Effect of Long-Term Yoga Practice on Stress, Blood Pressure, and Pupil Limbus Diameter Ratio

Archana R.[1], Nivedha Kumari G.[2*], Mokana L.[3]

[1]*Department of Physiology, Annaii Medical College and Hospital, Rajalakshmi Health City, Tamilnadu, India*
[2]*CGHS, Ministry of health and family welfare, Chennai 600099, India*
[3]*Sai Clinic, Kanchipuram 631501, India*

KEYWORDS
Yoga, stress, blood pressure, pulse rate, respiratory rate, pupil limbus diameter.

ABSTRACT
Background:Yoga has been reported to provide potential health benefits for anxiety, stress reduction, and general well-being. The relaxation induced by meditation helps to stabilize the autonomic nervous system with a tendency towards parasympathetic dominance. Long-term yoga practice helps yoga practitionersbecome more resilient to stressful conditions and reduce a variety of important risk factors for various diseases. Pupil to limbus Diameter [PLD]is a simple non-invasive technique to identify the altered autonomic responses during yoga practice. Perceived stress scale [PSS] is the most widely employed psychological instrument for measuring the perception of stress. It measures the degree to which situations in one's life are appraised as stressful. Methodology: Thus the study aims to assessthe autonomic changes and stress levels in long-term yoga practitioners by assessing the PLD ratio and noting the PSS scale in 48 control and 45 yoga practitioners recruited from the Yogisha Mission Trust. As the regular practice of yoga is known to regulate Systolic blood pressure (SBP) and Diastolic blood pressure (DBP) in hypertensive patients, changes in blood pressure, pulse rate (PR) and respiratory rate (RR) were recorded. Result: There was a significant decrease in the mean PLD ratio of the right eye, left eye and both eyes when compared between the control and the study group[yoga practicing group] ($p<0.05$). A significant reduction in perceived stress levelblood pressure, PR and RR was noted in people practicing yoga when compared to the control group ($p<0.05$). Conclusion: From our study, we conclude that long-term practice of yoga helps in the reduction of stress, blood pressureand PLD ratio.

1. Introduction and Background

Yoga is an ancient therapeutic way of practice to provide potential health benefits in anxiety, stress reduction, improvement in sleep quality and general well-being [1, 2]. Practicing yoga regularly has been shown to increase physical and psychological comfort and at the same time create conditional relaxation responses in the nervous system [2, 3]. Yoga practice helps in reducing BP and improves lipid profile [4, 5]. Abnormal physiological stress reactivity is considered a vulnerablepotential marker for various physical and psychological health problems in children and adolescents [6]. The state of the mind and that of the body are closely connected. If the mind is relaxed, the muscles within the body also will be relaxed. Physical and mental tensions are the consequences of experiencing stress. Yoga, developed thousands of years past, is recognized as a style of mind-body medication. In yoga, physical postures and respiratory exercises improve muscle strength, flexibility, blood circulation and oxygen uptake as well as hormone functions. Additionally, the relief evoked by meditation helps to stabilize the autonomic nervous system with a bent towards parasympathetic dominance. Physiological benefits that follow facilitate yoga practitioners to become additionally resilient to disagreeable mind-depressing conditions and reduce a variety of important risk factors for varied diseases, particularly cardio-respiratory diseases [7].

Meditation is taken into account as an ancient spiritual practice that has potential profit on health and well-being [8, 9]. It is a complex physiological method that affects neural, psychological, behavioural, and involuntary functions. It is thought of as an altered state of consciousness thatdiffers from wakefulness, relaxation at rest, and sleep [10, 11]. Most of the meditation techniques affect ANS, therefore indirectly regulating many organs and muscles. Consequently, functions of heartbeat, sweating, breathing, and digestion are controlled by the ANS. Recent studies highlighted the psycho-physiological aspects of meditation and its impact [12].

There are two branches of the ANS, specifically the sympathetic branch, which will increase the heartbeats and the parasympathetic branch which decreases the heartbeats. Thus, the vital heart rate variations (HRV) are an indicator of the dynamic interaction and balance between these 2 nervous systems. Under resting conditions, sympathetic and parasympathetic system operate simultaneously, with a predominance of parasympathetic tone. The balance between each system is consistently varied to optimize the result of any internal/external stimuli [13]. Though HRV has been widely used to assess autonomic alterations we have tried to use the PLD ratio as a

novel method to evaluate the autonomic responses.

