings are the suggestive of improved vascular endothelial health and cardiovascular responses.

***Keywords:*** *Yoga, Vascular Endothelium, Nitric Oxide, Heart Rate, Blood Pressure.*

## Introduction

The endothelium is a single cell layer lining the luminal surface of entire vascular tree. Itserve in wide vascular homeostatic processes.[1,2] Modulation of blood flow, vascular tone[3,4] and vascular wall protection[5] are some of the noted functions of vascular endothelium. Normally, it releases diverse vasoactive agentscausing vasoconstrictions and vasodilation. Nitric Oxide (NO) is one of the potent endogenous vasodilatory agents released in response to physical stimuli i.e. sheer stress, hormones and platelet-derived substances. Through these agents, healthy endothelium is proactively involved in vascular tone regulation and protection.[6–8] The damaged endothelium is critical in a variety of human disorders including peripheral vascular disease, stroke, heart diseases, venous thrombosis,disturbance in the physiological haemostatic processes, renal failure, diabetes, etc.[1]

Endothelial dysfunction primarily characterized by reduced NO production, bioavailability and vasomotor response which plays crucial role in pathogenesis of atherosclerosis.[9,10] Lack of regular exercise, high blood pressure, diabetes mellitus, and aging are some of the risk factors linked with vascular endothelial dysfunction.[11] Insufficient NO release may cause vasoconstriction in coronary arteries during exercise and mental stress which may result in myocardial infarction, ischeamia and promote vascular inflammation.[2]

There is reduction in cardiovascular risks factors especially hypertension with improved vascular endothelial functions.[12,13] Scientific literature indicate the beneficial effects of regular aerobic exercise in improving vascular endothelial health[14], reducing arterial stiffness[15] and blood pressure in healthy individuals.[16] Vascular endothelium-dependent vasodilatory response

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is principally depends on the NO release. Therefore, measurement of plasma NO and basal blood pressure could be reliable approach to recognize its functional status.[17]

Various studies reports yoga as a mind-body exercise modality which enhances cardiopulmonary fitness and mental wellbeing, if practiced regularly.[18,19]

Physiological role of NO is all apparent, however effect of yoga to assess the vascular endothelial functional status with large sample size in healthy individuals has been least attempted. Therefore, the present study was primarily intended to evaluate the effect of long term yoga training on Total Plasma Nitric Oxide (NOx). Secondarily, to assess the cardiovascular responses at rest to long-term yoga practice.

## Material and Method

**Design and Sample size:** In this pre- and post yoga interventional study, healthy individuals (n=200; 120 Male and 80 Female) within 30-50 years of age range (mean age 39±0.95 years) were recruited.

**Inclusion and Exclusion Criteria:** Healthy individuals willing to practice yoga dailyfor six months were included. While, individuals with any systemic, mental disorders, pregnant women and receiving any physical and/or yoga training were excluded from the study.

**Ethics:** Written consent was obtained from all study participants. The study was approved by institutional ethical committee (Registration No. ECR/581/INST/MH/2014).

**Intervention:** Yoga (Asanas, Pranayama and Meditation) intervention was given for six months (1 hour per day, 6 days per week) by trained yoga instructor.

**Variables Studied:** Total plasma nitric oxide (NOx); resting heart rate (HR), resting SBP and DBP were measured at baseline i.e pre-yogic and post-interventioni.e post-yogic, respectively.

**Statistical Analysis:** For statistical data analysis, SPSS (24$^{th}$ Version) was used. Quantitative data was presented as Mean±Standard Deviation (SD). Mean±SD was calculated as Mean Difference. Paired t-test was used for data comparison. P-value at 5% was established for significance.

## Results

Pre-yogic and post-yogic Total Plasma Nitric Oxide (NOx); Resting HR, SBP and DBP were measured and are shown in Table I. There highly significant ($p<0.0001$) reduction in post-yogic resting HR, SBP and DBP compared to their respective baseline values was observed.

**Table I: Comparison between Mean Pre- and Post-yogic NOx, Resting HR, SBP and DBP**

| Variables | Measure-ments | Mean±SD (n=200) | Mean Difference | p-value |
|---|---|---|---|---|
| NOx (μMole/L) | Pre-yogic | 36.25±4.76 | 6.27 | p<0.0001** |
| | Post-yogic | 42.52±5.32 | | |
| Resting HR (bpm) | Pre-yogic | 79.97±8.13 | 5.15 | p<0.0001** |
| | Post-yogic | 74.82±4.99 | | |
| Resting SBP (mmHg) | Pre-yogic | 128.41±7.64 | 4.36 | p<0.0001** |
| | Post-yogic | 124.04±6.21 | | |
| Resting DBP (mmHg) | Pre-yogic | 79.63±4.70 | 1.08 | p<0.0001** |
| | Post-yogic | 78.55±3.61 | | |

NOx: Plasma Nitric Oxide; SD=Standard Deviation; HR=Heart Rate; SBP=Systolic Blood Pressure; DBP= Diastolic Blood Pressure, p<0.0001**=Highly Significant.

Post-yogic Resting SBP and DBP were correlated with post-yogic NOx level and are shown in Fig. 1 and Fig. 2 respectively. There significant negative correlation between post-yogic resting SBP and DBP ($p<0.0001$) with post-yogic NOx was observed and is shown in Table II.