PLD ratio is defined as "the ratio of the pupillary diameter measured at an axial plane with the limbal diameter measured at the same or parallel axial plane[14]. The pupil of the eye is located in the centre of the eye and is responsible for regulating light entry. It responds immediately to lighting changes in the surrounding environment by constriction or dilation according to the current need, thereby always allowing optimum light entry [15, 16]. Variations in the pupil diameter are regulated by two muscles, the sphincter and dilator which are innervated by the parasympathetic nervous system and sympathetic nervous system simultaneously. Sympathetic stimulation causes the pupil to dilate by the release of adrenaline, while parasympathetic inhibition also occurs[17]. Sympathetic stimulation and parasympathetic inhibition contribute to pupillary dilation through the corresponding muscle fibres[18]. Studies on the immediate effect and short-term effects of yoga practice on stress, anxiety, depression and other morbidities of stress are adequate. However, long-term studies are comparatively less [19].

Although numerous tests(cold pressor test, Valsalva, isometric handgrip test, head-up tilt test and analysis of heart rate variability) evaluate autonomic function, no concise, rapid test exists to specifically capture autonomic adaptations in individuals practicing yoga. So we have chosen the PLD ratio to note the autonomic alterations.Yoga's beneficial effect on cardiorespiratory function was assessed by measurement of systolic and diastolic blood pressure, pulse rate and respiratory rate.The Perceived Stress Scale (PSS) is the most popular psychological tool for assessing stress perception, gauging how individuals evaluate the stressfulness of life situations.As long-term yoga practice is known to alter the handling and perception of stress,PSSwas assessed in the form of a questionnaire amonglong-term yoga practitioners.

2. MATERIALS AND METHODS:

The study was initiated after obtaining clearance from the Institutional Ethics Committee (IEC/2018/07/128). A purposive sampling technique was used to select the study participants. 93 participants in the age group of 20 to 60 yearsfulfilling the inclusion criteria were chosen for the study. 45 participants for a minimum period of 1-2 yearsfrom the yoga centreYogishaMission Trust in Chennai and 48 participants with no experience in yoga were recruited for the study after obtaining written informed consent. All yoga practitioners in the age group of 20 to 60 years who were willing to participate in the study and who were practicing yoga for general health for a period of 1 to 2 years,4-5 sessions per week with 30-40 minutes duration were included in the study group. Participants with history of diabetes, hypertension, cardiac disease, asthma and any chronic health problems were excluded from the study.

Measurement of BMI:

Body Mass Index (BMI) is a widely used measurement that calculates body fat based on height and weight, applicable to males and females across all age groups.BMI is calculated by dividing a person's weight (in kilograms) by the square of their height (in meters): BMI = kg/m². Asian BMI cutoff [20] is given below in Table 1

Table 1:

Nutritional status	Asian Criteria BMI Cut-off
Underweight	<18.5
Normal	18.5 – 22.9
Overweight	23 – 24.9
Pre-obese	25 – 29.9
Obese	>/= 30

Measurement of blood pressure (BP):

Blood pressure and pulse rate were measured using a fully automatic M60 Diamond Digital Blood Pressure Monitor (Industrial Electronic and Allied Products) from the right hand following American Heart Association (2017) guidelines.Participants seated comfortably with feet on floor and back supported for 5 minutes avoiding caffeine, exercise, and smoking for at least 30 minutes.. Correct cuff size and arm positioning done. Systolic BP and diastolic BP recorded at the onset and disappearance of korotkoff sounds respectively. Out of the three readings, lowest value obtained was used. (American Heart Association, 2017) [21].

Measurement of pulse rate

After 20 minutes of rest, pulse rate was measured by gently pressing three fingers on the inner wrist and counting

beats for 1 minute[22].

Measurement of Respiratory rate:

Measured at rest, concurrently with pulse rate, by counting chest rises for 1 minute to minimize subconscious influence on breathing patterns[23].

Measurement of Pupil to Limbus Diameter ratio (PLD)

PLD ratio is defined as "the ratio of the pupillary diameter measured at an axial plane with the limbal diameter measured at the same or parallel axial plane" [14].

PLD ratio was measured by the two-box method [15].

Image Capture Protocol:

Before capturing eye images, participants were acclimated to ambient light for 5 minutes. Background illumination was measured and maintained constant using a Luxmeter (Metro Q MTQ 1010A, 0-20,000 Lux range, ±2% repeatability). [Fig 1]

Image Acquisition

A Samsung cell phone camera withBuilt-in spot metering and Autofocus capabilitywas used to capture images without flash. The camera automatically adjusted exposure based on reflectance from the iris/pupillary area.

Figure 1: Luxmeter – Ambient light condition measurement

Image Processing and PLD Ratio Measurement:

To enhance visibility of pupillary margins, images were optimized for brightness and contrast. Using Microsoft Office PowerPoint 2010, PLD ratios were calculated employing the two-box method. Two identical-height boxes were drawn using the rectangular tool. Boxes were superimposed and widths adjusted manually to represent limbal and pupillary diameters. Limbus and pupillary diameters were measured in the same or parallel axial plane (Figure 2)[15].

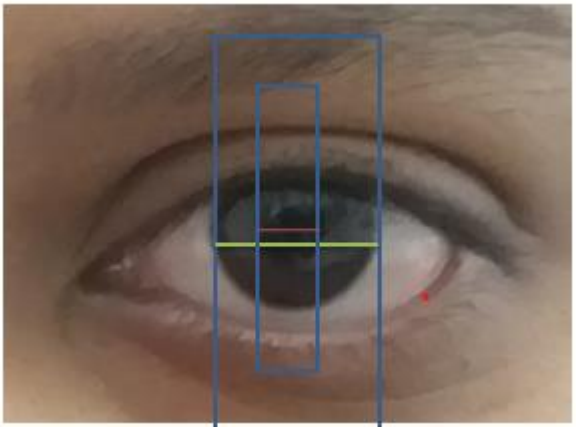

Figure 2: Measurement of PLD ratio

Limbus diameter [YELLOW LINE] 3.18 cm, Pupil diameter [RED LINE] – 1.19 cm, Pupil to limbus diameter ratio: 0.37

The Perceived Stress Scale (PSS)

The Perceived Stress Scale (PSS) is the most commonly used questionnaire-based tool to assess stress levels, with scores ranging from 0 to 40[24].Highest score value is 40 with scores ranging from 0-13 would be considered low stress, Scores ranging from 14-26 would be considered moderate stress and scores ranging from 27-40 would be considered high perceived stress [21].

Statistical analysis

The data obtained was analyzed by SPSS software version 20.0. Student t-test was applied between the normal and yoga-practicing groups to assess the significant difference in stress levels, blood pressure, PR, RRand PLD ratio. P-value less than 0.05 were considered significant.

3. RESULTS:

Data from 45 yoga practitioners (study group) and 48 non-yoga practitioners (control group)were analyzed. Table 2 presents thecomparison of the mean ± SD (standard deviation)value of age, gender and BMI of the control group andstudy group using the t-test. Age wasnot significantly different among the control and study groups. Normal BMI was seen in the yoga practicing group whereas pre-obese stage was observed among the non-yoga practicing group which was statistically significant as per Asian criteria BMI cut-off.

Table 2: Demographic details of the study participants

Parameter	Study group (n=45)	Control group (n =48)	t value	P value
Age (yrs, Mean, SD)	39.42±2.27	40.12±2.14	1.5308	0.1293
1. 20-30(n,%)	05 (11.11)	04 (8.33)	0.1255	0.9042
2. 31-40(n,%)	20 (44.44)	17(35.41)		
3. 41-50(n,%)	16 (35.55)	22 (45.83)		
4. 51-60(n,%)	04 (8,88)	05 (10.41)		
Gender (n,%)				
1. Male(n,%)	21 (46.66)	26 (54.16)	0.6000	0.6094
2. Female(n,%)	24 (53.33)	22 (45.83)		
BMI (kg/m^2)	21.4±1.37	27.95±1.25	24.1077	0.0001*

Data is presented as Mean±SD. *P<0.05 is considered statistically significant

Mean ± SD (standard deviation) value of systolic blood pressure (SBP), diastolic blood pressure (DBP) parameters, pulse rate (PR) and respiratory rate (RR) of the study and control group was taken. There was a significant decrease in SBP, DBP, PR and RR in the study group when compared with the control groups (*P<0.05, table 3)