**Fig. 1: Correlation between post-yogic Resting SBP and post-yogic NOx level**

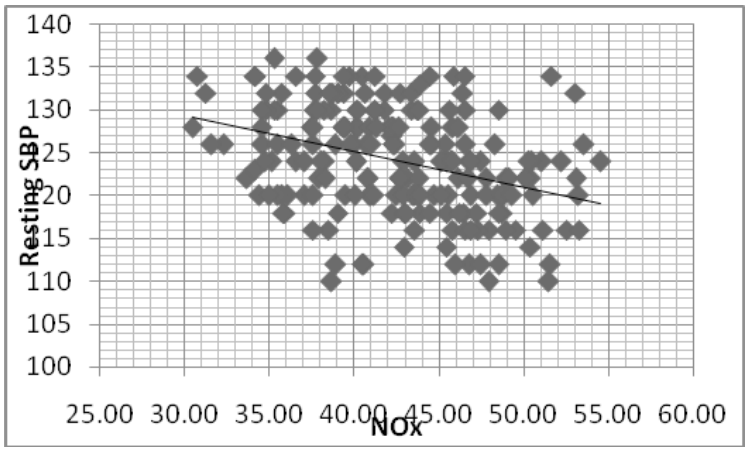


**Fig. 2 :Correlation between post-yogic Resting DBP and post-yogic NOx level**

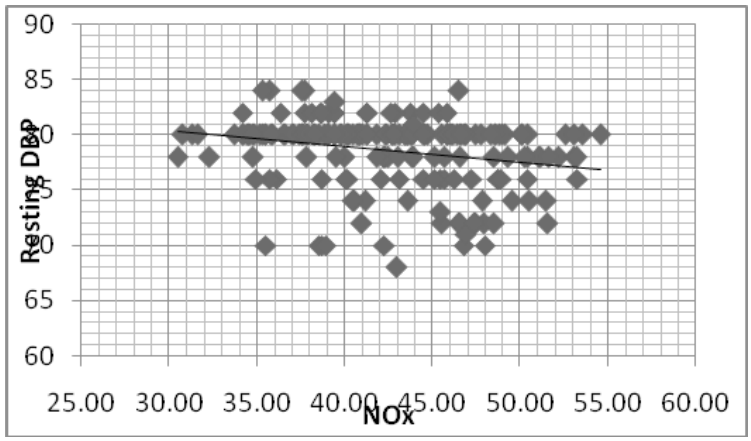


**Table II: Correlation between post-yogic NOx level with post-yogic Resting SBP and DBP**

| Variables | r-value | p-value |
|---|---|---|
| Resting SBP (mmHg) vs NOx (µMole/L) | -0.359 | p<0.0001** |
| Resting DBP (mmHg) vs NOx (µMole/L) | -0.245 | p<0.0001** |

NOx = Total Plasma Nitric Oxide level; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; S = Significant; p<0.0001** = Highly Significant.

## Discussion

The present study was intended to find efficacy of long term yoga training on vascular endothelial functional status by measuring total plasma nitric oxide level andon cardiovascular responses by measuring heart rate and blood pressures at rest.

We found, highly significant (p<0.0001) increase in post-yogic NOx level and reduction in resting HR, SBP & DBP compared to their respective baseline values (Table I). Further,correlation showed significant (p<0.0001) reduction in resting SBP (Fig. 1) & DBP (Fig. 2) with post-yogic NOx (Table II).

Significant increased level of total plasma NO level after long term yoga practice was one of the novel finding of our study. The outcome of this study is in accordance with the finding of Preethi Bangalore Lakshmangowda, et.al.[20] Patil SG et.al[21] had reported the significant increase in NO level in yoga practicing elderly subjects which resulted in reduction in arterial stiffness. Another study has reported the NO elevating effect of Bhramari Pranayama.[22] A range of studies showed exercise

stimulates NO release from the endothelial cells.[23-25] Increased blood flow through vessels is identified as the root cause of endothelial release of NO.[26,27]The exact mechanism behind the elevated post-yogic NOx remained unclear. However, we presume that it is most likely the stimulation to increased blood flow due to yoga practice have caused the sheer force over the endothelium. As a consequence, it releases more NO than normal.

Our finding regarding significant reduction of Resting HR was consistent with the findings of various researchers.[28-32] According to theme, that was probably due to stronger vagal activation and balance in autonomic activities caused by yoga practice. On that context, we attribute the reduction in post-yogic Resting HR to increased vagal tone, deep psychosomatic relaxation and reduction in exercise induced stress on cardiovascular system over the period of yoga training.

The Our findings i.e. significant reduction in post-yogic Resting SBP & DBP compared to their respective baseline values were similar with the outcomes of various studies.[28,29,33-35]It is suggested that the arterial stiffness causes not only elevation of resting BP but also influence BP responses to exercise.[36] Arterial stiffness not only decided by the structural components but also by vascular tone and endothelial functional status. It is implied that NO and vascular tone are the key components in the regulation of arterial stiffness therefore they are vital determinants for exercise induced BP response. A study reveals that, pharmacological inhibition of NO synthase increases BP during sub-maximal level of exercise.[37] Hence, it may be assumed that, reduction in Resting SBP & Resting DBP might by due to increased parasympathetic activity, reduced vascular tone; increased cardiopulmonary endurance, blood flow to the muscles at rest; elevated post-yogic NOx might have increased vasodilatory effect, decreased arterial stiffness which collectively have caused significant reduction Resting SBP & DBP after long term yoga training.

## Conclusion

Increased NOx level due to long term yoga may reflect the improved functional status of the vascular endothelial layer. Reduced resting HR, SBP & DBP also indicate the cardiovascular response modulating efficacy of regular yoga training. This also suggestive of improved cardiac endurance and fitness. Elevated NO levelis the indicator of improved endothelial functional status. Therefore, it may be concluded that, yoga as a complementary exercise modality to reduce the risk of CVDs in healthy adult individuals.

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**Conflict of Interest:** None

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