Table 3:Cardiorespiratory parameters of the study participants

Parameter	Study group (n=45)	Control group (n =48)	t value	P value
SBP (mmHg)	115.17± 5.03	132.02± 4.71	16.6837	0.0001*
DBP (mmHg)	74.37± 2.52	82.04±3.09	13.0672	0.0001*
Pulse rate (beats/min)	74.47±2.23	81.31±4.78	8.7461	0.0001*

Respiratory rate(RR/min)	13.24±0.85	15.81±0.71	15.8621	0.0001*

Data is presented as Mean±SD. *P<0.05 is considered statistically significant

The mean PLD ratio of both left and right eyes including both eyes was taken. Between the control and study group, there was a significant decrease observed in the PLD ratio of the yoga practicing groups when compared [p<0.05] individually for each eye and also upon comparing both eyes. (*P<0.05 Table 4).

Table 4:PLD ratio of the left eye, right eye and both eyes in the study group [yoga practicing group] and control group [normal group]

Parameter	Study group(n=45)	Control group(n=48)	t value	P Value
Left eye PLD	0.376±0.06	0.424±0.05	2.72	0.004*
Right eye PLD	0.380±0.05	0.418±0.05	3.40	0.0006*
Mean both eye PLD	0.383±0.05	0.424±0.05	3.36	0.0007*

Data is presented as Mean±SD. *P<0.05 is considered statistically significant

As per the PSS score, scores ranging from 0-13 would be considered low stress, 14-26 would be considered moderate stress and scores ranging from 27-40 would be considered high perceived stress. Among the control group 15% showed low stress, 60% showed moderate stress scores and 25% showed high perceived stress. Whereas among the yoga practicing study group 52.5% showed low stress, 47.5% showed moderate stress and there were no personnel with high perceived stress score showing the stress alleviating efficacy of long term yoga practice. [Figure 3].

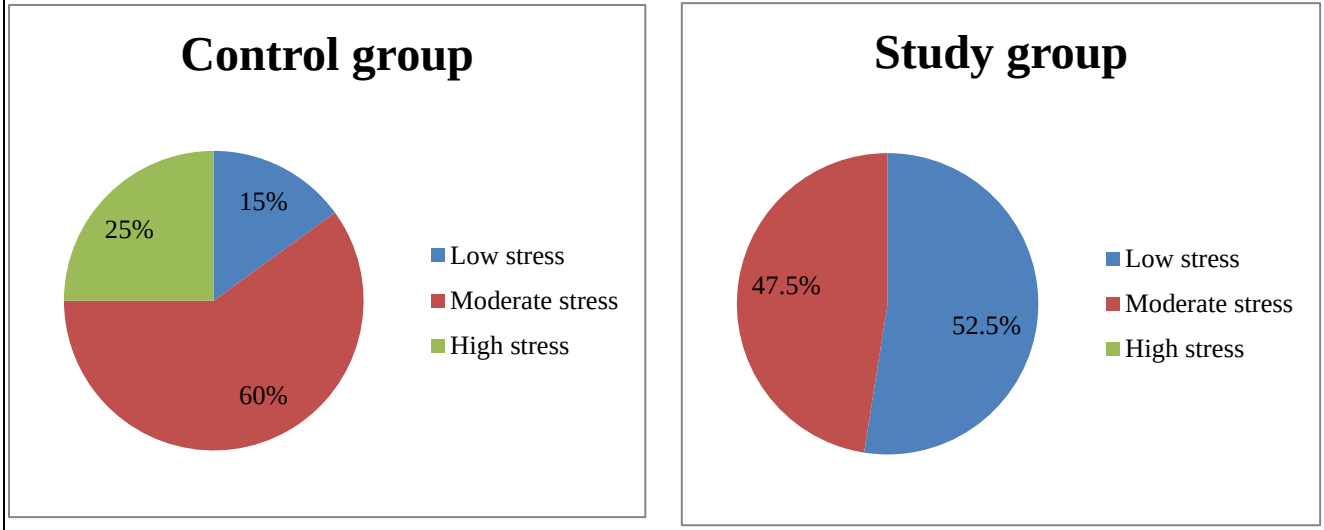

Figure 3 PSS % Control and Study Group

4. Discussion:

Stress is outlined as "a state of mental or emotional strain or tension ensuing from adverse or hard circumstances" [25].Stress might hurt health and well-being, resulting in detrimental physical and emotional symptoms such as headaches, anxiety, depression and several other diseases [26]. Yoga is an ancient Indian science and is a method of life that includes the practice of specific postures, regulated breathing and meditation [27]. Yoga texts mention that the root cause of many diseases is often traced to lifestyle and amplified likes and dislikes at the mind level. Intense emotional distress can have physical manifestations, potentially leading to disease development[28, 29]. Hence, yoga is an efficient therapeutic tool in physical, psychological and neurotic disorders[30]. In a recent study by Vempati et al. on healthy adults, the yoga-based guided relaxation was shown to cut off the sympathetic activity as measured by autonomic parameters, oxygen consumption and breath volume which might be the cause for reduced stress observed in our study [31]. Medical and pre-medical students showed lesser anxiety and stress during an examination period after practicing 8 weeks of meditation which is in agreement with our study findings where yoga has been practiced for more than a year [32].

Two main systems make up the physiological stress response: the autonomic nervous system and also the hypothalamic-pituitary axis [HPA]. The autonomic nervous system encompasses two primary divisions: the parasympathetic and sympathetic nervous systems. According to polyvagal theory, the ventral branch of the vagus which is the primary component of the parasympathetic nervous system is responsible for maintaining homeostasis during rest, thereby keeping heart rate low[33,34]. When there is an episode of stress, the immediate response involves vagal withdrawal, which leads to an increase in heart rate, indicating the organism's preparedness to respond to an anticipated stressor. If this response is insufficient, the sympathetic nervous system is activated and there comes the fight-or-flight response which elevates heart rate and blood pressure[35]. Our study was designed to assess the stress levels in yoga and the control group using a perceived stress scale questionnaire and to relate it with the body's autonomic nervous system by measuring the pupil to limbus diameter and blood pressure. Yoga has been associated with decreased sympathetic and increased parasympathetic responses. There are many ways of assessing the autonomic nervous system, but limited evidence exists in the literature to demonstrate ANS effects using a simple, non-invasive technique with no side effects. Measurement of the diameter of the pupil is indicative of autonomic functions. Changes in blood pressure among women are correlated with variations in the pupil-to-limbus diameter (PLD) ratio [11]. The pupil dilates through sympathetic stimulation by the release of adrenaline and by parasympathetic inhibition[35, 36]. The changes in the PLD ratio observed in our study could be due to long-term yoga practice induced autonomic alterations.Previous studies have shown a positive correlation between blood pressure and PLD ratio and a strong correlation between PLD ratio and pulse rate in healthywomen [14,5].There was a significant decrease in the amount of oxygen consumed and in breath rate and an increase in breath volume after the practice of yoga and meditation[37]. Mindfulness meditation reduces proinflammatory cytokines and C-reactive protein levels. Yoga is known to decrease these inflammatory markers, reduce vagal tone and cause physiological relaxation thereby helping to reduce blood pressure level, pulse rate and respiratory ratein theyoga intervention group [4,38].

In this study, there was a significant decrease in the mean PLD ratio of the right eye, left eye and both eyes when compared between the control and the yoga-practicing group. There was a significant association of reduced stress levels in people practicing yoga compared to the normal control group which is evident from the PSS scores. Perceived stress scale values in long-term yoga practitioners showed significant parasympathetic dominancewhich along withdecreased sympathetic activity decreases the activity of the dilator muscle, inhibiting dilation, whereas the increase of parasympathetic activity increases constriction of the sphincter muscle, which decreases dilation.The observed difference in PLD ratio and PSS values might be due to long term practice of yoga induced autonomic changes.

5. Conclusion:

Long-term practice of yoga helps in reducing stress, blood pressure, pulse rate, respiratory rateand PLD ratio through autonomic alterations. PLD ratio is asimple, cost-effective way of assessment of autonomic function.

Study Implication:

The study will throw new light on using the PLD ratio as a simple non-invasive technique to assess the changes in autonomic function as observed in long-term yoga practitioners with parasympathetic dominance.

Limitations:

The study was done with a small sample size.Longitudinal studies with larger sample sizes are required for further validation of results.

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